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Engineering Copywriter provided us with quality content that surpassed my expectations. Their demonstrated subject matter knowledge, paired with their ability to research and develop the content (keeping in mind our audience and goals), is commendable. I value their dedication to client satisfaction and attention to detail. They have been really supportive and responsive throughout the process, and we look forward to a continued partnership.

Khaliya Rashid
Global Director of Digital Communications Golder

GD&T BASICS

Dean did an amazing job writing for my audience and helped us push a great campaign for our program. I would highly recommend his work!

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Founder
gdandtbasics.com

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How NewEngineer.com Blogs Accounted for More Than 55% of Overall Website Traffic.

James Alston
Content Marketing Manager
NewEngineer.com

OTM

OTM Servomechanism worked with Engineering Copywriter to develop a white paper showcasing one of our greatest achievements – a niche project which overcame massive technical hurdles. We're a small company and Dean and the team were brilliant at extracting the real reasons for this success – much of which rested only in the heads of those concerned!

Jeremy Able
International Partner Manager

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I highly recommend the team at Engineering Copywriter. I have been impressed with the quality of articles, the engineering knowledge, reliability and engaging content Easy to deal with, they listen and create the type of content to suit my business.

Lisa Cohen
Director
Customer Experience
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BLOGS AND ARTICLES

Mechanical Engineering

Vickers Hardness Test: What it is and how it's measured

- The Vickers Hardness test can help with the material selection process for your chosen application
- The test measures indentation hardness, using a diamond indenter
- It's easy to use, with advantages over other tests that include less risk of damaging your test piece

How often have you wondered if a material you need for your project is hard enough for its intended purpose? Hardness is a critical property for many applications. Fortunately, there is a relatively easy method to measure the hardness of materials, called the Vickers Hardness test.

According to the Metals Handbook, hardness is defined as the "resistance to plastic deformation". Since different materials behave in different ways, there are three kinds of hardness that are typically measured. Depending on the material, they are:

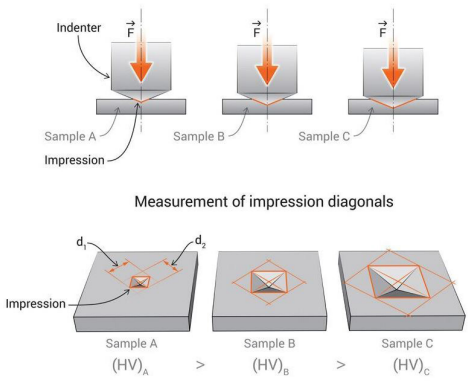
- indentation hardness
- scratch hardness
- rebound hardness

A modern LCD monitor digital Vickers optical hardness tester Machine (Sinowon)

The Vickers Hardness test measures the indentation hardness for small parts or thin sections of metals, ceramics, and composites – almost any type of material in fact.

How is the Vickers Hardness test carried out?

This test consists of applying a force (also called a "load") on the test material using a diamond indenter, to obtain an indentation. The depth of indentation on the material gives the value of hardness for the specimen. In general, the smaller the indentation, the harder the object is. Hardness tests can be classified into micro-indentation tests and macro-indentation tests, depending on the force that is applied to the test material. (Micro-indentation tests typically use loads of up to 200 gf, while macro-indentation tests use



Vickers Hardness Test indentation examples – 3 materials of different hardness. Image is © 2017 EngineeringClicks

loads up to 1000 gf). The Vickers Hardness test and Knoop Hardness test are the most commonly used tests that can be used for both micro-indentation and macro-indentation.

Why use the Vickers Hardness test?

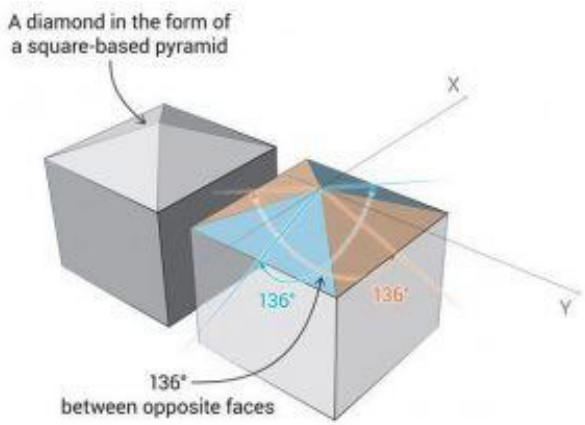
Initially designed as a substitute for the Brinell method, which had a large indenter and the possibility of damage to the test-piece, and also the Rockwell method which used multiple test forces; the Vickers Hardness test is easy to use and offers a number of advantages over other hardness tests, such as:

- the indenter used is small in size, which reduces the risk of possible damage to the test material
- the indenter can be used for any kind of material, irrespective of its hardness
- the resulting calculations are independent of the size of the indenter
- it has a very wide scale, compared to other hardness tests
- a single test force is applied

How is the hardness measured?

The test is implemented by pressing the diamond indenter into the surface under testing. The indenter is pyramid-shaped, with a square base and an angle of 136 degrees between opposite faces. Typically, loads vary from 1 to 100 kgf. The full load is normally applied for 10 to 15 seconds.

The length of both diagonals formed on the test surface is measured, and the average is used for calculating the hardness, given by the ratio F/A (where F is the force or load, in kgf; and A is the surface area of the indentation, in sq. mm.). The hardness value is expressed as Vickers Hardness (HV) or Diamond Pyramid Hardness
(DPH) (usually a number, without units).



Vickers Hardness Test indentor geometry. Image is © 2017 EngineeringClicks

The measurements are made using built-in microscopes. Some more advanced testing scales use software to obtain faster and more accurate results.

Applications

The indentation produced by the Vickers test is relatively small, and therefore, it is extremely useful in testing the hardness of small parts or sections and very thin objects like foils for example.

Things to consider

To obtain accurate results from the test, it's best to consider the following:

- choosing a sample that is small enough to fit on the scale
- making the surface of the test material smooth, in order to achieve a proper indentation and to minimize error in measurement. Additionally, this helps in holding the material perpendicular to the indenter
- making the indentations as large as possible to maximize the accuracy of measurement (the possibility of error is higher as indentation size decreases)

Limitations

Despite all its advantages, the Vickers Hardness test has its own limitations. Critics argue that at lower loads, there is a degree of bias that sets in. Some test materials are pre-coated, in which case the thickness of the coating affects the accuracy of measurement for micro-indentations. To overcome this, advancements in the field of nanotechnology have resulted in the development of nano-indentation methods.

Conclusion

The Vickers Hardness test is easy to use, and its benefits far outweigh any potential disadvantages. The versatility of its use – the fact that it can be used to measure the hardness of almost any type of material – still makes it very attractive and widely applicable.

Shear Stress Equations with Explanation

- Why are shear stress equations necessary?
- This article looks at some examples of shear stress equations: average shear stress, beam shear, impact shear and shear stress in fluids
- We'll talk about the measurement of wall shear stress in applications involving fluids.

Did you realise that when you rub your hands together while washing, you are causing shear stress on the surface of your hands? Or that when you brush your teeth, there is shear stress on the surface of your teeth? In this article, we'll discuss some examples of various shear stress equations.

What are the basics of shear stress?

Whenever two materials rub against or slide over each other, there is shear. While normal stress results from the force applied perpendicular to the surface of a material, shear stress occurs when force is applied parallel to the surface of the material. A few common everyday examples include the cutting of paper with scissors, rubbing our hands while washing, brushing our teeth, rubbing sandpaper on a surface for polishing etc.

Fig.1 illustrates the shear stress (τ) and normal stress (sn) acting on a line segment AB.

Shear stress differs across materials and cross-sections, and is measured using a set of formulas called the shear stress equations.

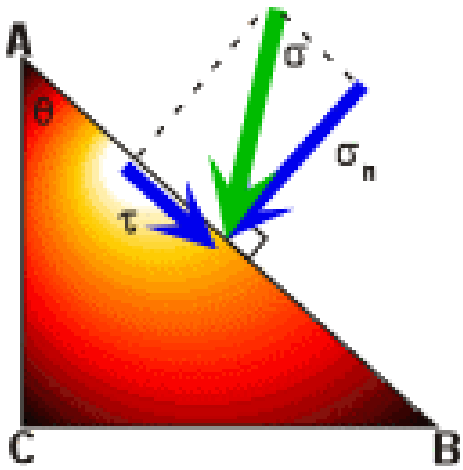


Fig.1 illustrates the shear stress (τ) and normal stress (sn) acting on a line segment AB

Why are shear stress equations necessary?

Shear stress occurs whenever there is contact between two materials or components. Examples include stress exerted on a set of cantilever beams (with or without adhesion between layers), horizontal beams used in construction, pipelines carrying flowing fluids, soil when it is subjected to loads from the top surface etc. Shear stress equations help measure shear stress in different materials (beams, fluids etc.) and cross-sections, which play an important part in the design of engineering structures, to determine the load that can be carried. Most engineering structures are designed for both normal stress and shear stress limits.

Average shear stress equation

General shear stress, represented by the Greek letter tau, τ, is given by the ratio of force applied to the area on which it acts.

$$\tau = \frac{F}{A},$$

Where,

- **τ** = shear stress
- **F** = force applied
- **A** = cross-sectional area of the material

Notes:

- Shear stress is the same irrespective of the direction in which it occurs, i.e., left to right or right to left.
- The above formula gives the average shear stress. In practical applications, shear stress is seldom uniform throughout the surface.

Beam shear stress equation

$$\tau = \frac{VQ}{It},$$

Beam Shear is the internal shear stress that occurs on a beam when it is subjected to a shear force.

Where,

- **τ** = beam shear stress
- **V** = shear force
- **Q** = static moment of the area (which is the summation of all areas multiplied by the distance from a particular axis)
- **I** = second area moment of the cross-section
- **t** = thickness of the material

Impact shear stress equation

$$\tau = 2\left(\frac{UG}{V}\right)^{\frac{1}{2}},$$

This gives the maximum shear stress in a solid round rod subjected to a force.

Where,

- **τ** = impact shear
- **U** = kinetic energy, given as the sum of rotating kinetic energy and applied kinetic energy
- **G** = shear modulus/modulus of rigidity
- **V** = volume of the rod

Shear stress in fluids equation

$$\tau(y) = \mu \frac{\partial u}{\partial y} \quad ,$$

Any fluid moving along a solid boundary will cause shear stress on the solid boundary. The shear stress for a Newtonian fluid, at a point y, is given by:

Where,

- **μ** = dynamic viscosity of the fluid
- **u** = velocity of the flow along the boundary
- **y** = height above the boundary

Measurement of Wall Shear Stress

Following on the above examples of shear stress equations, wall shear stress is the measure of the tangential component of the force exerted on a wall by a fluid flowing on its surface. Wall shear stress measurements are an important part of fluid mechanics. For instance, they could be key in understanding phenomena like corrosion, or the formation of deposits in pipes etc. The velocity gradient close to the wall is used to measure wall shear stress.

Depending on the system in which they are used, there are various techniques to measure wall shear stress. They can be broadly classified as follows:

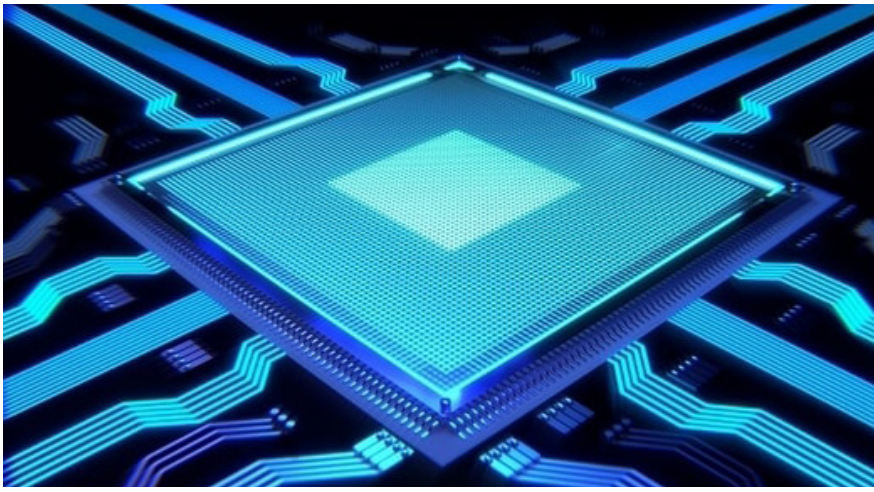
1. Techniques, which use a normal stress that is related to the shear stress – Stanton Gauge, K-Tube, Preston Tube, and sublayer fence.
2. Using a floating section of the surface to make a direct measurement of the shear stress through magnetic techniques or strain gauges.
3. Methods that rely on heat transfer or mass transfer. For mass transfer, an electrochemical reaction on a probe mounted on a surface produces an electrolysis current, whose measurement is directly related to shear stress. In the case of heat transfer, a probe is maintained at a specific temperature higher than its surroundings; the voltage thus used is related directly to shear stress.

Conclusion

Shear stress occurs almost everywhere around us. More so in engineering structures, which comprise of a variety of components that are subjected to different kinds of loads. The measurement of shear stress, using the shear stress equations, thus forms an integral part of the design of these structures.

Artificial Intelligence (AI) in Mechanical Engineering Design

The stand out feature of most emerging technologies is their ability to disrupt the traditional way of doing things. This applies to artificial intelligence (AI) which focuses on providing machines with the ability to mimic cognitive functions needed to learn and solve problems. With the integration of AI, machine learning, and deep learning in the design of machines and mechanical systems, traditional design processes have been disrupted for the foreseeable future. But the question of how extensively AI will disrupt mechanical engineering design remains.



How is artificial intelligence disrupting the field of mechanical engineering design?

To provide an accurate answer to this question, a dispassionate analysis of artificial intelligence in mechanical engineering is needed. Starting with the design of original equipment, assemblies, and structures, AI enhances the design process in multiple ways. One example is the use of generative design to solve complex mechanical engineering problems. Generative design is an iterative process that endeavors to solve complex challenges within specified constraints. Users of Autodesk Fusion 360 or the Grasshopper 3D application must have experimented with generative design. In these use cases, the necessary design parameters needed to run simulations are completely defined by the mechanical engineer.

The integration of artificial intelligence, however, changes the above scenario. Constraints are defined by AI-enabled programs or applications reducing the need for human supervision. The end result is hundreds of permutations that define how a product can be developed to meet specific requirements. A practical example of how generative design has been used to design complex structures is the popular Airbus story. The task Airbus faced was the design of lightweight cabin partitions for the A320 commercial aircraft. With the help of AI and the generative design features of Autodesk Dreamcatcher, Airbus designed a lightweight bionic partition which was 45% lighter than previous versions.

Airbus achieved this feat through a combination of AI, generative design, and another emerging technology, 3D printing. As stated earlier, this 2016 Airbus achievement has been highlighted in many studies as the quintessential application of AI in mechanical engineering design but more recent examples exist. In 2018, RUAG (a space OEM) developed innovative brackets for star-tracking cameras

on artificial satellites. Generative design was used to design the innovative brackets and, once again, additive manufacturing was used to produce the prototype. The end result was the engineering of the largest bracket for the relevant cameras within eight weeks.

Artificial intelligence in designing and maintaining mechanical engineering systems

The mechanical engineer is also tasked with designing and manufacturing mechanical engineering systems. Here, mechanical systems refer to multiple machines working together to achieve a common goal. This means that the engineer must take the design, analytics, and maintenance of engineering systems into consideration – which are areas where artificial intelligence has huge roles to play.

The rise of Industry 4.0 and the smart factory have created environments where the use of AI and machine learning can be used in designing automated systems. The design and maintenance process is also rather complex as hundreds of manufacturing variables and constraints must be defined and standardized while developing optimal systems. A decade ago, computer-aided design (CAD) software applications were the tools needed to design engineering systems and plan shop floor layouts. Today, the need for designing smart equipment, managing interconnectivity, and handling data analyses in interconnected systems means traditional CAD tools are limited.

This is where AI can help. With the correct tools and proper integration of AI, mechanical engineers can design automated engineering systems that can function without human support. These systems will include equipment that can diagnose machine failure, repair themselves, or order replacement parts. In more complex situations, AI can be used to drive a system of mechanical components or autonomous assemblies to achieve set goals.

An example of this is the automated container terminal at the Port of Qingdao in China. The port integrates artificial intelligence, automated guided vehicles and equipment, and cranes to load and unload containers. This completely autonomous engineering system increased efficiency levels by 30% while reducing labor costs by 70%. A YouTube video highlighting how the system functions in real-time and the role sensors, actuators and system modeling play in automation highlight the evolving role of the mechanical engineer. Here again, the disruptive nature of artificial intelligence is set to also change how mechanical engineers think and approach future challenges.

Artificial intelligence and the future of mechanical engineering design

The disruptive nature of AI means mechanical engineering design as we know it is being irreversibly changed. This means new skill sets are needed to develop designs for emerging manufacturing technologies – 3D and 4D printing – and to take advantage of the high-performance computing power cloud services offer.

The Difference Between Yield Strength and Tensile Strength

When selecting materials for an engineering application, critical mechanical properties of the material must be reviewed. Two such properties are yield strength and tensile strength. They are both measures of a material's resistance to failure, either by deformation or fracture. Despite this similarity, yield strength and tensile strength are two very different parameters.

Yield strength

When subjected to stress, a material undergoes recoverable deformation. The yield strength of a material represents the stress beyond which its deformation is plastic. Any deformation that occurs as a result of stress higher than the yield strength is permanent. Because of the linearity of elastic deformation, yield strength is also defined as the greatest stress achievable without any deviation from the proportionality of stress and strain. Beyond this point, large deformations can be observed with little or no increase in the applied load. Yield strength is measured in N/m^2 or pascals.

The yield strength of a material is determined using a tensile test. The results of the test are plotted on a stress-strain curve. The stress at the point where the stress-strain curve deviates from proportionality is the yield strength of the material. It is difficult to define an exact yield point for certain materials from the stress-strain curve. This is because these materials do not display an abrupt curve; rather the onset of yield occurs over a range. It is therefore practical to use proof stress as a representation of the yield strength.

Proof stress

Proof stress is measured by drawing a line at 0.2% of the plastic strain, parallel to the straight-line elastic region of the stress-strain curve. The stress at the point where this line intercepts the curve is the proof stress. The yield strength of a material can be increased by certain material processes.

Tensile strength

Often referred to as ultimate tensile strength (UTS), tensile strength is the maximum tensile load a material can withstand prior to fracture. It is a measure of a material's resistance to failure under tensile loading.

The tensile strength of a material is determined using a tensile test. It is the highest point on the stress-strain curve, which is plotted after the test. Tensile strength can also be determined using this formula:

$\sigma f = Pf/Ao$

Where Pf is the load at fracture, Ao is the original cross-sectional area, and σf is the tensile strength, measured in N/m² or pascals. It is important to note that the tensile strength of a material is a specific value under controlled standard test conditions. However, in practical applications, tensile strength varies with temperature. At 100°C, the tensile strength of copper falls from 220Mpa at room temperature, to 209Mpa. These variations are compensated for by using a factor of safety, which is usually a fraction of the original tensile strength in design considerations.

Comparative analysis of yield strength and tensile strength

The following are some of the major differences between yield strength and tensile strength:

- Yield strength is measured at the point of plastic deformation.
- Tensile strength is measured at the point of fracture. Tensile strength is rarely used in the design consideration of structures made from ductile materials. This is because these materials undergo substantial deformation before their tensile strength is reached. Rather, yield strength is considered for ductile materials, while tensile strength is used for brittle materials.
- During design considerations, tensile strength is analysed only in uni-axial loading. Multi-axial stress states are estimated in yield strength analysis.
- Deformation of materials occurs after yield strength has been surpassed, while tensile strength is reached after deformation has taken place. In brittle materials, tensile strength is reached with minimal or no yield.
- Tensile strength is usually of a higher numerical value than the yield strength of a particular material.
- The tensile strength of a material can be ascertained with 100% accuracy. However, yield strength has to be estimated for most materials.

Yield and tensile strengths of some common engineering materials

Below are examples of the yield and tensile strengths of some engineering materials.

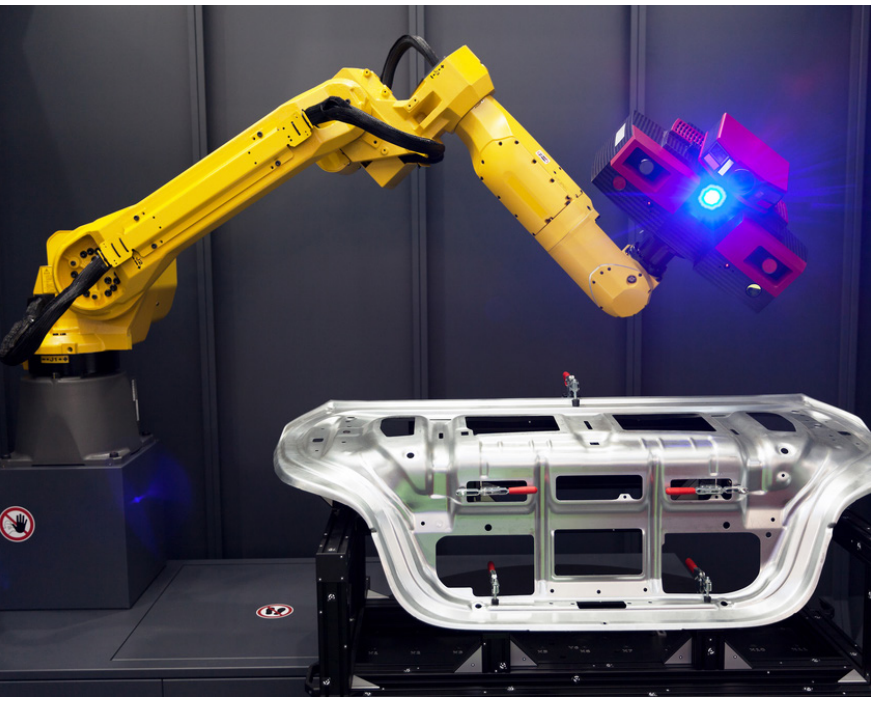
Material	Yield strength (Mpa)	Tensile strength (Mpa)
copper	70	220
aluminium	95	110
structural steel *(ASTM A36)*	250	400
cast iron 4.5% *(ASTM A48)*	130	200
stainless steel *(AISI 302)*	502	860

titanium alloy	730	900
high strength alloy steel ***(ASTM A514)***	690	760
chromium-vanadium steel	620	940
tungsten	941	1510
kevlar	3620	3757

(Table Source: https://www.engineeringtoolbox.com/young-modulus-d_417.html)

Photogrammetry in mechanical engineering

- Photogrammetry is a great way to visually analyse complex 2D and 3D systems.
- This article looks at the basics of what it is and how it is used in different applications.
- Reverse engineering and quality control are two of the main benefits, both of which are discussed in the article.
- Curious? Read on to learn more about how photogrammetry might help in your mechanical engineering project.



Photogrammetry in mechanical engineering is becoming more popular, so let's take a look at the concept and how it's used.

Photogrammetry derives from the Greek words photos, meaning light, gramma, meaning record, and metreo, which means measurement. It's a process that has been used since the mid-19th century, of taking measurements from photographs. Obviously, the technology has advanced significantly since the early days of taking crude hand measurements and scaling them.

Close-range photogrammetry is most commonly used in topography (for terrain mapping), in architecture for building archiving, and civil engineering for structural analysis.

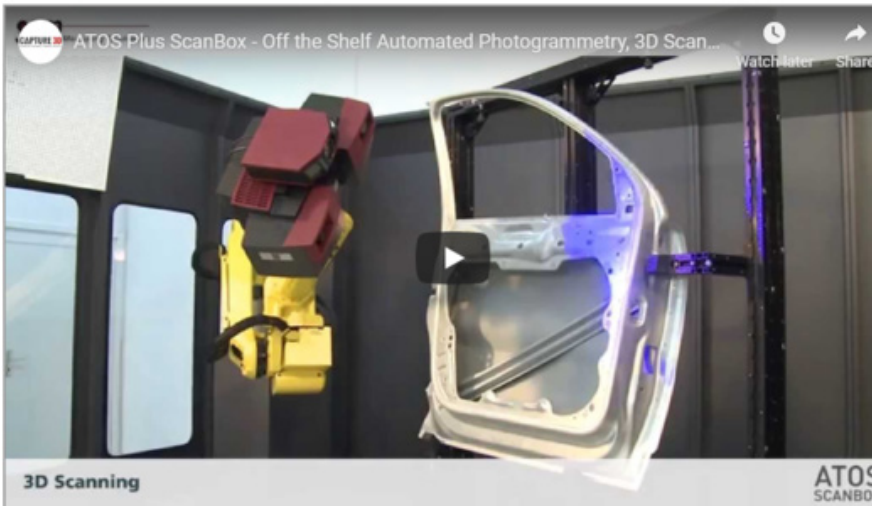
In recent years, close-range photogrammetry has been used to measure and analyse complex 2-D and 3-D systems, by applying optical scanning, triangulation and projective geometry. Due to these advancements, it can now be used as a useful tool in mechanical engineering to reverse engineer mechanical parts or systems.

Component Manufacturing

Photogrammetry techniques can be used in the manufacture of duplicate parts, providing a relatively inexpensive method of creating a prototype and mould for the final product, when compared to reverse engineering.

The reverse engineering process involves using a 3-D optical scanner or CMM (Coordinates Measuring

Machine) to create a point cloud. The generated data is then fed into software that constructs a 3-D CAD representation of the object. This is an expensive method due to the cost and complexity of the scanning hardware, and it can also be a time-consuming process.



Photogrammetry methods typically use three or more photos to get the dimensions and shape of the object, which are then modelled as point clouds to create the 3-D CAD image. The benefits of this approach are that it can be carried out with a relatively cheap digital camera and is much faster.

Photogrammetry is especially useful in the manufacturing process of small mechanical components. A system of rapid-prototyping can be employed, whereby photographs of the object are taken, a point cloud surface model created in CAD, then a prototype is printed using a 3-D printer and finally a mould made for the final product.

There are some limitations regarding the accuracy of the photogrammetry method. It is best used for rough prototypes, depending on the tolerances required. Photogrammetry techniques are typically accurate to within one-tenth of a millimeter (+-0.1mm).

Penn State University has been conducting pioneering research into the use of photogrammetry in the manufacturing of mechanical parts. Michael Immel of Penn State University's department of industrial and manufacturing engineering stated, "If we can take pictures of the parts and use commercial software to create the point cloud file from the images, we can come up with the dimensions within some reasonable amount of accuracy and apply it in industry."

Quality Control

Another application of photogrammetry that overlaps mechanical engineering and manufacturing is in quality control. A series of cameras could photograph parts from different angles as they come off the production line. The image data would be used to create a 3-D point cloud that a quality control engineer or technician can use to compare to the original file, highlighting any items that are out of tolerance. This has the potential to make the quality control process far more streamlined and less expensive for manufacturers, compared to hand measurements.

Mobile device photogrammetry

You can download smartphone apps as a very cheap (often free) photogrammetry option, but they obviously lack the accuracy of 3-D scanning or more conventional photogrammetry techniques. They

can be used to get a very rough point cloud that creates a 3-D model. Trnio and Scann3D are two of the main free ones.

This technology may have practical mechanical engineering applications in situations where obsolete machinery is being repaired. An on-site fitter can take a 3-D scan of a broken part with his smartphone, relaying it to a mechanical engineer who can then upload the data to CAD and create a replacement part using the method described earlier.

Photogrammetry Software

There are several companies that offer photogrammetry and 3-D scanning software. Arc3D is completely free but lacks some of the functionality of the other commercial software.

Autodesk Recap 360 is probably the most frequently used, with licences costing around £230 or $300 per year, but usually come with a short free trial period.

Summary

Photogrammetry offers a way to get most of the benefits of 3-D scanning, without the expense and technical know-how needed to use infrared or laser scanning. As it is low cost, it is ideal for the process of reverse-engineering and quality control within the manufacturing industry, especially for small-scale mechanical parts.

Additive Manufacturing

How additive manufacturing helped launch SpaceX

SpaceX is by far the most exciting company of the 21st century. No other company claims to have such lofty goals, like giving internet access to the entire planet or colonising Mars. SpaceX, however, has a track record of proving they can achieve the impossible... from being the first private company to launch an orbital rocket to being the first organisation in history to land a huge, first-stage rocket upright on a barge in the middle of the ocean. This article will focus on how SpaceX's additive manufacturing adoption is being used to push the boundaries of what's possible in manufacturing through cutting-edge technologies.

How does SpaceX use additive manufacturing?

SpaceX have been using Additive manufacturing increasingly in their production in order to optimise their processes and produce parts that aren't possible with conventional manufacturing methods.

SpaceX is a champion of vertical integration; this means that they bring in raw material at one end of the factory and a fully manufactured rocket comes out the other end. Additive manufacturing allows the implementation of this philosophy, for example a typical cast part

needs to be designed in CAD, a complex mould then needs to be manufactured, a test casting is done at the foundry and if necessary, any alterations to the mould must be made before manufacturing can commence in earnest. Additive manufacturing eliminates this entire process as the design and manufacture of a complex metal part can be done in the SpaceX factory without having to outsource to other suppliers. This reduces cost, safeguards intellectual property, allows for stricter quality control and reduces lead times.

SpaceX has been continuously evaluating the benefits of AM and perfecting the techniques required to develop and manufacture flight hardware. With innovation and efficiency at the core of SpaceX, it's no wonder they've been one of the first companies in the sector to embrace additive manufacturing as a major part of their production.

What technology does SpaceX use?

SpaceX makes use of direct metal laser sintering (DMLS). This type of AM works by laying down thin layers of metal powder in a heated chamber. A laser then traces out the 2D cross section of the part. The laser brings the temperature of the powder above its melting point and the metal melts. The next layer is then added on top and the process is repeated, thus sintering each layer to the previous one. SpaceX prints also run through cooling cycles.

SpaceX additive manufacturing projects

SuperDraco Engine Chamber

The SuperDraco rockets are designed primarily as an emergency launch escape rocket in the unlikely event the first stage of the rocket fails explosively. These rockets need to accelerate the crew capsule with an incredible thrust of 120,000 pounds in order to safely escape the blast. The engine chamber of the SuperDraco was Additive manufactured out of Inconel; a superalloy used in the aerospace industry for high-stress parts. This component was put through a variety of tests such as multiple starts, high temperature and extended firing durations to name a few. These tests proved that the engine chamber was ready for use on a Dragon 2 capsule rated for human flight.

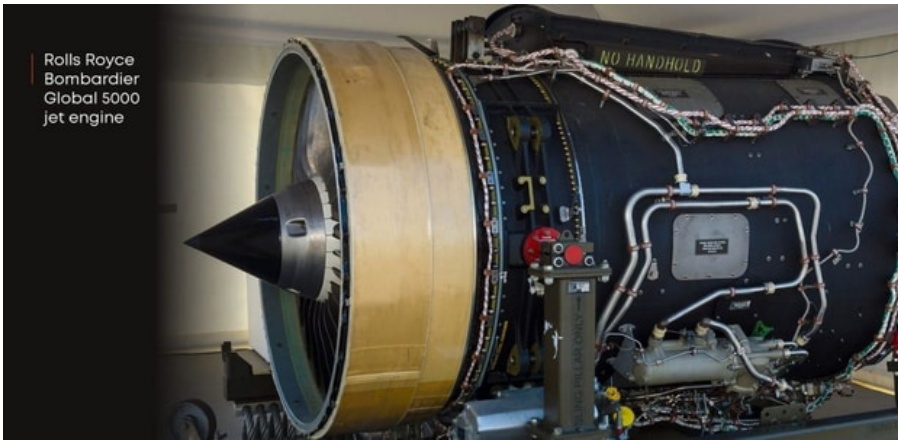
Main Oxidiser Valve Body

This valve body was successfully tested in one of the 9 Merlin 1D engines used on SpaceX's Falcon 9 in 2014. The component managed to withstand cryogenic temperatures at excessive pressures and high vibration. This component was also manufactured within 2 days, a record time when compared to the typical 2-month cycle of traditional mould making and casting. After various tests and qualifications this part was allowed to replace cast parts on all Falcon 9 flights.

These critical components are just the first step in a future dominated by additive manufacture,

due to SpaceX's willingness to adopt new technology. As long as it benefits the ultimate goal there will be more and more AM parts in SpaceX's inventory. As the technology matures the number of applications will begin to expand and any technological developments made by companies like SpaceX will trickle down into other industries. With the AM torch being carried by SpaceX the future of the technology looks bright.

How Rolls Royce is embracing additive manufacturing in its aircraft engines



Rolls Royce Bombardier Global 5000 jet engine

Rolls Royce describes itself as a technology company committed to providing clean, safe and competitive power solutions. One of its core drivers apart from electrification is digitalisation. This includes amongst many other things, additive manufacturing (AM). Rolls Royce has been a literal powerhouse in the aerospace industry with its jet engines – Airbus and Boeing both being long-standing Rolls Royce clients. It can be safely said that Rolls Royce is at the top of the list when it comes to jet engine design and manufacture. This blog post will describe how they are making use of additive manufacturing to push the horizons of what is possible.

Advantages of additive manufacturing for jet engines

Some key advantages of additive manufacturing in jet engine manufacturing settings are listed below.

- **Make lightweight aerospace components** – Aerospace parts are designed to save weight and reduce the flight to weight ratio. Incorporating topological optimisation further reduces the weight. Often these optimisations lead to very organic and complex shapes; shapes that are only possible to manufacture additively.
- **Faster production cycles** – When compared to mass-produced car parts, additive manufacturing is very slow. But for aerospace parts that often require multiple manufacturing processes which often include casting, AM is much faster.
- **Design of complex parts** – The aerospace industry is often on the forefront of technological progress, as such there are always new methods of optimisation being developed to gain a competitive advantage. More often than not these theoretically optimal designs are highly complex in geometry with hidden cavities and are not very practical to manufacture using traditional machines. Metal AM is ideal for these types of parts.

What technology does Rolls Royce use?

Rolls Royce makes use of additive layer manufacturing (ALM), specifically, Rolls Royce has used electron beam melting technology (EBM). This technology is different from selective laser sintering, or

selective laser melting, as it uses a focused electron beam to heat the powder past melting point and fuse subsequent layers to each other. It must be noted that EBM can only be used on a select list of materials like titanium alloys and cobalt chrome alloys. EBM produces very high-density parts – up to 99.9% – which are ideal for aerospace applications.

Rolls Royce additive manufacturing projects

Advance3 Demonstrator Engine

This demonstrator engine has a large proportion of its components manufactured with additive technologies. It is designed from the ground up to be energy efficient and environmentally friendly, and accomplishes this by improving fuel efficiency by 25% thus reducing its overall impact on the environment. This engine is not a production engine but rather a demonstrator for new techniques and technologies designed to be implemented in the UltraFan engine being developed by Rolls Royce.

Trent XWB Turbofan Jet Engine

According to Rolls Royce, this was the most powerful jet engine ever built. The model is not new but it was upgraded and modified with a range of new components and technologies; one of these new components was an advanced aerofoil within the engine's front bearing housing that was manufactured using ALM. This titanium aerofoil was one of the largest ever additive manufactured components incorporated into a jet engine and helped increase the engine's thrust output from 84000 lbs to 97000 lbs. This engine was tested on an Airbus A350 XWB and replaced one of the four typical engines used. Despite this part not being in a production model of the engine this is a very big step for additive manufacturing in general.

Directed energy deposition

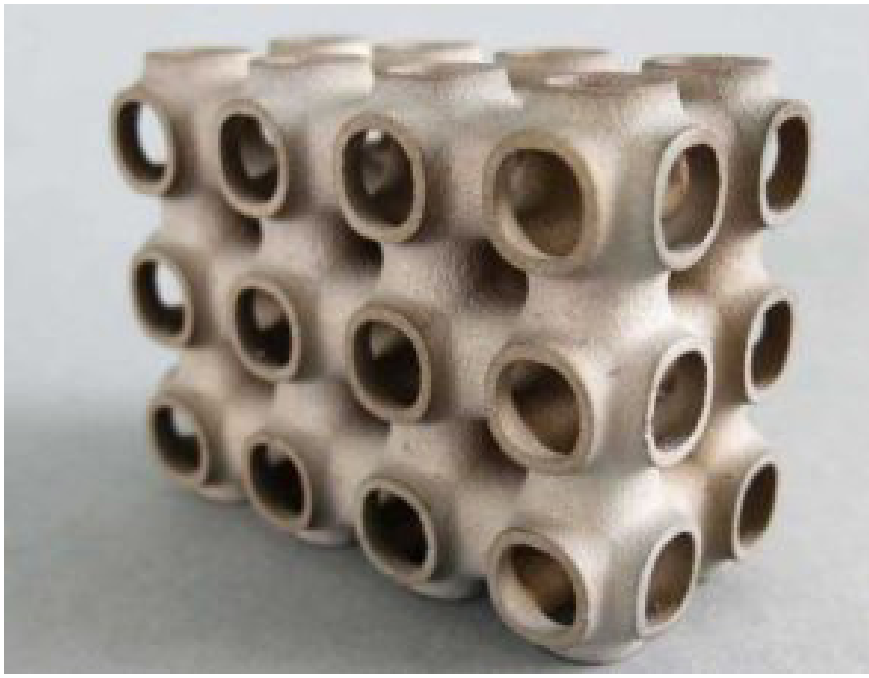
This is an advanced form of additive manufacturing that allows damaged components to be repaired by building up any material that was lost when it was initially damaged. Rolls Royce uses this technology along with traditional subtractive manufacturing to repair a component and machine it back down to the required surface finish.

In conclusion

The aerospace industry has always been one of the most aggressive technology drivers and often adopts what many would consider bleeding edge technology. Additive manufacturing allows incredible design flexibility as engineers are not limited by current manufacturing technologies. With competition like General Electric, which also has an extensive additive manufacturing programme, Rolls Royce has to keep pushing the forefront of technology to out-innovate the competition and as it stands they are achieving this with flying colours.

3D Printing with Metal Powders

Metal additive manufacturing (AM) has been steadily gaining traction in the manufacturing industry. At present, there is a big focus on advanced aerospace, medical and military products. There is a drive to reduce the cost of metal powders in order to open up the technology to a larger portion of the manufacturing industry. There are numerous metal printing technologies available, and the vast majority make use of metal powder. Some of the more common 3D printing machines are listed in the following section.



Different types of 3D metal printers

- **SLS & SLM** – Selective laser sintering (SLS) is one of the most common 3D metal printers, it works by depositing a layer of metal powder and then tracing out the cross-sectional shape of the part with a laser. This action sinters the powder to the previous layer. The process repeats with the next layer, and so on. Selective laser melting (SLM) is a similar process, but instead of sintering the particles, they are melted together, creating a stronger, more dense part.
- **EBM** – Electron beam melting (EBM) is a highly advanced process that is similar to SLM systems. The difference is that the build volume is held in a vacuum, and instead of a laser a focused electron beam is used to fuse the particles together. The vacuum build volume makes it possible to print reactive metals like titanium.
- **DED** – Directed energy deposition (DED) is a method whereby the metal powder is delivered to the bed plate via nozzles, and is melted with a laser at the required location. This process is ideally suited for intricate repair work on existing components and it is limited in its material availability.

How is metal powder made?

Metal powders are the most superior metal 3D printing material, as they allow highly irregular designs to be manufactured with ease and allow the simplification of previously complex assemblies.

Metal powder is made in 3 main processes as listed below. All of these processes are a form of gas atomisation.

- **Gas Atomisation** – The base material is melted and is then fed into the atomization chamber. Gas is introduced into the top of the melt chamber and thus forces the melt through a ring nozzle where it comes into contact with gas that then disperses and atomises the melt. The spherical particles are collected at the bottom of the chamber.
- **Plasma Atomisation** – Plasma atomization is a relatively new technique for making metal powder and works by feeding wire from a spool into contact with plasma torches which then melt the material. Gas is simultaneously blasted into the melt to disperse and atomise it. The spherical particles produced are then collected at the bottom of the chamber.
- **Electrode induction melting gas atomisation** – This process is best suited for reactive materials like titanium. The material is fed into the atomisation chamber in the form of bar stock, this material is rotated while it moves through an induction coil which melts the material. The melt then falls down where it is atomised by a gas stream. The spherical particles are collected at the bottom of the chamber.

Characteristics of metal powders

Metal powders are characterised by their particle size distribution as this will determine the minimum layer height that is achievable. The particle size, purity and shape are very important factors in determining the quality of a powder. The more spherical and contaminant free the particles, the higher the quality of the powder.

It must be noted that the mechanical properties of parts made with powdered metals in a laser sintering or laser/electron beam melting processes are not as good as the base material.

The final strength achieved will depend on the process being used. However, the strength of many 3D printed metal parts can be compared to that of cast parts. It should also be noted that many high stress components are made using the metal powder process and thus the mechanical properties achieved are often 'good enough' for the application they are being designed for. In all cases, accurate mechanical properties must be determined by doing tests.

Grade of metal powders

Almost any metal can be atomised for use in metal additive manufacturing machines. A comprehensive list of suitable materials can be found here. Some key metal groups and their metal powders are listed below:

Titanium

- **Ti-6Al-4V** – This titanium alloy is the most widely used titanium alloy and is characterised by excellent corrosion resistance. Due to its versatility it is used in anything from sporting equipment to aerospace components. The ELI-A version is designed for use in laser powder bed processes whereas the ELI-B version is designed for use in electron beam melting processes.

Cobalt

- **CoCr F75** – This alloy consists of cobalt and chromium. This material is used extensively in the medical industry for implants as well as for turbine components. It is characterised by high wear resistance and stiffness.

Steel

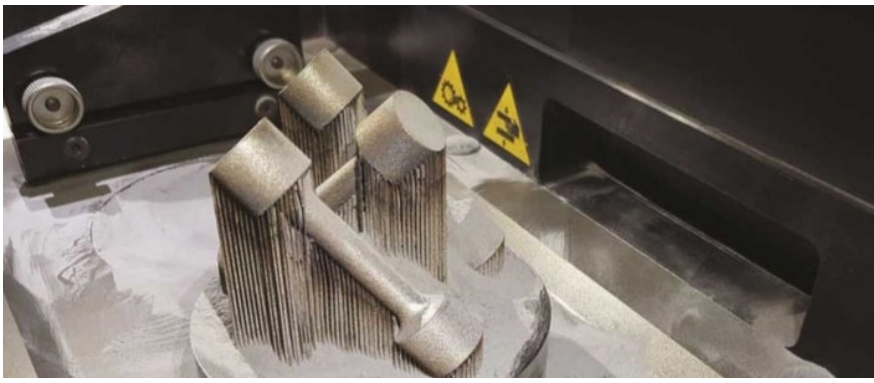
- **316L** – This is a widely available grade of steel and is used where higher corrosion resistance is required. It is also characterised by high creep strength at elevated temperatures. It is used extensively in maritime applications where a high corrosion resistance is essential. This material can be used in laser power bed electron beam melting and directed energy deposition machines.
- **H11** – This is a hot work tool steel optimised for laser bed fusion applications. It has excellent impact toughness and thermal fatigue cracking resistance. This powder is designed for use on laser powder bed machines.

Nickel

- **Ni 625** – This alloy is a nickel chromium alloy more commonly known as Inconel and is an advanced aerospace alloy used for turbine blades and jet engine components. Inconel is characterised by its high strength and corrosion resistance.
- **Ni 230** – This Nickel alloy consists of chromium, tungsten and molybdenum and is ideally suited to high temperature applications. It can withstand high temperature environments for long periods of time.

In conclusion

The range of machines making use of metal powder for 3D printing is continuously increasing, thus opening up a multitude of new applications. With improved and optimised manufacturing processes, the price of the powders used in these machines will continue to fall. Furthermore, with improvements in the manufacturing processes, the mechanical properties of these powders will approach that of forged materials.



Additively manufactured parts in Aerospace

In recent years, additive manufacturing (AM) has been in development in almost every major aerospace company, from Boeing to SpaceX. Components manufactured have been used in production and have proven themselves as a viable replacement to traditionally manufactured parts. Some of the key benefits of AM technology in the aerospace industry have been reduced part counts, reduced mass, and increased design flexibility. Some industry experts are even projecting a 20% growth rate of AM in the aerospace industry over the next 5 years. This growth rate will position AM as a standard technology in the aerospace industry.

Leading companies developing 3D parts for aerospace

There are thousands of components currently being developed and manufactured in the aerospace industry. Many of which are only for test and development, while others are production line parts. The list below highlights some of the major players using 3D parts for aerospace:

Nasa's Orion spacecraft is a human rated spacecraft that aims to remove American dependence on the Soyuz Launch System. It forms part of the Space Launch System (SLS) architecture currently under development by various aerospace giants including Lockheed martin. Arconic manufactured the vent housings on this spacecraft out of an advanced nickel super alloy. These components are critical, as they maintain the pressure between the inner and outer hull of the spacecraft. These parts first flew in the 2014 maiden flight of the Orion module and were found to be in good condition after the craft was recovered.

Safran helicopters develop and manufacture helicopter engines such as the Anteo-1K which has numerous AM components including those within the engine's combustion chamber, creating an engine that is 30% more powerful than its traditionally manufactured engine.

SpaceX uses AM technology to manufacture the SuperDraco engine chamber. These rocket engines are used for the Dragon 2 launch escape system. The Dragon 2 is SpaceX's crew launch vehicle that is set to transport astronauts to the international space station in the next few years. A recent catastrophic failure of the Dragon 2 has pushed this timeline back, however, the failure was not attributed to the AM engine chambers.

BAE Systems in collaboration with the University of Manchester recently developed a UAV that does not use any flaps to manoeuvre, but instead uses supersonically blown air to improve handling at low

speeds. This is achieved with an advanced nozzle called a fluidic thrust vectoring nozzle and is printed out of titanium.

Relativity Space is aiming to make their rockets entirely from AM techniques. This is to allow for faster manufacturing time and more design flexibility. Their Aeon engine and Terran 1 launch vehicle rely heavily on AM, with the Terran 1 being made entirely using AM technology.

Rolls Royce is using AM to develop advanced components such as a front bearing housing for their Trent XWB-97 engine. The component is 1.5m in diameter and has 48 aerofoil shaped vane components. This is one of the largest civilian components that has been manufactured using additive techniques. The use of AM allowed design engineers the flexibility of optimising the component without the pressures of finalising the design early on to allow for long lead tooling.

Liebherr Aerospace has developed a nose landing gear bracket for the Airbus A350 XWB. These parts are manufactured from titanium. Liebherr has also developed a 3D printed primary flight control hydraulic component. This component is a high-pressure hydraulic valve block. This new 3D printed version is 35% lighter than the traditional manufactured component but offers the same performance.

WAAM3D is a company that is a commercial spinout from Cranfield University and is developing a rear frame for the Eurofighter Typhoon in conjunction with BAE systems using AM. This frame is made from Ti-6Al-4V, a titanium, aluminium and vanadium alloy. The frame is designed to support the EJ200 engines and WAAM3D claims that the fatigue properties of the part are similar or equal to the existing forgings.

The future of 3D parts for aerospace

The aerospace industry is uniquely positioned to benefit from 3D parts for aerospace, as the production volumes are relatively small when compared to other industries. Furthermore, aerospace components can benefit greatly from optimisation techniques like generative design and shape optimisation which fit in well with additive technology. AM is quickly becoming a standard manufacturing technique in the industry with most major aerospace companies employing the technology in one way or another. The improvements in efficiency, strength and weight when using AM means that companies who do not embrace this technology will soon find themselves falling behind the curve.

7 Aspects of additive manufacturing

Additive manufacturing is a process that uses 3D design software and a multi-axis arm to deposit materials onto a printing platform. The material can be resin, nylon, ceramic, and many others. It differs from conventional subtraction techniques which remove unwanted pieces from a solid block to reveal the final product. Not only does this save on material waste and costs, it is also environmentally friendly and can create highly complex and customizable structures.

Additive manufacturing techniques

The increasing popularity of miniature components in a wide variety of industries has given rise to new manufacturing techniques. As computers, robots, and other technological innovations become smaller in size, additive manufacturing processes have become more popular due to their versatility and precision. Therefore, it is crucial for those working in the manufacturing industry to understand how the additive process works. Continue reading below to learn more about 7 such additive manufacturing techniques.

1. VAT Photopolymerization

VAT Photopolymerization, also known as digital light processing or continuous liquid interface production, is a process that uses liquid photopolymer resin to construct an object in an additive way. The resin has to be made from materials curable under a UV light, such as this MS Resin from Sigma-Aldrich. The UV light can harden the liquid resin into shape to form the finished product. It is a process that provides a high degree of accuracy and complexity as well as a smooth surface in the finished product.

2. Powder Bed Fusion

This process involves using a laser or electron beam to melt and fuse powdered material together. To start off, a 0.1mm thickness of material is spread over the building platform to create the first layer. This layer is then fused together by laser before a new layer of powder is spread over the top and then fused together. The powder provides structural support and the process is repeated until a final product is created. It is good for creating highly complex designs and working with materials such as plastics, metals, ceramic powders, and sand.

3. Binder Jetting

Binder jetting is an additive process that uses a binder and a powder. First, the powder is spread over the building platform. Then, a binder adhesive is deposited over it before another layer of powder is spread over that. This process repeats until the final product has been created. It is good for full-color printing and working with materials such as powdered plastic, metal, ceramics, glass, and sand.

4. Material Jetting

Material jetting involves a jet of liquid which is injected onto the build surface. The jet creates one layer of the object at a time and the material is deposited horizontally across the platform. The layers are then allowed to harden or are cured under a UV light. It is a great method for creating products that require a high level of accuracy and it also allows for the creation of colored parts. Typical materials that can be used include photopolymers, polymers, and wax.

5. Sheet Lamination

This process uses metal sheets or ribbons which are welded together. First, the material is positioned on the cutting bed and bound into place. Then, a laser or knife cuts the material into the required shape before the next layer is added and cut. This process repeats until a final product is

created. The process is ideal when a high volumetric build rate is required at relatively low cost and can be used with materials such as paper, plastic sheets, and metal foils.

6. Material Extrusion

The material extrusion method involves drawing materials through a nozzle, where it is heated and deposited onto the building platform. Multiple layers are deposited on top of each other to fuse together as the heated material hardens and cools. It is an inexpensive and economical method to create products with good structural properties and in multiple colors. Some typical materials used include thermoplastic filaments and slurries.

7. Directed Energy Deposition

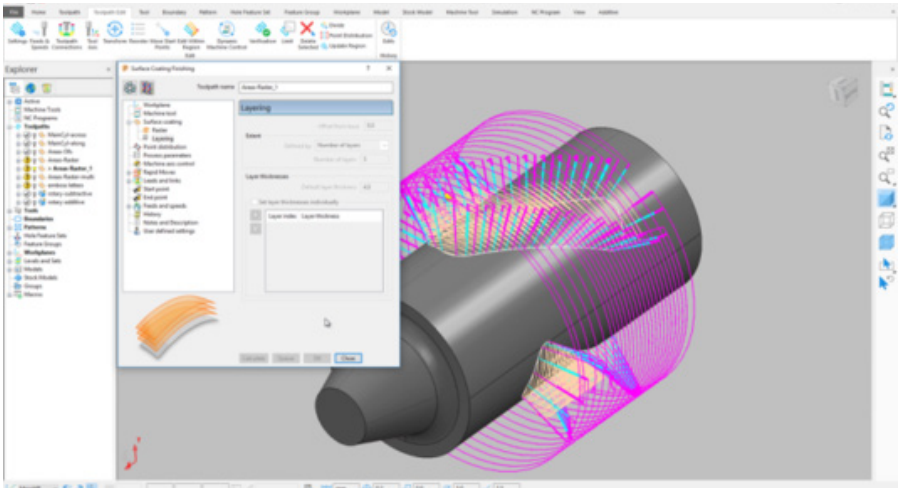
This is a more complex method used to repair or add additional materials to an existing structure. An arm with a nozzle moves around a fixed object to deposit material onto its surface. The material can be in powder or wire form and is added in layers which then solidifies. It is great for making repairs on high-value equipment such as gas turbine engines or adding components to an existing object. You learn some more about Directed Energy Deposition, or DED, in this YouTube video.

Conclusion

Additive manufacturing is a process that uses a multi-axis arm to create 3D products. The seven versions mentioned in this article all require access to 3D design software. A popular choice is Autodesk's Fusion 360 for machining, printing, inspecting, and fabricating better quality parts. The software can be used to create or update new and existing files, as well as to share and collaborate with multiple personnel on major projects.

CAD / CAM / Software

How is the Autodesk manufacturing suite of software changing the face of industry?



The use of software in engineering is growing day by day. Automation and computer technology are on the rise, with new innovations being released for commercial use in quick succession. This technical software has a profound impact on how engineers solve real-world problems as each new version is aimed at making complex engineering more elegant, accurate, and streamlined. In this article, we focus on how the Autodesk manufacturing suite affects engineers working in the industry.

What is the Autodesk manufacturing suite?

Autodesk has been around for quite some time, being founded back in 1982. The multinational software giant has expanded its expertise in software development of various kinds: engineering software for CAD (Computer Aided Design), CAM (Computer Aided Manufacturing), simulation, and manufacturing; programs for the media industry, as well as other fields of endeavor like entertainment and architecture.

Through years of experience, Autodesk has established itself as one of the world leaders in engineering software production. The Autodesk manufacturing suite is a complete package of engineering software that aids engineers in manufacturing processes right from the planning phase to quality assurance.

The Industry 4.0 revolution

Industry 4.0 is the talk of engineers everywhere. The possibility of a deeply interconnected company comprised of several factories around the globe, with real-time information sharing, is something professionals might not have even dreamt about a couple of decades ago.

In the realm of manufacturing, Industry 4.0 is about the integration of design processes with manufacturing processes via data collection across the whole product lifecycle, cloud computing, and the Internet of Things.

How is Autodesk at the forefront of the Industry 4.0 revolution?

Innovators at Autodesk have long since talked about what they call The Future of Making Things, and the Autodesk manufacturing suite is a testament to their commitment to this goal, with dedicated software like Fusion Production.

Fusion is an exemplary product, enabling complete collaboration between design engineers and manufacturers. An interesting example of the application of such software can be taken from this blog, where a digital refractometer and computer program were used to optimize the seemingly menial process of managing cutting fluid flow in cutting machines.

How has Autodesk improved inspection engineering?

Inspection engineers use various tools at numerous stages of the manufacturing process to check whether the product meets required standards or not. These may be the dimensions of the part being inspected, its mechanical strength, thermal properties, etc.

The Autodesk manufacturing suite comes with effective inspection tools that allow engineers to properly assess the quality of their products. Autodesk PowerInspect is a leading tool which offers a range of innovative options which contribute to the improvement of manufacturing processes.

PowerInspect is designed to support multiple inspection devices used in the industry. It can be programmed to inspect complex shapes not manageable by normal software, and can be linked directly to manufacturing software leading to error removal and time saving.

A practical example of how inspection software is used in industry is here, where NASA used robotic inspection tools to develop safer and more cost-efficient manufacturing processes for the fuselage section of their aircraft.

How is Autodesk promoting the trend of additive manufacturing?

Additive manufacturing (AM), more commonly known as 3D printing, is a trend that is gaining popularity among engineers owing to its practical applications and potential. Autodesk has been quick to respond to this customer behavior and introduced its own additive manufacturing tool, Netfabb.

This ingenious product offers engineers the ability to design 3D-printable parts on their computer screens, define tool paths in multi-head printing machines, and even simulate the whole printing environment to avoid failure.

The industry has been moving towards the use of AM, such as Audi experimenting with 3D-printed parts and tools, such as this replica of a 1936 Grand Prix car.

What else does Autodesk offer?

Described above are just a few tools that are offered by Autodesk to manufacturers willing to excel in their chosen field. Autodesk boasts numerous further examples; TruNest that facilitates working

with composites and a variety of fabrication processes with minimal material wastage; Moldflow which simulates mold-making processes for better mold designs; Factory Design Utilities for efficient factory layout planning enabling maximum productivity, and many more useful products that are changing the face of industry.

Concluding remarks

This article presents just a few cases of how the Autodesk manufacturing suite of tools is playing a role in defining new industry standards. With such a wide collection of engineering software, any industry can conduct and refine its manufacturing processes with remarkable accuracy, and carve its way to a bright future.

What role can generative design play in the future of vehicle design?

The automotive industry has always been on the forefront of technological developments and tends to be the first adopter of new technology. Even if these new technologies are only used initially on their concept vehicles or in high-performance racing vehicles. The massive manufacturing advances being made across the board point to a future of significant energy and cost efficiency, and generative design has placed itself firmly in the middle of this revolution.

What is generative design?

Generative design is machine-learning-assisted design and is used to optimize a given design based on a set of user-specified parameters. Autodesk is at the forefront of this technology, and has termed its system 'Autodesk Generative Design' (AGD).

AGD mimics natural evolution in the way it iterates a design solution based on external factors. It must not be confused with topology optimization which is focused on improving an existing design. Furthermore, it takes manufacturability into account when creating all the different configurations. This ensures that you don't end up with a good-looking design that would be completely impractical to manufacture. Another advantage is that homogenous parts can be created that replace sub-assemblies of multiple different components.

Types of inputs

When a designer sets up an analysis in AGD, the following parameters must be defined:

1. Material
2. Part Mass
3. Part Size
4. Manufacturing Methods
5. Cost Constraints

These factors are then used as a basis for the algorithms to iterate through. Multiple configurations are presented to the designer and each of these configurations meet all the criteria in different ratios. The designer can then choose the best configuration. However, if additive manufacturing techniques like SLS (Selective Laser Sintering) are being used then it is not necessary to do any modifications on the part as it can be directly printed.

Automotive applications

Generative design has massive potential in the automotive industry since there are thousands of components that make up a vehicle, and many of these can be revised using this system.

General Motors have historically been one of the early adopters of new manufacturing technologies. For example, GM has been 3D printing components for the last decade and has created over 250,000 prototype 3D-printed parts. GM plans on using AGD software for mass reduction and part consolidation. The first test case at GM was a seat bracket that was made 20% lighter and 40% stronger than the original part. Furthermore, the original bracket consisted of eight parts and the redesigned bracket only consisted of one part, thus drastically reducing component complexity and manufacturing time.

There are many benefits of using AGD for automotive engineering, some are listed below:

- **Cost Efficiency** – Components created with AGD use less materials, less energy and less time. This results in an overall cost saving for automotive manufacturers, creating more value for customers.
- **Simulation** – Usually components are designed and put through extensive simulations to verify the design, thereafter the part is tweaked and simulations are run again. With AGD, the simulations are run during the design phase and each of the thousands of iterations created have already passed a strength test.
- **Modeling** – This design tool also has the advantage of reducing time spent on the development of conceptual designs as the 3D CAD (Computer Aided Design) model is generated as part of the process, freeing up the designer to focus on more top-level design concerns. Once the designer decides on the final configuration, it can be slightly modified to meet the designer's preference.

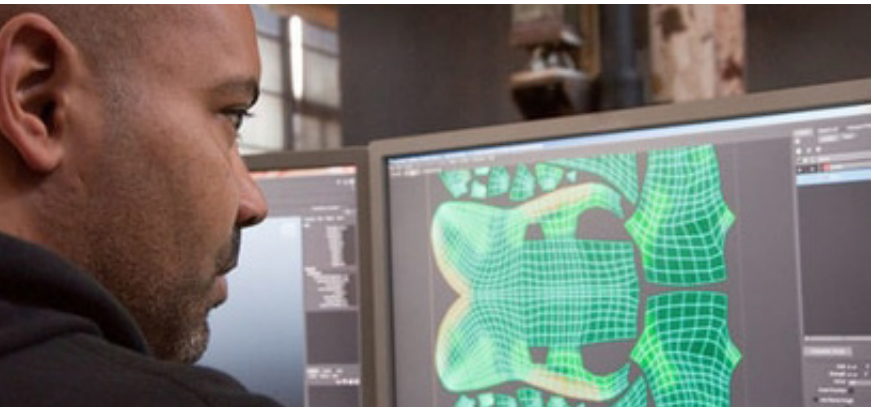
In conclusion

Autodesk is the undeniable leader in the practical application of generative design. Their latest iteration of the software can be found in their innovative design package, Fusion 360. This allows seamless switching between the traditional CAD design environment and the AGD system.

If the design is too organic for traditional manufacturing techniques you can export the model into Autodesk's Netfabb package to prepare the file for metal 3D printing.

With the advent of ever more efficient additive manufacturing techniques, AGD will become increasingly relevant as an alternative product development technique, and we can expect to see organically designed components appear in our vehicles, buildings and consumer products.

An introduction to Autodesk CAM software for robotics



Robotic automation and Computer-Aided Manufacturing (CAM) are rapidly changing the way traditional manufacturing processes are carried out.

Traditionally, many manufacturing companies have been rather slow to embrace change, especially in certain industries, for a variety of reasons. One of the main objections is the cost of implementation.

Autodesk, with its powerful range of CAM and CAD (Computer-Aided Design) software, that is both affordable and user-friendly, is seeking to open up the possibilities of smart-manufacturing to more and more businesses.

This article will give you an overview of Autodesk CAM software and how it links with robotic automation to create a more productive and smarter manufacturing environment.

Autodesk CAM software – the key to smart manufacturing

One of the many advantages of using Autodesk software solutions is that they all integrate seamlessly, piecing together to create a complete end-to-end manufacturing solution. Here's a selection of the main CAD and CAM packages in the Autodesk manufacturing suite of software:

Fusion 360

Fusion 360 is a fusion of CAD and CAM software, as well as being an overall management and organizational tool.

It's a powerful package for product development that allows the importing and manipulation of, or creation of 3D geometry. It features a generative-design tool which iteratively optimizes designs given certain constraints.

The CAM element of the software prepares the design for additive or subtractive manufacturing, automatically generating the required code. This means prototypes or finished products can be 3D printed or CNC (Computer Numerical Control) machined very quickly and efficiently.

Fusion 360 is entirely cloud-based and can be run in a browser, removing installation and compatibility issues. It is also very convenient for collaborative, remote working.

PowerShape

PowerShape is CAM software which includes some elements of CAD to allow users to edit imported geometry, or to create shapes and surfaces. It is designed to be used with CNC machines to make molds, dies, tools, and complex parts.

FeatureCAM

FeatureCAM is dedicated CNC machine control software that automatically detects the features of imported parts and corrects errors, before creating the numerical code to run the machine.

PowerMill

PowerMill is CAM software that links with PowerShape, FeatureCAM or Fusion 360 to control 3D printers or CNC machines. It is a powerful piece of software that can work with 3 to 5-axis, high-speed machines.

PowerMill Robot

This software is designed to program, control and simulate robotic operations. It links directly with the PowerMill CAM package and makes it easy to optimize robotic actions and simulate automated manufacturing systems.

With the increasing automation of production lines and the use of both robotics and 'cobotics'(robots that collaborate with humans), this software will prove invaluable for companies that are looking for integrated ways to control their systems.

Applications of Autodesk CAM and robotic software

Autodesk CAM software and PowerMill Robot can be used for all sorts of manufacturing processes that assist with the increasing use of robotics in the manufacturing world:

Sculpting

Creators of wood or stone sculptures and statues can use the tools to help create large and intricate designs. For instance, marble sculptors can use the software to generate complex robotic tool paths, quickly creating designs that would take months to finish by hand.

Machining

Any type of machining can be carried out: milling, cutting, drilling, turning, routing, etc. Companies that machine plastic or foam can use the software to precisely carve designs with smooth finishes for example, therefore cutting down on the production time and cost of traditional methods.

Finishing and trimming

PowerMill, with its 5-axis capabilities, is a great tool for trimming and deburring products. For example, Southern Spars, a yacht-manufacturing company, uses the software to make high-quality, smooth-finish masts and rigs for racing vessels.

Other applications

There are lots of other robotic applications including laser cutting, wire EDM (electricaldischarge machining), laser cladding, sanding, grinding, etc.

Manufacturing over the next few years

There is no doubt that CAM software is playing a big part in the direction of manufacturing. As the use of robotics grow continues to increase, Autodesk software can make fully integrated workflows possible, reducing cost and increasing productivity.

Expect Autodesk to release further updates and additions to its range, allowing for even more automation and innovation in the coming months and years.

SolidWorks vs Solid Edge – which is best?

- SolidWorks has a wide reach in industry and has vast amounts of online resources.
- The Solid Edge price is less expensive than SolidWorks by a large margin, making it ideal for those with a constrained budget.
- Solid Edge has generative design which is an extremely powerful product design and optimisation tool.
- Solid Edge can use both parametric and direct modelling making it a very flexible and fast CAD package.

The amount of CAD packages available is overwhelming and it is often a painful exercise to decide which is best. This article will compare two of the most popular CAD packages; Solid Edge software by Siemens, and SolidWorks software by Dassualt Systemes. Both are very capable at 3d modelling and simulation. However, they have unique advantages that make each one better suited to a specific application.

Kernel Technology

The kernel is the heart of any CAD program. Instead of manually inputting all the code required to create a shape, the kernel handles all the mathematical heavy lifting, making CAD much easier to use. Both SolidWorks and Solid Edge use the Parasolid kernel. However, Parasolid is owned by Siemens. It must also be noted that despite sharing a kernel, the modelling techniques used by each software is completely different.

Modelling Technology

The type of modelling techniques used by each of these CAD packages is what sets them apart most, the differences of which are described below.

Solid Edge Software – Synchronous Modelling

This technique allows the user to switch between direct and parametric modelling without missing a step. This creates a lot of freedom in the modelling process. This also means that models and assemblies can be modified on the fly without worrying about breaking features and assemblies. This method has the following advantages;

- Flexible Design
- Ease of late stage design changes
- Simultaneous editing of multiple parts

Solidworks Software – Parametric Modelling

This is a more traditional modelling technique that allows the user to change the dimensions (Parameters) of a component, thereafter the part is updated. Components in an assembly with that part also need to be updated making this a more time-consuming modelling technique. Complex components and assemblies also make it easier to break a model if the wrong parameter is changed. However, some of the key advantages of this technique are as follows:

- A model can be archived and used as a basis for further designs
- Parameters can be embedded with equations making smart designs
- Constraints can be added to eliminate unwanted design changes

Both CAD packages have extensive engineering tools. SolidWorks is slightly stronger when it comes to engineering support, however Solid Edge includes generative design which is the next big thing in manufacturing and is far more capable than topology optimisation.

Cost & Packages

Both the SolidWorks and Solid Edge price have multiple licenses at different levels allowing the user to choose the product that best fits their budget and functionality requirement. Solid Edge has 4 licenses and SolidWorks has 3 licences. It must be noted that depending on where you are situated, the cost of the software is determined by your local resellers. However, a general cost comparison is shown below. It is clear that Solid Edge is the cheaper of the two. A detailed feature breakdown for Solid Edge 2019 can be found here and SolidWorks here.

Solid Edge

The Solid Edge cost breakdown is indicated below:

1. Design and draughting – $1390 (£ 1092)
2. Foundation – $2220 (£ 1744)
3. Classic – $3988 (£ 3133)
4. Premium – $5493 (£ 4315)

SolidWorks

The SolidWorks cost breakdown is indicated below:

1. Standard – $ 3995 (£ 3128)
2. Professional – $5490 (£ 4313)
3. Premium – $7995 (£ 6280)

For full SolidWords pricing click here

Student Version

If you are still a student and want to check out each of the CAD packages, then the easiest way is through a student version. To use the Solid Edge free student version, you must be an active student and must not use the software for commercial purposes. The SolidWorks student version is not free, and so it is not as accessible to students. However, your school or university may have a free version so you should check with them first.

In Conclusion

When choosing a CAD package, it is extremely important to understand what your specific requirements are. In general, most CAD packages have the basic functionality required to do any CAD work and create 2D manufacturing drawings. If you require specific engineering related features such as FEA or generative design, then each of the packages has its strengths and weaknesses. The Solid Edge cost is definitely the better of the two and has some interesting features, whereas SolidWorks is a powerhouse in the industry with wide reach.

7 key benefits of manufacturing inventory management software

With manufacturing gearing up for Industry 4.0, the rapid development of automated equipment and processes mean the pace of manufacturing has outgrown traditional techniques and procedures.

Keeping track of everything going on in a modern manufacturing shop is incredibly difficult. Using excel sheets and paper-based systems is highly inefficient and will undoubtedly lead to a wide range of issues down the line. This is where manufacturing inventory management software comes in.

In this article, we'll look at some benefits of a software-based inventory management system and why you're manufacturing business might be missing out.

Firstly, what is inventory management software?

Inventory management software is an integrated management system that helps companies manage and plan their manufacturing and production activities. This is done by making use of various methods to automate and control inventory. The software removes the human element from inventory management, and as such, dramatically improves efficiency and all but eliminates errors.

Why inventory management software?

In the age of automation, it is critical to maintain a competitive edge. One way to do this is to automate inventory control. There are various options available that can manage the following:

- **Order Management** – Sales, purchasing and invoicing can all be controlled by the system. This functionality is even more powerful when integrated with accounting software.
- **Ordering** – With an automated system it is possible to automatically order manufacturing inventory well in advance of firm or anticipated orders.
- **Barcode Scanning** – Inventory can be tracked around the workshop by manually scanning barcodes.
- **Up to date product data** – Any changes to products can be easily updated to the entire system ensuring that there is no time and money wastage.

Advantages of manufacturing inventory management

1. Save money

At the core of any company there is one simple goal; and that is to make money. Due to the highly competitive nature of manufacturing, it is difficult to deviate far from your competitors' price point, and as such, one of the ways to remain profitable is to increase productivity, reduce wastage and improve efficiency.

It is very difficult to maintain an organic inventory that reacts immediately to changes. Therefore, attempts at doing this manually often result in various wasteful practices such as purchasing excess material for a project. Holding excess inventory results in carrying costs, and if the material cannot be used on other projects it is an outright loss.

Another way in which manufacturing inventory management software saves money is by empowering employees to make better use of their time, therefore less time is wasted on low value labour.

2. Save time

In today's manufacturing environment, time is an increasingly rare commodity. Deadlines are perpetually on the limit of feasibility due to the highly competitive nature of the industry. There are many factors that influence the timeframe of a manufacturing project. For example, if you have a large order, then the procurement of materials becomes critical and even the smallest delay can have a domino effect that jeopardizes the entire project.

Manufacturing inventory management software can keep track of exactly how much material is needed for every product, and can ensure that there is sufficient stock available based on projected sales. Furthermore, many of the more labor-intensive processes such as manually counting and controlling stock can be eliminated. Your staff can therefore be trained on more complex tasks that can result in higher levels of productivity and job satisfaction.

3. Data

Software systems can keep track of data and display trends that won't be apparent if systems are monitored manually. Data science is a fast-growing field that can benefit any industry where large amounts of data can be generated. Some of the more obvious insights are as follows:

- **Sales Tracking** – The ebb and flow of sales can be tracked in real time. By doing this, the best-selling products can be determined, and strategic decisions can be made on which products to cut from the line, and which can benefit from increased attention.
- **Wastage Tracking** – Wastage can be easily tracked. If a certain product is showing high percentages of waste, management can step in to optimize the process.

- **Tool life** – The life of your tools can be monitored so that replacements can be ordered before a failure occurs, this means that there will be minimal production down time.

4. Traceability

The entire life cycle of the product can be monitored in real time all the way from raw materials through to manufacturing, and finally completed products. This is important for proper quality control and certification.

Another advantage of this high level of traceability is to reduce theft within your workshop. If a part or product leaves its designated area, an alert can be raised immediately.

5. Integration with other departments

Manufacturing inventory management can be a part of a more complex ERP (Enterprise Resource Planning) systems. This creates an environment where the different business units of a company such as manufacturing, accounting and management can all communicate with each other in real time, and decisions can be made based on accurate up to date information. If these systems are actively used by employees and managers, it can truly be a powerful tool.

6. Customer satisfaction

Inventory management software has the added advantage of improving customer relations. This is due to various factors, some of which are listed below:

- **On time delivery** – Nothing can sour a relationship faster than a late delivery. If a salesperson sells a product based on outdated inventory data, this can result in cascaded delays.
- **Quality products** – If a product does not meet quality standards it can be flagged on the system and it can be barred from being accidentally shipped out to the customer.
- **Progress Tracking** – The act of automatically tracking progress means that it's a simple exercise to share the progress of their product. This level of transparency instills confidence in your products and processes, and will improve the chances of having repeat clients.

7. Production rates

Lean manufacturing principles go hand in hand with inventory management software. Lean manufacturing is basically the process of optimizing manufacturing in such a way as to increase productivity. More efficient control of the flow pf parts around the workshop is a very effective way of trimming off wastage from individual processes.

Inventory management software results in an organized warehouse. An example of how this is typically implemented is by placing all the components and materials used by the best-selling products within easy reach, to further improve on efficiency. This may not seem like a big change but over the lifespan of a production run, a few minutes per product can translate to a significant overall improvement in production rates.

Final Thoughts

It should be clear that integrating your workshop with manufacturing inventory management software can have far-reaching benefits for your company. In the age of automation, there is an unstoppable drive to integrate everything with software systems, so don't wait for your competitors to gain the edge before you. The good news is that it's not as far out of reach and as costly as you might think, thanks to the availability of cloud-based systems.

Industry 4.0 / IoT / Smart Factories

Is the aerospace industry leading the way when it comes to smart factories?

Humans have never ceased to evolve no matter what the walk of life is. When it comes to engineering, it all started off with applying basic technologies to make objects like hunting tools and carts. Major advancements resulted when the Industrial Revolution came, an event which was further refined by the introduction of automation. Now our industries are moving towards the use of what has come to be known as smart factories.

What is Industry 4.0?

This latest phase of industrial development, highlighted in the above paragraph, is becoming increasingly important in modern times. Dubbed as Industry 4.0, or the fourth industrial revolution, it integrates the physical world with the cyber world, with the help of interconnectivity across the whole product lifecycle, allowing optimization across each stage of production.

In this article, the relevance of Industry 4.0 for the aerospace industry and how it has been moving towards the use of smart factories will be discussed.

Why the aerospace industry?

This industry has been chosen due to its consistent growth rate and rise in demand, as indicated by these IATA statistics, which show a 9.4% increase in revenue alone from 2017-2018. This growth rate means that aviation companies will be facing rising demands for aircraft production in the near future, for which they will have to upgrade themselves with the latest trends in manufacturing.

Furthermore, considering the complexity involved in aircraft production, the industry itself is willing to realize these changes, with 62% of manufacturers having a smart manufacturing initiative in 2017, second in the list after industrial engineering (67%).

Smart Factory: what is it?

Smart factories are, simply put, a revolution for any industry. The essence of the whole concept is that with the help of hundreds of thousands of data collection devices, placed at strategic points in a production factory and its whole supply chain, maximum information can be gathered in real time.

This information is then fed into a system of computers, connected to each other via the Internet of Things, which utilizes its algorithms to analyze data like humans do and take intelligent decisions autonomously that favor overall productivity and quality.

What makes smart factories so important?

Let's consider an example to completely understand the importance of smart factories. Consider a driverless autonomous drone. With the help of a computer program and some sensors, it automatically adjusts itself to a gust of wind that forces it in one direction, just like a human pilot would do in a similar situation.

Extending this example to include the application of the Internet of Things, this drone might also be programmed to collect data from the meteorological department to identify elements like rain or wind in advance and take alternate routes, this would make the drone far more efficient and increase its chances of performing within the designated time frame.

This example clearly shows how important the development of smart factories is. With such systems in our industries, we can surely achieve productivity rates never seen before.

Aerospace and industry 4.0: a match made in Heaven?

The question remains whether the aviation industry is ahead of others in terms of adopting smart manufacturing or not. Considering that 62% of companies (higher than most mainstream industries like automobiles) are already working on the issue, there is little room for doubt.

The application of smart manufacturing was seen in the design of the Airbus A350 XWB. This aircraft was designed using advanced simulation software, virtual reality systems, supply chain components, and thousands of engineers, all of which were interconnected via a centralized system, allowing each element to complement others. The result is one of the most efficient, lightweight, and strong aircraft the world has yet seen.

This report by the European Commission highlights some key areas where smart factory applications could be introduced. An interesting example from it is the use of sensors inside aircraft engines to gather real-time information which is then used for engine behavior modeling. These immensely accurate models can be used to predict the optimal fuel demand for the required thrust level in given conditions, resulting in an increase in fuel economy of up to 15%.

The reasons for the aerospace industry adopting such trends is that they have several benefits ranging from better utilization of resources, more reliance on AI-based systems, better supply chain management in plants, and the use of autonomous decision-making in industrial planning.

How can the Autodesk software suite help aerospace industry realize Industry 4.0?

The Autodesk suite, offering an elite class of smart manufacturing software, is the ideal choice for aerospace companies willing to move their manufacturing plants towards a smart-factory setup.

The whole software suite is integrated with the Internet of Things via Autodesk's Fusion Production software, which collects real-time data from various nodes throughout factory floors, identifies errors, updates its cloud-based database, and gives quick access of information to users.

With easy to use manufacturing software for everything ranging from CAM (computer aided manufacture), composite material design, CNC machining, to additive manufacturing, engineers can excel in aircraft production and extend the aerospace industry's lead in implementing Industry 4.0 standards.

Real world applications of Augmented Reality (AR) in manufacturing

Augmented reality, or AR for short, overlays virtual information over a user's existing natural environment. Sound, graphics and touch feedback are seamlessly integrated to create an enhanced experience.

The information overlaid is highly topical and relevant to what the user is doing. It ranges from simple text to instructions for complicated surgical procedures. Uses for the technology vary from mobile phone apps to aerospace.

Applications of AR in manufacturing

Augmented reality is a very new concept in manufacturing, with many potential benefits. Manufacturers are starting to explore these benefits in various applications, for example:

- Assembly
- Maintenance
- Quality assurance
- Product development
- Training

Assembly

Work instructions are traditionally made available as printed or displayed PDFs. These are often very hard to work through and time consuming to review. As they are static documents it is difficult to ensure that they are kept up to date.

AR allows information from work instructions to be displayed in real time in the operator's field of view. This eliminates the need to consult documents or other display devices.

Boeing managed to reduce the wire assembly time on their 787-8 airplane by 25%, and reduced assembly errors to nearly zero.

At GE Healthcare a study found that it was possible to pick an order 46% faster compared with the standard paper-based process.

Maintenance

AR can allow maintenance crews to identify equipment that needs servicing, as well as any potential problems. This eliminates guesswork, reduces the risk of breakdowns, and allows for faster and more effective servicing.

ThyssenKrupp uses AR to assist with service calls of their products. Technicians can visualize and identify problems ahead of time, and have hands-free, on-site access to technical support. By prioritizing service requests in advance, and having holographic guidance on site, the average length of service calls was reduced by 75%.

Quality assurance

Products can be inspected and visually compared with information provided by the supplier. Any deviating features are highlighted, and defective products can be discarded immediately.

Product features to be inspected and the equipment needed for the inspection can be visually displayed in the operator's field of view. Results are displayed in real time and can also be recorded in the cloud for future use and analysis.

Porsche introduced AR in 2016 at their Leipzig vehicle assembly plant. Employees use mobile devices to compare an assembled vehicle to the original design before sending it to the customer. This ensures they meet high customer quality expectations, save time, and save money.

Product development

Traditional development of products is a lengthy and resource-intensive process. Several divisions may be involved, and the process normally requires several instances of back-and-forth communication to discuss and resolve design changes.

With AR, the cooperation and collaboration between parties are improved. It is possible for senior staff to view the development of products in real time and provide valuable input, eliminating the back-and-forth inherent to traditional processes.

Ford Motor Company uses AR to improve their product-design phase. Design teams are able to overlay potential designs onto physical models. The technology also allows for remote operation, so staff can cooperate on the same project whilst in physically different locations. This allows the team to collaborate better, work quicker, and improve decision making.

Training

Appropriate application of AR means that trainees and apprentices can be trained, protected and informed without wasting resources. These novices can be put to work straight away, with instructions, manuals and support resources displayed in front of them at all times.

Lockheed Martin was able to reduce the assembly time of their F-35 airplane by 30%. Holographic renderings of parts are displayed in real time, along with instructions on how to assemble them.

Digitizing workflow further improved Lockheed Martin's engineering efficiency to a remarkable 96%.

Final thoughts

Autodesk provides a range of software suitable for AR, VR (virtual reality) and MR (mixedreality). The software can be fully integrated with Autodesk manufacturing software.

The software includes:

- **3ds Max** – turn designs into interactive experiences
- **Revit Live** – turn Revit models into an immersive experience
- **VRED** – 3D virtual prototyping software for automotive design
- **Forge** – use cloud services, APIs and SDKs to create data and apps
- **Project Play** – make interactive 3D presentations and experience them via mobile devices
- **Maya LT** – 3D animation and modelling software for PC, console, mobile and VR game creators

This article gives only a brief insight into the potential of AR in the manufacturing industry. As the technology continues to grow in popularity and its benefits become more apparent, areas of application will also expand.

Smart Manufacturing and MRP: Two Sides of The Same Coin

Running a small manufacturing business has its challenges. Implementing smart manufacturing practices will go a long way in solving some of the more significant problems. However, to remain competitive over the long term, you have to continuously change with the times.

Continuous improvement is not easy, and it's here that most small manufacturers fall by the wayside. It's not all bad news though. Read the rest of the article to find out why MRP and Smart Manufacturing will keep you competitive.

What is Smart Manufacturing?

Whatever line of business you're in, be it aerospace, medical, food & beverage, construction materials, or pharmaceutical; getting your product to the customer on time is vital to business success. Running a manufacturing company is just like any other type of business. You have a manufacturing process that turns inputs into finished goods.

Smart manufacturing is the concept of using advanced tools to manage the flow of raw materials, the manufacturing process, and fulfillment of inventory on time. It aims to optimise the manufacturing process through big data analysis and computer controls.

It achieves this through the use of advanced information analysis and manufacturing technologies, such as sensors and RFID tags for example. It utilises artificial intelligence (AI), and provides a competitive advantage in the pursuit of satisfying the increasing demands of a dynamically changing global market.

Introducing you to Manufacturing Requirements Planning (MRP)

On its own, smart manufacturing is a powerful concept. Married to MRP, however, you have a winning combination that can take your manufacturing business to the next level. MRP is a system to control planning, inventory, scheduling, and production within a factory environment.

With the data from an MRP system, you can order raw materials, schedule a production plan, clear warehouse space and release finished goods on time.

Working with demand forecasts, you can use this data to plan how much raw material you need to purchase. With smart manufacturing and MRP, you can break down the master production schedule into a detailed program including every component of the finished product. Armed with a complete schedule, you can proceed to order necessary raw materials or parts.

How can MRP benefit you and your business?

Getting products to the customer on time is the goal of every business. There are several standard goals for most companies when it comes to MRP. Such goals include ensuring adequate inventory is in place, that purchase orders are scheduled correctly, that a plan exists for raw material delivery, and that manufacturing processes are lean.

If you regularly find yourself running out of inventory or experiencing long waiting times for components to manufacture, you need MRP.

Here are some of the benefits you will enjoy with an MRP system:

- You can reduce or eliminate instances of raw material or component shortages.
- You can reduce the amount of stored inventory to levels that ensure you are meeting your orders on time.
- You will enjoy more accurate scheduling which will leads to increased customer satisfaction, since delivery times are met.
- Your improved scheduling will increase productivity and efficiency.
- You will experience an overall increase in competitiveness.
- You will have the potential to ultimately boost your profitability.

Steps to implementing MRP in your business

Adopting MRP may mean a change to the way your business process currently works. Making changes to your process is something you have to prepare for and have a plan for before going ahead with it.

For MRP to be a success, your accounting and billing processes should be as accurate as possible. To quote a common saying: “Garbage In, Garbage Out”. While MRP has massive potential, it relies heavily on the data points it receives. These data points include customer orders, inventory levels, demand forecasts, and details for raw materials or components (bills of materials).

MRP will track the levels of these inputs and perform calculations based on them. The outputs of the calculations are reports which will guide how you plan a production run, how much raw materials to order, and when you expect finished products to be ready for delivery.

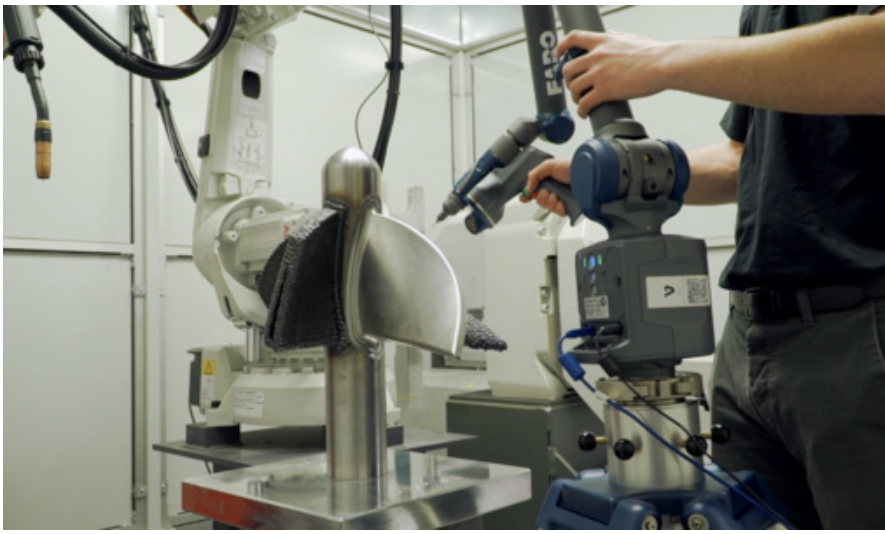
You can find more tips here on implementing MRP in your business.

Final thoughts

A good MRP system will boost the effectiveness of your manufacturing business, making your operations much leaner and more profitable. However, it's very dependent on the inputs it receives so it's important when researching an MRP system that you choose a reputable platform, with great user support.

The beauty of smart manufacturing, when linked to your MRP system, is that it will be able to learn and work autonomously, independent from humans. With such an advanced system in place, manufacturing firms of all sizes can elevate their success rates to higher levels, and provide tough competition to their counterparts.

How are smart factories changing the face of manufacturing?



There's little doubt that the manufacturing industry is undergoing some seismic changes at the moment.

Technological advances in automation, computing power and communications (the 4th industrial revolution) have made intelligent manufacturing and smart factories a reality.

In a nutshell, smart factories employ advanced technology to optimize planning, production, transportation, and management processes.

A recent report highlighted that 76% of US manufacturers are either planning or in the process of adding smart factory elements to their operations. Despite this, less than 15% are happy with the progress they've made regarding implementation.

This article will take a broad overview of how smart factories are changing the manufacturing industry, the pros and cons of implementing the new technologies and what the future may hold.

Smart factories – intelligent, flexible, and hyper-connected

Over the past 40 to 50 years, the manufacturing industry has been characterized by increasing automation. Modern factories still rely on robotics and automated processes, but smart factories are pushing things even further with AI and data-driven systems and highly connected workflows.

So, what does a smart factory look like?

Let's take a look at a possible application of smart technology in a factory that makes specialist, customized products.

A customer orders several hundred products via the internet. The order data would be fed into management software, such as an enterprise resource planning system. The data is automatically sent to the shop floor to prepare the machinery and, if necessary, to outside suppliers to order the materials.

A design is drawn up using CAD (Computer-Aided Design) or automatically with generative design technology. The design details are automatically converted into machine language.

Smart machinery ensures that everything needed for assembly is sent to the right place and at the right time, using electronic tags attached to the materials and components. When it arrives on the shop floor, robots or a collaboration between human workers and robots (also known as cobots), begin the assembly process.

In some cases, an additive manufacturing process (3D printing) may be used to fabricate the product, especially for small customized orders.

Industrial Internet of Things (IIoT) remote sensors built into the machinery will constantly monitor and record data on the production process and the functioning of the equipment. Fully or semi-autonomous AI systems can adjust operating parameters or change workflows to optimize them for quality and speed.

If the customer has a change of mind and wants something altered mid-order, this can be done quickly and easily with little disruption.

Finally, the finished products are automatically quality-checked with sensors and AI before being loaded and dispatched, with tracking devices fitted to keep the customer fully informed.

The advantages of smart manufacturing

The smart factory approach has many benefits including long-term cost savings, improved efficiency, and increased productivity. In fact, it's estimated that by 2022 factories that adopt smart technology will be up to 7 times more productive.

Productivity is constantly optimized in a smart factory. If something is slowing production down, the data will highlight it, and the AI systems will seek to solve the problem. With these highly adaptable systems comes greater flexibility.

One of the main efficiency savings is the decrease in production downtime. Modern machinery is often equipped with remote sensors and diagnostics to alert operators to problems as they occur. Predictive AI technology can highlight problems before they even occur and take steps to mitigate the productivity and financial costs.

In a well-designed smart factory, everything will flow smoothly and will have features of automation, as well as human-machine collaboration.

The disadvantages of smart manufacturing

The most obvious downside is the initial cost of implementation. The considerable costs of the technology will put off many small to medium-sized companies, especially if they adopt a short-term philosophy or they don't have the capital or investment needed. The long-term savings will certainly outweigh the starting costs, so companies need to plan for the future even if they aren't in a position to implement smart factories straight away.

Another disadvantage is the technological complexity of the systems. If it is well-thought-out and installed initially, this shouldn't be a problem, but systems that are poorly designed or not adequate for the required operations could hurt profits.

Where are smart factories heading?

Nobody can say for certain what factories will look like in ten or twenty years' time. New technology, materials or concepts may come along and completely change the direction of manufacturing.

However, the way things appear to be heading at the moment is towards an increasingly interconnected and flexible manufacturing environment. With adaptable systems and machinery, companies will be able to offer a wider range of products and more opportunity for customization.

It's likely that the price of the technology will come down over the coming years, meaning that smaller companies can get involved. We have seen evidence of this already with Autodesk offering a range of affordable products that make Computer Aided Manufacturing (CAM) and generative design available to more businesses.

How can smaller manufacturers make the most of Industry 4.0?

Industry 4.0 is set to revolutionize the manufacturing industry and the way manufacturing businesses operate. Fully integrated factories will generate massive amounts of data. This data will be constantly analyzed, allowing manufacturing processes to learn and adapt to new demands.

To remain competitive, existing businesses must embrace technological advancements and the changes required to maximize their benefits. These technologies will allow processes to run with less manual intervention, improving efficiencies and helping to resolve complex business problems.

So what's in it for your small manufacturing business?

Scalability with Industry 4.0

The cloud is an integral part of Industry 4.0 and offers small businesses the opportunity to scale their operations by focusing on their core competencies, rather than focusing on IT systems. Because many small businesses do not have sufficient IT resources, they have to strategically manage the utilization of resources, especially people.

The cloud levels the playing field by giving a small business access to the latest software without having to strategically manage it. This frees up staff from having to monitor and manage the infrastructure needed to run the software. Staff can be reassigned to more value-adding functions.

Customization

Customization and personalization of products require shorter production runs and more frequent switching out of production lines. To minimize downtime and waste, businesses must be able to quickly and efficiently adapt their manufacturing processes.

Interconnected machines, processes, materials, and products allow for more efficient resource planning. It is possible to reduce manufacturing batch sizes to one part, meaning a bespoke part

can be produced at the same cost and within the framework of the existing business, and within the existing production processes.

Smart factories can auto-adjust schedules and automatically adjust material and process flows. Factory uptime is maximized, and downtime minimized.

Optimized inventory levels

The person receiving the order in a small business must have overall visibility of the production process and material availability. Without this visibility it is difficult to determine if the requirements of an urgent customer order can be met.

The only way quick manufacturing of products can be accommodated is by carrying excess inventory. If this is not done, the business will always be at risk of not being able to produce the customer's demand. However, carrying excess inventory will have a negative impact on cash flow and the business's balance sheet. Industry 4.0 provides in-depth supply chain visibility, leading to more predictable and lower inventory levels.

Control and visibility

Transparency provides greater visibility, ensuring that a small business can make more informed decisions. This visibility across assets and processes allows for greater flexibility, productivity, and the ability to adapt more quickly to customer demand changes, leading to greater customer satisfaction.

Integration into the value chain

Implementing Industry 4.0 in a small business may at first seem unnecessary. Although large companies are driving the concept, small companies form an integral part of their supply chain. It is inevitable that this industrial revolution will affect small companies.

Supply chain visibility means that large companies will want to link smaller companies' production systems to their supply chain. Knowing the status of production and location of materials is critical for larger companies to fully implement and meet their own Industry 4.0 targets. Failure to implement Industry 4.0 may result in a loss of a major customer.

Improved quality control

With more and more businesses implementing Industry 4.0, it will become more difficult to differentiate your business from its competitors. One way of achieving this is through improved product quality.

Predictive maintenance proactively monitors tool and machine performance within set tolerances. When deviations from nominal settings are identified, tools can be replaced, and machines recalibrated to maintain product quality.

Advances in measuring and evaluation systems mean that measuring technology can be integrated more thoroughly in the production process. This provides accurate measurements in real time to not only provide transparency into the production process but also allow for communication between integrated systems.

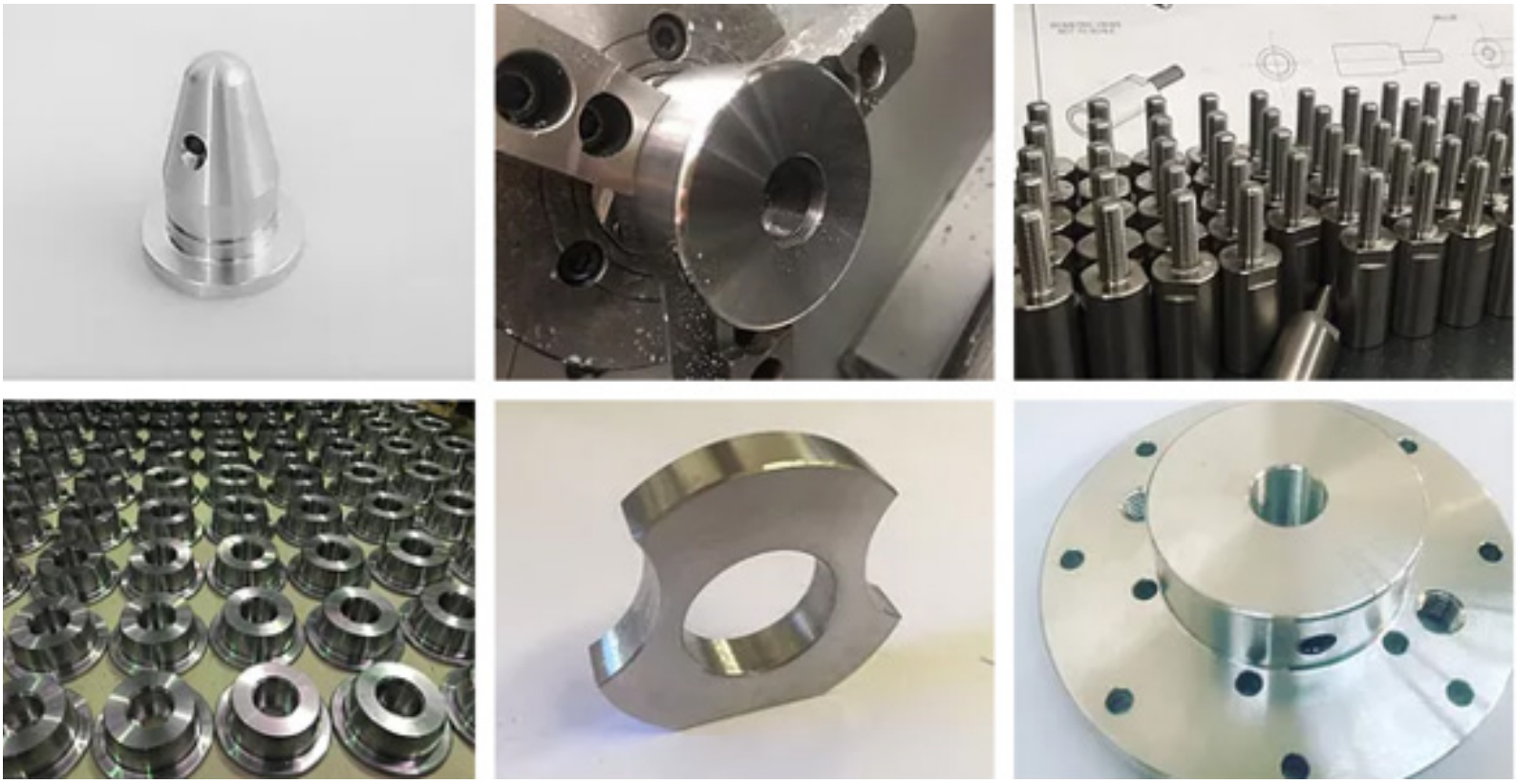
Conclusion

With the suite of Autodesk manufacturing software it is possible to fully integrate the various operations of your small manufacturing business. Project management, design, additive and subtractive manufacturing, and quality control can be seamlessly managed from the cloud.

In the long run, the small manufacturing business will appear more professional and have greater insight into its own operations. It will be able to more effectively manage its inventory and provide greater levels of customer satisfaction by minimizing stock-out conditions.

CNC / Manufacturing

Forging vs CNC Machining: which one should you choose?



CNC machining undertaken by our team at Challenge Engineering

There are some things you need to get right when deciding how to get metal parts manufactured. How should they be made? Do you go for cast, forged or machined parts?

If you're not sure, we're going to explain and compare two specific ways of making metal parts, forging and CNC machining.

Hopefully, by the end of it you should be able to decide which is going to work best for your situation and specific requirements.

What are the differences between Forging and CNC Machining?

Let's start by looking at each process.

Forging metal involves using a mould made from very tough steel. The mould comprises of two parts; the 'tool' which is the movable part, and the 'die' which is the stationary part. A press that exerts tons of force pushes the two halves of the mould onto a sheet of metal, creating the desired shape. The process can be done hot or cold, depending on the metal being forged. The part normally needs a little finishing, and that's it

CNC (Computer Numeric Control) machining, involves passing a lump of metal (or a billet as it's known in the trade) into a machine tool. The machine has sensors built in to position and guide the billet. It is fully motorised and is controlled by a computer panel. A rotating tool cuts away unwanted metal to form the part. The computer interpolates the design to give smooth curves and circles.

What are the pros and cons of forging?

Advantages

If you are making tens of thousands of replicas of the same shaped piece of metal, simple nails for example, then forging is ideal as you create a single tool and die and off you go.

Forging changes the microstructure of the metal considerably, creating a finer grain and improving the fatigue resistance.

One way to think of it is that forging compresses the metal into having a similar structure to wood, so the resulting part is very strong perpendicular to the grain. Again, for simple items like nails, this is ideal as they will stand up well to being hammered into a surface.

While setting up the press and mould aren't cheap, it can be a cost-effective process if you are mass producing similar parts. Let's say you are making 500,000 of the same basic connecting rod that requires no further machining, then forging is probably your best bet.

Disadvantages

Forged metal is generally strengthened in only specific directions, i.e. perpendicular to the grain flow. This is no good for parts that need to be tough all around such as crank shafts, for instance.

Forging cannot create parts that have acute angles (less than 90 degrees) as they are too difficult to remove from the mould, meaning sharpened points are out of the question.

Also, there are other features that cannot be made by forging, such as internal threads. You would have to have a separate machine to tap the thread when the forging process is complete.

What are the pros and cons of CNC machining?

Advantages

CNC machining is ideal if you're making parts that have complex or acute-angled shapes. For example, aerospace engineers making unique parts for a space shuttle or fighter jet would find it more convenient and cost-effective to use CNC machining.

Some forges actually use CNC machines to create the moulds to be used in their forging press.

If you have specific requirements, such as internal threads or sharpened points, and you're not looking for mass production levels of output, then CNC is the best option for you.

Surface finishes on a CNC machined part will typically be near perfect and appear very consistent and precise, whereas cast or forged parts will be a little rougher, usually requiring polishing or tumbling in an abrasive media to achieve a better surface finish.

Disadvantages

CNC machining takes time, unlike forging which bangs out simple parts quite quickly. However, it depends on volume and complexity.

However, the real cost is in the amount of waste created. Metal is cut away from each fabrication, which ends up as shavings that can only be sold for scrap, meaning production overheads can mount up quickly if you're manufacturing large numbers of intricate parts.

CNC machines are quite complicated bits of kit with various motors and moving parts. This means it needs lots of oiling and continuous maintenance, further adding to the cost of running.

If you are using the services of a CNC machine shop, however, this will all be factored into their operating costs, so you won't need to worry too much about the expense of the process. The larger the run the cheaper the cost per part.

Making a decision

In most circumstances, given the size of typical volume of runs in Australia, CNC machining is the way to go. Make sure to talk to your specialist CNC machinist, as they will be able to advise you on the best option for your specific needs.

Why Engineers Specify Precipitation Hardened Stainless Steel for CNC Machined Parts

Stainless steel is an iron-based alloy, with minimum 10.5 wt.% chromium content, widely used for its anti-corrosive properties and high strength. It is low-maintenance and is 100% recyclable.

Stainless steel is an integral part of modern society and is found in many applications including construction, architecture, automotive, medicine, and energy. Stainless steel properties are improved by the precipitation hardening (PH) process and engineers tend to specify this material most of the time for their products.

Let's find out why.

CNC Machining PH Stainless Steel. See Challenge Engineering in Sydney.

What is the precipitation hardening process?

Precipitation hardening is a heat treatment process that hardens stainless steel through ageing. This process allows stainless steel to cope with its susceptibility to stress corrosion cracking. Precipitation hardened stainless steels (PHSS) possess the combined properties of martensites (high strength) and austenites (high corrosion resistance). PHSS is hardened through strengthening its particles by the formation of intermetallic precipitates. PHSS has base elements of iron, chromium, and nickel and hardening is achieved by adding one or more of the following elements:

- Aluminium
- Copper
- Titanium
- Molybdenum
- Niobium

Three types of PH hardened characterisation

PHSS is classified by the characterisation of its final microstructure after heat treatment.

1. Martensitic Alloys

Martensitic PH stainless steel has a primarily austenitic structure at annealing temperatures. These alloys undergo a transformation that changes the austenite to martensite when brought to cool down in room temperature. Martensitic grade 17-4PH (17% Chromium, 4% Nickel, 4% Copper, and 0.3% Niobium) is the most common martensite PH alloy and its transformation occurs typically at 250°C, and is then strengthened further by ageing between 480 and 620°C.

2. Semi-austenitic alloys

Semi-austenitic PH stainless steels are fully austenitic after solution treatment and are then subjected to a second heat cycle before cooling to room temperature to form martensite. Some semi-austenitic alloys require very low temperatures at -50°C to -60°C for eight hours, in order to facilitate the full formation of austenite and martensite structures. Some alloys such as FV520 and 17-7PH though, do not require refrigeration to develop its optimum properties.

3. Austenitic alloys

Austenitic PH stainless steels retain their austenitic structure after annealing (1095°C to 1120°C) and hardening by ageing. These alloys are typically stable down to room temperature and strength is developed at ageing between 650°C to 750°C. The austenitic PH alloys have lower hardness in comparison to martensitic alloys but they exhibit good toughness in cryogenic applications. Austenitic alloys are also excellent in applications where high strength and non-ferromagnetism is required.

Composition of common PH hardened stainless steel

Specification	Common Name	Type	Typical Chemical Analysis %								
			C	Mn	Cr	Ni	Mo	Cu	Al	Ti	Others
A693 Tp630	17/4PH	martensitic	0.05	0.75	16.5	4.25	-	4.25	-	-	Nb 0.3
	FV 520	austenitic-martensitic	0.05	0.6	14.5	4.75	1.4	1.7	-	-	Nb 0.3
A693 Tp631	17/7PH	austenitic-martensitic	0.06	0.7	17.25	7.25	-	-	1.25	-	-
	PH 15/7 Mo	austenitic-martensitic	0.06	0.7	15.5	7.25	2.6	-	1.3	-	-
A 286		austenitic	0.04	1.45	15.25	26.0	1.25	-	0.15	2.15	V 0.25 B 0.007
	JBK 75	austenitic	0.01	0.04	14.75	30.5	1.25	-	0.30	2.15	V 0.25 B 0.0017
	17/10P	austenitic	0.07	0.75	17.2	10.8					P 0.28

Table 1 Source: https://www.twi-global.com/technical-knowledge/job-knowledge/precipitation-hardening-stainless-steels-102

Why do engineers specify PHSS?

Due to the high strength to weight ratio of PHSS, it is vastly used in a variety of applications including:

- Aerospace engineering
- Automotive engineering
- Chemical engineering
- Medical applications
- Metalworking industries

The formability and machinability of PHSS are excellent for parts that require CNC machining. For example, in aerospace applications, engineers commonly specify martensitic PHSS for CNC machined landing gear parts, valves, shafts, pins, and blades where hi-strength and toughness are required. Designers prefer semi-austenitic PHSS in applications where severe plastic deformation is required to achieve the final part geometry.

With these many advantages, PHSS is widely used and specified in applications where high-strength, corrosion resistance, and formability is desired.

5 Customer Benefits of ISO 9001 Certified CNC Machining

What is ISO?

The International Organisation for Standardisation (ISO) develops and publishes more than 18,000 international standards. ISO 9001 is a standard that sets out the requirements for a quality management system (QMS). It helps businesses and organisations to be more efficient and improve customer satisfaction. The latest version of the standard is ISO 9001:2015.

A standard is not a law, but an agreement or best practice that an organisation can apply voluntarily. A standard reflects a good level of professionalism. A quality management system is a tool with which an organisation can determine how it can meet the requirements of its customers and the other interested parties that are involved in its activities.

The adoption of a quality management system shows a commitment from a CNC machining service to continuously improve its overall performance.

What is ISO 9001:2015?

ISO 9001:2015 is the latest standard and specifies requirements for a QMS when an organisation:

a) needs to demonstrate its ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements, and

b) aims to enhance customer satisfaction through the effective application of the system, including processes for improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements.

The most recent ISO 9001:2015 standard is constructed around seven quality management principles that senior management can apply for organisational improvement. They are:

- Customer focus
- Leadership
- Engagement of people
- Process approach
- Improvement
- Evidence-based decision making, and
- Relationship management.

ISO 9001:2015 describes the requirements all products, services and the organisation itself must meet in order to enjoy the above benefits. ISO 9001:2015 strives to give additional momentum to the continuous and systematic improvement of processes within organisations.

Crucially, certified CNC machining companies use ISO 9001:2015's requirements as a foundation to build relationships with their customers. They will engage customers through formal feedback and demonstrate that they value that feedback by driving corrective action to address any concerns customers may have.

What are the benefits to customers of ISO 9001:2015 certification?

1. Better customer experience and management

ISO 9001:2015 deals with customer satisfaction directly. It states that the "organisation shall monitor customers' perceptions of the degree to which their needs and expectations have been fulfilled."

The standard goes on to list examples of how this information can be obtained, citing customer feedback and surveys, warranties, and dealer reports as examples. These can be effective ways of establishing whether the customer is satisfied with the organisation.

A critical part of ISO 9001:2015 deals with performance evaluation in general, with customer satisfaction specifically mentioned in one section. An organisation that continually evaluates, acts, and improves the QMS will always improve the manufacture and delivery of goods or services.

Such organisations have a code of conduct and a complaints procedure which ensures that you are always approached in a professional manner. The company must demonstrate its effectiveness in dealing with problems and complaints via a corrective action system.

Your CNC machining service will also endeavour to solicit customer feedback regularly and in a precise format. If you provide feedback, you will be shown evidence of action and closure to assure you that the feedback is read, valued, and most important, acted on.

There is a requirement that these processes must include, where relevant, communicating with customers in relation to the handling or treatment of customer property and specific requirements for contingency actions.

2. Quality Products and Services

Compared to the previous ISO 9001:2008 standard, there is more emphasis in ISO 9001:2015 on measuring and properly assessing the input and output of processes. According to ISO 9001:2015, organisations must closely monitor which articles, information and specifications are involved in the production process.

Such CNC machining companies must also clearly check whether high quality precision engineered components come out of the production process. In addition, they will provide consistent product and improved services through excellent operational planning and control of suppliers.

3. Improved efficiency and control

Improved efficiency and control always has been, and still is, key to satisfying customers. The ISO 9001:2015 standard covers the entire production process, from planning processes, controlling design and development, managing change, and tracking and managing external supplies.

The more effective a CNC machining company is at this process, the more it will satisfy its customers with a consistently excellent product.

4. Effective risk management

Risk-based thinking has a very important place in ISO 9001:2015. Organisations are encouraged as to use risk analysis to decide for which challenges they see in the management of the business processes. The new ISO 9001 standard now requires organisations to identify all issues both within and outside the organisation that are relevant to its context and that can help to achieve the intended outcomes of its management system.

Organisations must identify those risks and opportunities that have the potential to impact (negatively or positively) on the operation and performance of their QMS.

As a CNC machining service customer this means that this company undertakes regular operational and strategic planning. It will outlive its competitors as it has contingency plans in place to minimise risks.

5. Utilisation of best practice management and strategy

ISO 9001:2015 certification requires management to have direct involvement and ownership of the

process and to ensure that the QMS is achieving its intended results and drive continual improvement within the organisation.

ISO 9001:2015 also places emphasis on leadership and management commitment. It requires greater involvement by top managers and business leaders in controlling the quality management system.

Ensuring that business leaders take extra responsibility can only be good news for customers.

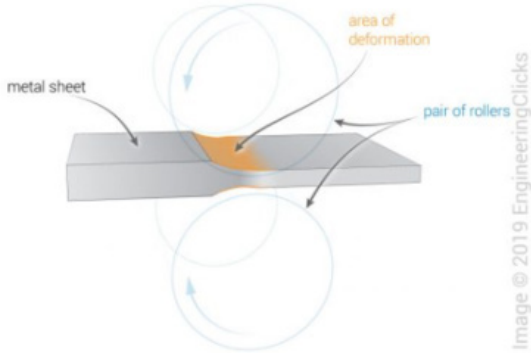
So, when engaging a CNC machining service for precision engineering work, do select on the basis of ISO 9001:2015 certification. It will bring many benefits to your business. You will be assured of quality products and excellent customer care.

Cold Rolling – process overview

- This article goes into the fundamentals of cold rolling and why it's such an important function in the steel industry.
- If you've ever been uncertain about the benefits of cold rolling, this article will help you understand what material properties can gain from the process.
- There are plenty of advantages and benefits from cold rolling - we'll look at them and provide you with some typical applications on the way.

In simple terms, cold rolling is an industrial process used to change the material properties of sheets or strips of metal. The metal is fed between two rollers which compresses it. The resulting mechanical properties vary, depending on how much strain is applied.

The main benefits of cold rolling are that it results in a smoother surface, greater dimensional accuracy and increased hardness.



Basic diagram of the fundamental cold rolling process

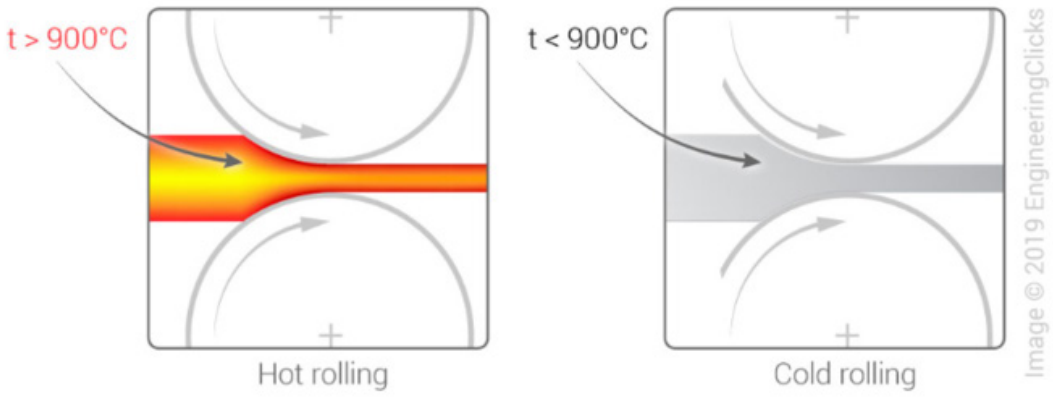
Cold rolling process

Rolling is an important function of the steel industry. It's a steel fabrication process involving passing the metal through a pair of rollers. There are two main types of rolling process:

Flat rolling – the finished product is a sheet

Profile rolling – the finished product is a bar or rod.

The process always starts with hot rolling. Hot rolling refers to the process of rolling steel at a temperature typically above 900° C, greater than its recrystallisation temperature. This allows steel sheets to be made in larger, thicker sizes, ideal for the manufacture of railway rails, large beams, or girders.



Hot rolling vs cold rolling

Before moving on to cold rolling, the metal is 'pickled', which means the scale formed by hot rolling is removed from the surface of the metal, otherwise it would interfere with the process.

Cold rolling takes the hot rolled product and processes it further. After hot rolling, the steel is cooled to room temperature, then passed through cold rollers at a temperature lower than its recrystallisation temperature. This rolling process is called annealing and relieves stress and leads to a higher yield strength and greater hardness. This is due to reorientation of the grain and the creation of flaws in the crystal structure, leading to microstructure hardening.

The cold rolling mill is usually fitted with thickness gauges that check the steel as it comes out of the rollers. Reversing mills are designed so that the steel can be reversed and pushed back through the rollers which are brought closer together each time until the desired thickness is achieved. Multi-stand mills have three to six pairs of rollers in a series, each pre-set to reduce the thickness by a certain percentage until the final thickness is reached.

Usually each pass will reduce the thickness between 50 to 90%. Due to the high compression forces and friction, the temperature of each pass has the potential to reach as high as 250° C. Therefore, a cooling agent must be used to keep the rollers and metal cold and lubricated. Oil or water are usually used for this purpose.

The resulting metal typically has a thickness of between 0.12 to 2.5 mm. Due to the thinness of cold-rolled steel, it is used for applications such as drinks cans or lightweight vehicle panels, light aircraft etc.

Modern, efficient cold rolling mills can roll pickled sheets or strips at speeds of up to 4 m/s and tandem mills that are continuously working can produce up to 2.5 million tons of cold rolled steel annually.

The advantages of cold rolling

Cold rolled products have the following advantages over hot rolled:

- greater dimensional accuracy
- hardness improved by up to 20%
- increased yield strength
- increased tensile strength
- improved surface finish
- improved straightness

Cold rolled metal properties

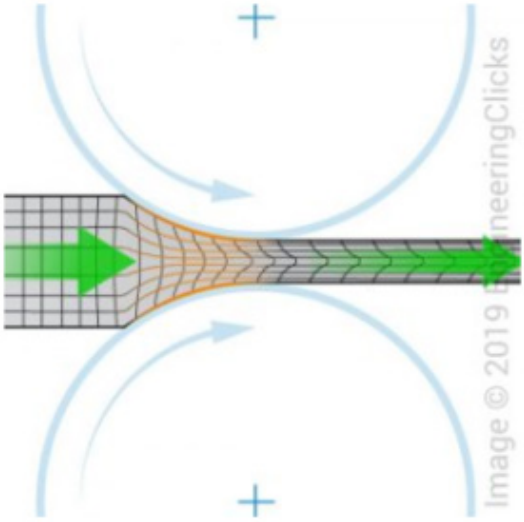
The result of cold rolling, i.e., increased hardness, is sometimes referred to as temper, but this is not to be confused with the heat treatment process known as tempering.

The amount of cold rolling that is performed on a sheet of metal determines the name given to the stock.

Full hard, half hard and quarter hard stock are terms used to describe to metals that have a reduction in depth of up to 50% after rolling. As a result, the yield point increases and ductility reduces. The grain orientation is also altered.

Skin-rolled metal is only reduced by up to 1%, and it may be necessary to smooth the surface to prevent wrinkling. The metal increases in ductility, making it ideal for stretching later.

Another main benefit of cold rolling is that finish material can be bent relatively easily. Full hard metal bends to a maximum of 45°, half hard to 90°, and quarter hard can bend right back on itself. The fact that the materials do not fracture make it useful for many applications that require bending and shaping of the material.



Adjustment of the grain structure during the process

Conclusion

Cold rolling is a process that occurs after hot rolling in order to reduce the thickness, increase the yield and tensile strength and pliability of metal. It is a relatively expensive and labour-intensive process, but the improved mechanical properties increase the value of the finished product, whether that is a sheet, strip, or coil.

What Is Friction Stir Welding and How Have SpaceX Embraced It?

Friction Stir Welding (FSW) is a process of solid-state joining of two metals with a rotating tool (without melting the workpiece material). Friction Stir Welding uses friction, just like you when rub your hands together on a cold day to warm them.

Here's an example of how it works: two aluminium alloy plates clamped together tightly in a machine. A metal tool resembling a drill bit is inserted in between the plates. The tool spinsas it travels along both edges.

The friction created by the spinning tool heats the atoms in the solid metal, making them move around (or diffuse). The metals become deformed and atoms from both plates are bonded together, without any melting. In a matter of minutes, the aluminium plates have been welded together and are cool enough to touch. The bond created by Friction Stir Welding is almost perfectly smooth and as strong as original aluminium plates.

> **"Friction between the tool and the work piece creates the heat, which then allows the material to become softer and become more plastic. So, the plasticized material moves around."**
>
> **Rajiv Mishra, University of North Texas**

In recent years, the field of engineering has experienced a wide variety of innovations that have led to novel manufacturing methods that are much more efficient regarding energy consumption and performance than conventional means.

Arguably, the professionals most affected by such developments are design engineers; the very people who are responsible for the design and fabrication of every complex device and structure we see and use in our daily lives.

Friction Stir Welding 20mm Copper DHP using MegaStir designed pin tool (Densimet). 250 RPM traveling at 6 ipm.

With design engineers always deeply concerned about the optimal utilisation of material and financial resources, and the overall quality of their inventions, such engineering innovations are always just around the corner.

This means that professional engineers continuously need to update themselves regarding recent developments in their field, in order to achieve perfection in their projects and stay up to the mark.

This article explores a mechanical welding technique that has gained significant popularity in modern times and discusses how engineers at Elon Musk's aerospace manufacturing company, SpaceX, have put it to use in their recently launched Falcon Heavy rocket.

How does friction stir welding work?

Friction Stir Welding (FSW) is a welding technique developed by The Welding Institute Ltd. back in 1991. Although it was invented more than 25 years ago, it has seen a swift rise in demand in the last few years, particularly owing to the increased demand of higher strength and durability requirements in modern engineering applications.

It boasts a distinct method of fusing metals into each other which is significantly different from traditional techniques such as arc welding or gas welding. Its uniqueness lies in the fact that it is a solid-state welding method, which means that neither of the materials being joined together are melted.

Instead, they are merely softened to the point where they can penetrate each other's surfacewith a little assistance. This technique yields extraordinary mechanical properties like fatigue strength and stiffness, and minimal defects in the weld region.

Moreover, this welding method also involves less wastage of material and a better appearance, which means lower surface finishing requirements. Finally, one of the most praised advantages is that it has no adverse effects on the environment, as no toxic fumes are produced in the whole process.

How is friction stir welding performed?

FSW is performed with the help of:

- a profiled welding tool
- a clamp to hold the workpieces together
- a mechanical setup to guide the tool along the joint line.

These components work in conjunction with each other to create the weld joint.

The tool is quite similar to a milling cutter in shape, which rotates throughout the machining process and is movable along the workpiece surface. The tool is practically pushed into the joint line surface initially and then traversed along the joint line periphery by the welding machine. The friction between this non-wear tool and the workpiece produces heat, raising the temperatures of the metals in the vicinity of the joint line.

A profiled probe placed at the very end of the tool is shaped in a way that it forces metals on both sides of the joint line into each other. Since they have been softened considerably due to the heat generated in the process at this point, they merge easily.

FSW is a solid-state process which produces welds of high quality in difficult-to-weld materials such as aluminium, and is fast becoming the process of choice for manufacturing lightweight transport structures such as boats, trains and aeroplanes.

Friction Stir Welding and SpaceX's Falcon Heavy

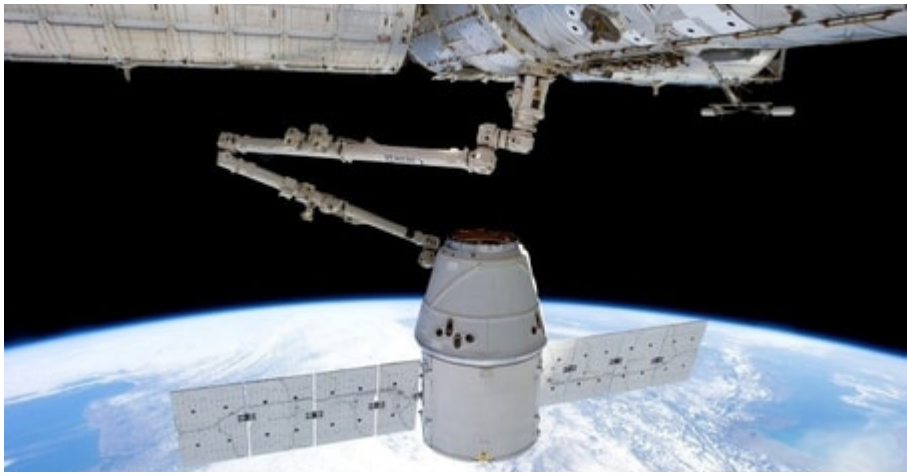
Owing to the superior qualities of this technique, it has particular relevance in applications requiring high strength properties and intense working conditions. The aerospace industry is one such example, with modern space vehicles being built to withstand unfathomable forces and temperatures.

SpaceX, the aerospace manufacturing company headed up by Elon Musk, has recently launched its Falcon Heavy rocket into space with a Tesla Roadster as the payload. This rocket is the fourth-highest of all rockets built up until now in terms of load-carrying capacity, and it featured the use of friction stir welding. This fact highlights FSW's importance in the aerospace industry and its possible usage in future engineering applications.

Design engineers at SpaceX used FSW to join the break-off fuel tanks of their rocket, which play a crucial role in the propelling of the spacecraft once it is in space and settled in its orbit. The reason for this application was obviously the need of exceptional strength in break-off fuel tanks of a rocket this powerful, which cannot be met by conventional means such as liquid-state welding or non-permanent joints like rivets.

Final Thoughts

Summing up everything discussed above, it is safe to say that the future of welding lies in the use of novel techniques like FSW that are more efficient, less costly, and environmentally friendly. It is a prime choice for design engineers who are looking for permanent joining techniques with results better than the ones being used currently.



EDM Machine – types & working principles

- Learn everything you ever needed to know about Electrical Discharge Machining (EDM), and the types of machines used for this unique manufacturing process.
- Read on if you'd like to understand more about a wire EDM machine, a Die Sinker or Ram EDM machine, and a hole drilling EDM machine.
- We'll also show you a list of some modern EDM machines available on the market today along with their key features.
- If you want to learn more about how EDM can be used for your applications, then you don't want to miss this article.

EDM stands for Electrical Discharge Machining. An EDM machine is the piece of equipment used to carry out this manufacturing process.

The principle behind EDM was first observed in 1770 by Joseph Priestley, who was experimenting with electrical discharges. He noticed that the sparks had eroded some of the electrode material.

Almost 200 years later in 1940's Soviet Russia, two scientists Butinzky and Lazarenko took things a step further towards a modern EDM machine by creating a machining process.

The EDM process

The theory behind EDM is simple. An electric spark is made between an electrode and the workpiece. As a spark creates intense heat, in the range of 8,000 to 12,000° C, it melts virtually any surface it comes into contact with.

In the machining process, the spark is controlled very carefully and is highly focused on a certain area making sure that only the surface of the desired material is affected.

EDM will not affect any heat treatment that has been applied to the material.

There are many different specialised types of EDM machine, but they generally fall into three separate categories:

- Wire EDM
- Die sinker or ram EDM
- Hole drilling EDM machines

In this guide we'll look at the workings of each one individually with some examples towards the end.

Wire EDM in process

Wire EDM machine

A wire EDM machine works in a similar way to a cheese cutter or a bandsaw cutting wood, although the wire moves rather than the workpiece. A metallic wire (usually brass or copper) has high voltage electrical discharges passed through it that allows it to cut through the entire thickness of the material. Cutting will either take place from the edge, or a hole will be drilled in the piece to pass the wire through if sections are to be cut out from the interior.

Wire EDM creates a spark in deionised water, in which conductivity is highly controlled. The deionised water cools the material and washes away the removed particles. Clean dielectric fluid is continually pumped in to flush away debris.

The wire is adjustable and can be inclined to create a taper or to shape a different profile on the edges. The electrical discharges make lots of little craters in the material, and the electrode and workpiece never come into physical contact. Usually, a single cut will be passed right through a solid section, and a scrap piece will drop off when complete.

If accuracy and smoothness are important factors, it may be necessary to skim the rough edges. A skim cut involves passing the wire close to the roughed surface, this time with reduced power, removing as much as 0.002” of surface imperfections on each pass, similar to sanding wood with a very fine grade sandpaper.

Die sinker or ram EDM machine

This type of EDM machine is used to create cavities in a workpiece, which is useful in the manufacture of tools and dies, metal stamping dies, and various plastic moulds, for example.

To bore the cavity, an electrode made from conductive graphite is shaped to form the required cavity and is plunged or ‘rammed’ into the object. This creates complex, 3-D cavities, but is expensive to produce and perform as the electrode has to be carefully machined, electrode wear is hard to control, and there may be problems flushing out debris from the cut.

Hole drilling EDM machine

The simplest way to drill a hole with EDM is to traditionally drill a tiny pilot hole into the workpiece before use. An EDM wire is then threaded through and used to widen the hole to the required diameter.

If a pilot hole isn't possible, a different type of EDM machine that 'drills' holes, sometimes known as a 'hole popper' can be used. This has a rotating electrode which cuts into the material while flushing it continuously with dielectric.

The 'hole popper' machine is commonly used to make a small pilot hole allowing a wire EDM to be threaded which is used to expand the hole. The advantage of this method is that very precise holes can be made in tough materials. For instance, jet engine turbines have been drilled using this process.

Typical EDM machines

Here is a brief list of some of the various EDM machines that are commonly used in manufacturing facilities today:

CUT 2000S

This is a state of the art easy threading wire EDM that features an in-built measurement device and automatic tool changing. It reduces machining by up to 30% and creates very smooth finishes.

Makino's EDNC85 Ram EDM

This ram EDM machine is very durable and hardwearing, featuring a simple programming interface and highly accurate results, even for large objects. It also has adaptive controls and automated tool changing.

Makino's EDNC85 Ram EDM

Sodick AP250L wire EDM

The Sodick AP250L is specially designed to eliminate backlash, meaning more precise movement. It also boasts high processing speeds.

AU-1440iA Z800 Submerged Wire EDM

This model boasts automated wire threading without having to drain the dielectric. In other words, the workpiece can remain submerged at all times, even if the wire breaks. This is ideal for speeding up the cutting process when multiple pieces are being machined, and tool wear is likely to be high.

Materials

Which Metals Are Commonly Used for Surgical Instruments?

There are many different considerations when choosing a material to use in the medical industry. After all, the wrong material choice could lead to disastrous consequences. In this article, we take a look at which metals are used for surgical instruments, and why.

The most common metals used for surgical instruments are:

- Stainless steel
- Titanium
- Tantalum
- Platinium
- Palladium

Read on to learn why these metals were chosen. The metals used for surgical instruments have to adhere to strict criteria.

Firstly, the metal must be relatively malleable so it can be shaped without causing flaws, but not too malleable as it needs to hold its shape once manufactured. Depending on the instrument, the metal used may also need to be fairly ductile, as many surgical instruments are long and thin, e.g. scalpels, forceps, scissors, etc.

The surface of the metal needs to be tough and needs to have a satin finish, so the instruments are easy to clean and won't harbour bacteria, helping to

prevent the spread of infection. Finally, the metal needs to be inert with the human body, so it won't cause any metal contamination when used internally.

When it comes to biomedical instruments, not all metals are up to the job, especially base metals. In fact, most surgical instruments are made from metal alloys. Stainless steel has traditionally been the metal alloy of choice, but there are alternatives when necessary.

Stainless steel grades for surgical instruments

Stainless steel (sometimes referred to as inox steel) is one of the most commonly used metal alloys in the manufacture of surgical implements.

Austenitic 316 (AISI 316L) steel is a type of stainless steel used often, and is referred to as "surgical steel". This is because it is a tough metal that is very resistant to corrosion. It is also used frequently in the chemical industry.

AISI 301 is the most commonly used metal for manufacturing springs which are useful in medical instruments. It gains mechanical strength when cold-worked, but loses corrosion resistance.

Stainless steel can withstand temperatures as high as 400°C, meaning it can be sterilisedeasily in an autoclave at 180°C. It also has the benefit of being almost as tough and hard-wearing as carbon steel.

Interested in stainless steel? Then read this article – everything about stainless steel, its composition, categories, and applications.

Titanium in surgical tools

Titanium alloy has only recently started being used as a material for surgical instruments, taking off in the 1960s.

The most obvious benefit of titanium is its superior strength. Its tensile strength is almost the same as carbon steel and it is 100% corrosion resistant. Despite its overall strength, it is more flexible than stainless steel and is approximately 40% lighter.

"Read more about technologies and materials enabling surgical tools and biomedical implants. The article is written by an expert in the field – the Doctor of Medicine, Hugo Herrero Antón de Vez."

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Titanium is perfect for both surgical instruments and implants, as it is biocompatible and has the intrinsic quality that it fuses well with human bones. For this reason, it has become the metal of choice for orthopaedic rods, pins, plates, and dental implants.

Titanium is more resistant to heat than stainless steel, withstanding up to 430°C, and it expands and contracts less when heated and cooled.

Depending on the properties required for the instrument, Titanium Grade 1 or 2 can be machined, welded, and hot or cold-worked quite easily, so it is a versatile metal too.

Overall, titanium is a tough, durable metal that has become a common material used for all kinds of medical purposes.

Tantalum in orthopaedics

Tantalum, a refractory metal, is strong, ductile and has a very high melting point (3017°C). But for the medical industry, its most attractive benefit is its high biocompatibility.

The metal is immune to bodily fluids, and also highly corrosion-resistant, so it can be used in surgery without causing adverse effects. For the same reasons, it's also used for implants and bone replacement material in prostheses.

Its ductility is also an attractive property, as it can be drawn into thin wire, while its malleability allows it to be easily fabricated into various shapes.

Platinum and palladium in medicine

Although platinum and palladium are expensive precious metals, they have similar properties that make them uniquely suited to certain surgical applications.

Firstly, they can both be easily formed into variety of shapes as they are highly malleable and ductile, meaning you can easily make rolls, sheets, tubes, wires, etc. They are especially useful for intricate parts, ideal for precision surgical instruments.

Both platinum and palladium are highly corrosion resistant and inert, so they won't cause problems when in contact with the body or internal organs.

One of the major uses in recent years has been creating ultra-thin wires that surgeons use to guide and position implants such as catheters and stents.

Another advantage is that both platinum and palladium show up very clearly on X-ray making them ideal to be used as markers on implants.

They are both strong, durable metals. The only real differences between the two are density, mass, melting points, and price, with palladium being the cheaper of the two.

Surgical instrument metals

Hopefully, this article has given you some idea of the different types of metal used to make surgical instruments and their properties.

As you have seen, the different varieties of stainless steel are the most popular as they are relatively cheap, plentiful, and practical for most applications.

Titanium is the next most common, as it has additional strength and is ideal for orthopaedic implants due to the fact it fuses easily with bone.

Tantalum's properties make it an ideal choice to use in surgical instruments.

Finally, there are the precious metals, platinum, and palladium. These are the most expensive, which is why they are rarely used in a medical setting, but they are ideal for small, precision implements and parts.

Polyamide Nylon: Properties, Production and Applications

Nylon is the commercial name for a type of polyamide thermoplastic. It was first developed by DuPont engineers in the mid-1930s and has since been used in almost every industry. Polyamide nylon has a wide range of uses including rope, gears and even stockings. It is usually formed into fibres for use in microfilaments and yarns but can also be cast.

General properties of polyamide nylon

Polyamide nylon has various advantages that make it an ideal candidate for a large range of applications. You'll find the key advantages and disadvantages of the material listed below.

Advantages

- **High Abrasion Resistance** – Higher levels of resistance to wear by mechanical action
- **Good Thermal Resistance** – Special grades of nylon can have a melting point of almost 300°C
- **Good Fatigue Resistance** – This makes it ideal for components in constant cyclic motion like gears
- **High Machineability** – Cast billets can be machined into various components that would be too costly to cast into intricate shapes
- **Noise Dampening** – Nylon is a very effective noise dampener

Disadvantages

- **Water Absorption** – Water absorbed results in lower mechanical properties. Nylon 6/12 is specially formulated to resist moisture absorption
- **Chemical Resistance** – Nylon has low resistance to strong bases and acids
- **High Shrinkage** – High percentages of shrinkage in cast applications

The table below indicates some of the main nylon grades used in industry.

Property	Unit	Nylon 6	Nylon 66	Nylon 11	Nylon 12	Nylon 46
Density	g/cm3	1.13	1.14	1.04	1.02	1.18
Tensile Strength	MPa	83	80	48	66	100
Water Absorption	%	1.2	1.6	1.9	0.7	3.7
Tensile Strain @ break	%	100	-	49	51	40
Melting Temperature	°C	220	255	190	184	295
Glass Transition Temperature	°C	47	70	42	97	80
Shore Hardness	D	85	88	71	75	85
Coefficient of Friction	-	1.4	0.55	0.36	0.38	0.45

Types of polyamide nylon and their applications

Nylon comes in four main grades of polyamide nylon: nylon 66, 11, 12 and 46. These names come from the length of their polymeric chains. The first number is the number of carbon atoms in the diamine and the second the number of carbon atoms in the acid. Typical applications include:

- Toothbrushes
- Wear pads
- Wheels
- Gloves
- Guitar strings and pics
- Tennis racket strings
- Medical implants
- Electrical connectors
- Fishing line
- Tents
- Gears

Nylon 6

Nylon 6 was developed in an attempt to reproduce the properties of nylon 66 without violating the patent. This grade of nylon is very tough and has high tensile strength. It must be noted that nylon 6 is produced by a unique process called ring-opening polymerisation.

Nylon 66

Nylon 66 is similar to Nylon 6 but has a higher melting point and is more resistant to acids. It is made from two monomers, while Nylon 6 is made from only one.

Nylon 11

Nylon 11 has increased resistance to dimensional changes due to moisture absorption. This is due in part to the lower concentration of amides. It must be noted that it generally has less desirable mechanical properties that other nylon grades.

Nylon 12

This nylon compound has the lowest melting point of the main polyamides. It is typically used as a flexible film or sheet to cover food and pharmaceuticals. It also has relatively good resistance to water absorption.

Nylon 46

Nylon 46 was primarily developed to have a higher operating temperature than other grades of nylon.

Production and processing

Polyamides are typically made by combining two monomers namely, adipic acid with 1,6-diaminohexane. Once these two monomers have reacted together they form water as a by-product of each polymer chain linkage. This linking of the two monomers is known as polymerisation. This creates a nylon salt which is then heated to evaporate the water. This heating is done inside an autoclave at 280C and 18 Bar. After the polymerisation process, various additives and pigments are added. These additives can change the physical properties of the polymer.

After the additives are added, the molten polyamide nylon is extruded through holes to form long

laces of nylon. These laces are extruded into a water bath which allows the laces to cool and solidify. Thereafter they are cut into granules with a length of 3 to 4 millimetres. These granules are then packaged and shipped to processing plants where they are re-melted and extruded through dies to create fibres and various extruded shapes or castings.

Nylons are manufactured either as casts or extrusions. There are differences in properties, however some of the key benefits of cast nylon are listed below.

- Less internal stresses
- Lower water absorption
- More crystalline structure resulting in higher mechanical strength
- Higher melting temperature

Boron Nitride: Properties, Production and Applications

Boron nitride (BN) is a heat and chemical resistant crystalline compound with refractory properties composed of boron and nitride. Because it exists in multiple polymorphs, BN has evolved as a highly useful compound, finding its purpose in a wide range of industries and applications.

Here, you will learn about:

- The properties of Boron nitride
- The production process and forms of Boron nitride
- The applications of Boron nitride

Boron nitride properties

The substance is composed of hexagonal structures that appear in crystalline form and is usually compared to graphite. It may come in the form of a flat lattice or a cubic structure, both of which retain the chemical and heat resistance that boron nitride is known for.

- **Heat and chemical resistance**: The compound has a melting point of 2,973°C and a thermal expansion coefficient significantly above that of diamond. Its hexagonal form resists decomposition even when exposed to 1000°C in ambient air. Boron nitride doesn't dissolve in common acids.
- **Thermal conductivity:** At 1700 to 2000 W/mK, boron nitride has a thermal conductivity that is comparable with that of graphene, a similarly hexagon-latticed compound but made up of carbon atoms.
- **Lubricating property:** Boron nitride has the ability to boost the coefficient of friction of lubricating oil, while reducing the potential for wear.
- **Density:** Depending on its form, its density ranges from 2.1 to 3.5 g/cm3.

Production and processing

Boron nitride is synthesized via the reaction of a boron precursor (either boric acid or boron trioxide) with a nitrogen-containing reagent (urea or ammonia) under a nitrogen atmosphere.

This reaction yields amorphous boron nitride containing trace amounts of boron trioxide impurities, which may be further purified by evaporation via heating above 1500°C.

The versatility of boron nitride as a compound is evident in the number of forms and polymorphs that occur in the real world:

Forms of boron nitride

Hexagonal

This form of boron nitride has the highest number of applications, because of its high lubricating property, electrical conductivity, and thermal stability.

Cubic

The cubic form of BN possesses significantly high electrical resistivity and thermal conductivity like diamond. It doesn't dissolve in steel components, thereby making it a good abrasive material.

Amorphous

The non-crystalline form of boron nitride is comparable to amorphous carbon in terms of structure and properties.

Atomically thin

Despite its ultra-thin property, this BN polymorph is characterised by high thermal conductivity, increased surface adsorption, and good dielectric properties.

Nanotube

As one of the rising developments in recent times, nanotube technology has been given a boost with the use of boron nitride. This rolled-up form of hexagonal BN is similar to carbon nanotubes in terms of structure. However, BN nanotubes have higher electrical insulation as well as better resistance to heat and chemical reactions.

Applications of boron nitride

Lubricant

The hexagonal form of boron nitride is used as lubricant for paints, cosmetics, pencil lead, and cement for dental applications. Its lubricating property occurs even in the absence of gas or water molecules within the compound layers, thereby making it a good component for vacuum systems.

Compared to graphite, BN has significantly better chemical stability and electrical conductivity.

Equipment in high-heat environments

Its exceptional resistance to heat lends the compound to a wide variety of applications involving extremely high temperatures. Hexagonal boron nitride is being used to improve the lubricating properties of rubber, plastic, alloys, and ceramics.

In the case of plastics, inclusion of a BN component provides lower thermal expansion. It may also be integrated into semiconductor substrates and microwave oven windows.

Boron nitride is an effective component of reaction vessels and crucibles because of its thermochemical properties.

Semiconductor industry

With a bandgap ranging from 4.5 to 6.4 eV, boron nitride is an excellent wide-gap semiconductor material. Its intrinsic thermal and dielectric properties make it a suitable substrate in developing metal-oxide-semiconductor field-effect transistors (MOSFETs) and semiconductors.

Abrasive and cutting implements

Due to the physical properties of cubic boron nitride, this polymorph is used as abrasive material for nickel, iron, and selected alloys in conditions where diamond was not found to be suitable (such as under extreme heat). Its cubic BN form is incorporated in cutting-tool bits and grinding equipment.

Polymers: Properties, Processing and Applications

Thermoplastics and thermosetting polymers are types of plastic that undergo different production processes and yield a variety of properties depending on the constituent materials and production method.

The main physical difference is how they respond to high temperatures. When heated to their melting point, thermoplastics soften into a liquid form. Therefore, the curing process is reversible, which means that they can be remoulded and recycled. On the other hand, thermoset polymers form a cross-linked structure during the curing process, preventing them from being melted and remolded.

Think of Thermosets like concrete, once they have set you can never go back to the liquid form (irreversible process). While Thermoplastics are like water, they can transition between ice and water with the application or removal of heat (reversible process).

Properties of thermoplastics and thermosetting polymers

Thermoplastics generally provide high-strength, flexibility and are resistant to shrinkage, depending on the type of resin (the polymer in melted liquid form). They are versatile materials that can be used for anything from plastic carrier bags to high-stress bearings and precision mechanical parts.

Thermosetting polymers generally yield higher chemical and heat resistance, as well as a stronger structure that does not deform easily.

Property	Thermoplastics	Thermosetting Polymers
Molecular structure	Weak molecular bonds in a straight-chain formation	Strong chemical molecular bonds that are cross-linked
Melting point	Melting point lower than the degradation temperature	Melting point higher than the degradation temperature
Mechanical	Flexible and elastic. High resistance to impact (10x thermosets)	Inelastic and brittle.
Polymerisation	Repolymerized during manufacture (before processing)	Polymerized during processing
Microstructure	Comprised of hard crystalline and elastic amorphous regions in its solid state	Polymerized during processing
Recyclability	Recyclable and reusable	Non-recyclable

Chemical resistance	Highly chemical resistant	Heat and chemical resistant
Crack repair	Cracks can be repaired easily	Difficult to repair cracks

Processing of thermoplastics and thermosetting polymers

Thermoplastic processing

Thermoplastics can be processed in a variety of methods including extrusion moulding, injection moulding, thermoforming and vacuum forming.

Granular material is fed into the mould, usually in the form of spherical granules of approximately 3 mm diameter. These granules are then heated to melting point, which requires very high temperatures.

As thermoplastics are highly efficient thermal insulators, cooling during the curing process takes longer than other plastics. Therefore, rapid cooling is undertaken to achieve a high output rate, usually by spraying with cold water or plunging into water baths. To cool thermosplastic plastic films, cold air is blown onto the surface. The plastic shrinks upon cooling, varying between a shrinkage rate of 0.6% to 4% depending on the material. The rate of cooling and shrinkage has a distinct effect on the crystallisation of the material and internal structure, which is why the shrinkage rate is always specified for thermoplastics.

Thermosetting polymer processing

Thermosetting resins are processed in their liquid form under heat. The curing process involves adding curing agents, inhibitors, hardeners or plasticisers to the resin and reinforcement or fillers, depending on the required outcome.

The most commonly used thermosetting resins include:

- Epoxy
- Polyester
- Phenolic
- Silicone
- Polyurethane
- Polyamide

Thermosetting polymer composites processing

Thermosetting polymer composites are made using a laminating process, which binds together resins such as epoxy, silicone, melamine, etc. with reinforcement base materials such as glass, linen and graphite.

Prior to curing, the reinforcement substrate is dipped into the resin binder in its liquified form. Once bound, the sheets of material are passed through an oven to partially cure them. Several sheets are then piled to the required thickness, heated and pressed together to form a laminate. Alternatively, the sheets may be wrapped together and heated to create rods.

Materials and applications

Types of thermoplastics and their applications

Polyamide (nylon) – Tough and relatively hard material used for power tool casings , curtain rails, bearings, gear components and clothes.

Polymethyl Methacrylate (PMMA, acrylic) – Stiff, durable and hard plastic that polishes to a sheen, used for signage, aircraft fuselage, windows, bathroom sinks and bathtubs.

Polyvinyl Chloride (PVC) – Tough and durable material that is commonly used for pipes, flooring, cabinets, toys and general household and industrial fittings.

Polypropylene – Light, yet hard material that scratches fairly easily, with excellent chemical resistance, used for medical and laboratory equipment, string, rope and kitchen utensils.

Polystyrene (PS) – Light, stiff, hard, brittle, waterproof material used mainly for rigid packaging.

Polytetrafluoroethylene (PTFE, Teflon) – Very strong and flexible material used for non-stick cooking utensils, machine components, gears and gaskets.

Low-density Polythene (LDPE) – Tough, relatively soft, chemical resistant material used for packaging, toys, plastic bags and film wrap.

High-density Polythene (HDPE) – Stiff, hard, chemical resistant material used for plastic bottles and casing for household goods.

Types of thermosetting polymers and their applications

Epoxy resin – Hard material that is brittle without extra reinforcement. Used for adhesives and bonding of materials.

Melamine formaldehyde – Hard, stiff and strong, with decent chemical and water resistance, used for work surface laminates, tableware and electrical insulation.

Polyester resin – Hard, stiff and brittle when unlaminated. Used for encapsulation, bonding and casting.

Urea formaldehyde – Hard, stiff, strong and brittle used primarily in electrical devices due to its good electrical insulation properties.

Polyurethane – Hard, strong and durable material used in paint, insulating foam, shoes, car parts, adhesives and sealants.

Phenol formaldehyde resin (PF) – Strong, heat and electrical-resistant material used in electrical items, sockets and plugs, car parts, cookware and precision-made industrial parts.

Using Ceramics in Exhaust Systems to Purify Emissions

Governing bodies around the world are introducing increasingly stringent emission regulations. This has led to a push to develop ever more efficient filters, especially for diesel exhaust systems.

Ceramics in exhaust systems offer a highly effective way to purify vehicle emissions, improving air quality and making urban environments cleaner places to live. Ceramic Diesel Particulate Filters (DPF) are particularly effective, with some removing nearly 100% of soot from the exhaust emissions.

Today, DPF systems are being fitted as standard on many diesel vehicles, especially large trucks, coaches and heavy machinery. To work on the road, they are designed to be highly durable and easy to maintain.

Types of Ceramic Used in Diesel Exhaust Systems

Ceramic isn't the only material used in exhaust filters. Paper and metal fibres can also be used to filter diesel particles. However, ceramic filters keep costs low, are easy to mass produce, are extremely durable, and provide fine filtration of particles. The following types of ceramic have become commonplace in DPF systems:

Cordierite

Cordierite is the most common ceramic used in wall-flow filters. Wall-flow filters force gas to flow directly through the filter, unlike flow-through filters such as catalytic converters.

Cordierite is an ideal material for DPFs as it filters out a very high percentage of particles and is fairly cheap.

The only downside of using cordierite ceramic is that it can melt if the filter is being regenerated – a maintenance process that involves burning off filtrate material to clean it. The risk of damaging the ceramic is especially high if there has been a large accumulation of soot and particles. Therefore cordierite filters often need a catalyst to lower the regeneration temperature.

The structure of the filter is similar to the honeycomb core of a catalytic converter, but the DPF has

plugged channels, meaning the gas is forced through the wall and the filtrate is collected on the inlet face.

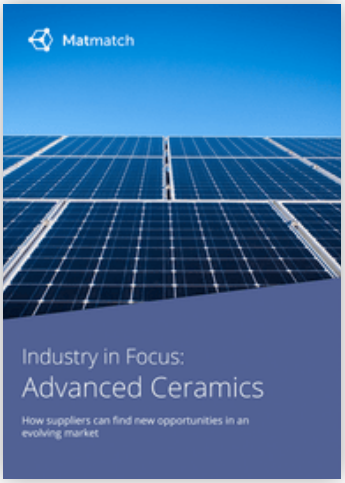
Silicon Carbide

Silicon carbide is a ceramic that is also used in wall-flow filters. Silicon carbide filters aren't as popular as cordierite ones, for the simple reason that they are more expensive. The reason for the added cost is that they are not thermally stable, so cement has to separate the filter cores to protect them from heat expansion.

Silicon carbide DPFs work on the same principle as the cordierite filters. The efficiency of these types of filter can be as high as 95%. Silicon carbide also has a high melting point of 2700oC.

In this white paper, we look at some interesting opportunities for advanced ceramics suppliers, including new markets and applications for piezoelectric devices, smart factories of the future and current industry trends. Download now.

Ceramic Fibres



Ceramic fibre filters contain different types of fibrous ceramic that are entwined, creating a porous material. The fibrous material is easily shaped and can be used in DPFs of various shapes and sizes.

Depending on the density of the ceramic fibres, the porosity can vary, which affects the efficiency of the filter. The main benefit of ceramic fibre filters is that they have a reduced back pressure compared to other wall-flow filters.

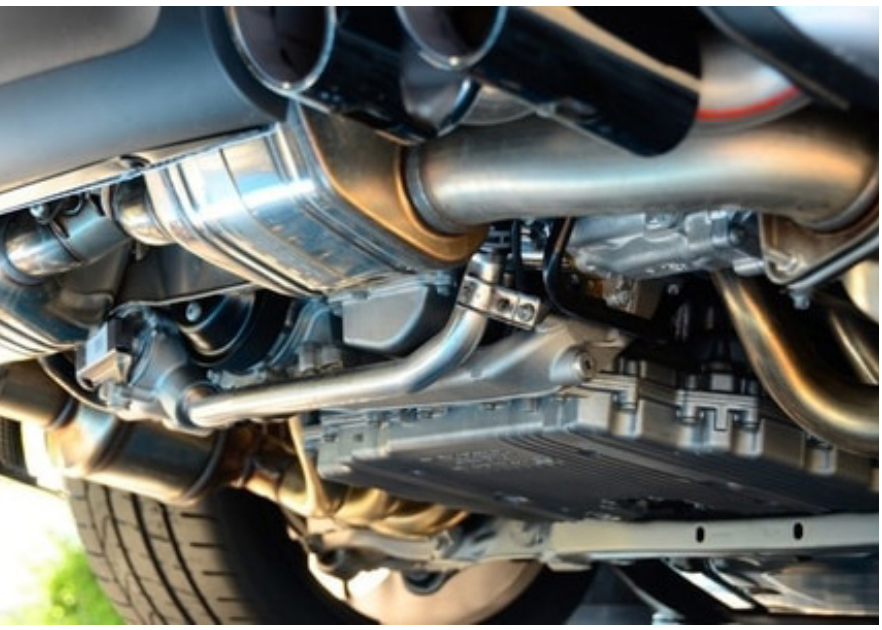
Ceramic wall-flow filters remove most carbon particles and other fine particulates that have diameters smaller than 100nm (nanometres).

Benefits of Using Ceramics in Diesel Particulate Filters

The main benefits of using ceramics are:

Efficient particle removal

Ceramic wall-flow filters remove most carbon particles and other fine particulates that have diameters smaller than 100nm (nanometres).



Low cost

Ceramics are relatively inexpensive compared to other filter materials such as metal fibres.

Easy maintenance

They are easily maintained through regeneration, thus giving them a longer lifecycle. A study carried out by The Engineering Society For Advancing Mobility – Land, Sea, Air, and Space cited easy maintenance as the main advantage of using ceramic filters.

Minimal back-pressure

Compared to other materials, ceramics such cordierite and silicon carbide create less of a pressure drop.

Regeneration of Diesel Particulate Filters

Ceramic filters need cleaning regularly to remove the build-up of soot. There are two ways to regenerate the filter:

- **Passive regeneration** – the exhaust system is warm enough to burn off the particles, or a catalyst is added to aid the removal.
- **Active regeneration** – very high temperatures are created in the exhaust system to burn off the filtrate.

These days, most diesel vehicles have a built-in filter management system that may use one or more of several regeneration techniques, including:

- Delayed fuel injection to increase the temperature of the exhaust system
- A catalyst that lowers the temperature at which the soot combusts
- An oxidiser catalyst that increases the temperature

- Microwave technology to raise the temperature of the filtrate
- Heater coils that raise the temperature

Summary

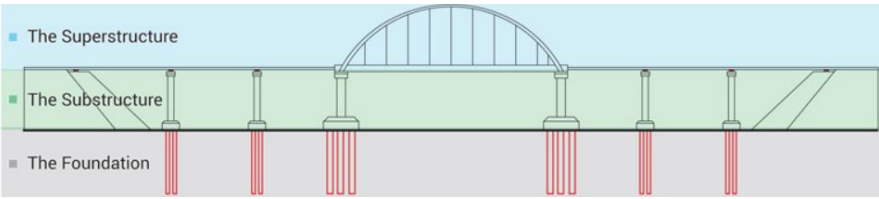
Ceramics are widely used in exhaust systems to filter out pollutants, especially in diesel particulate filters. Ceramic filters are low cost, easily manufactured, robust and long-lasting, making them ideal for use in road vehicles and plant machinery alike.

With recent developments in regeneration technology, ceramic filters are even easier to maintain and last longer than ever before.

Main Parts of a Bridge – Explained

- When you cross a bridge, do you ever stop to wonder how it's made?
- If you're curious about the main parts of a bridge and what their purpose is, you'll want to keep reading.
- This article looks at the foundation, substructure, and superstructure of a bridge, and the main components that make up each key area.

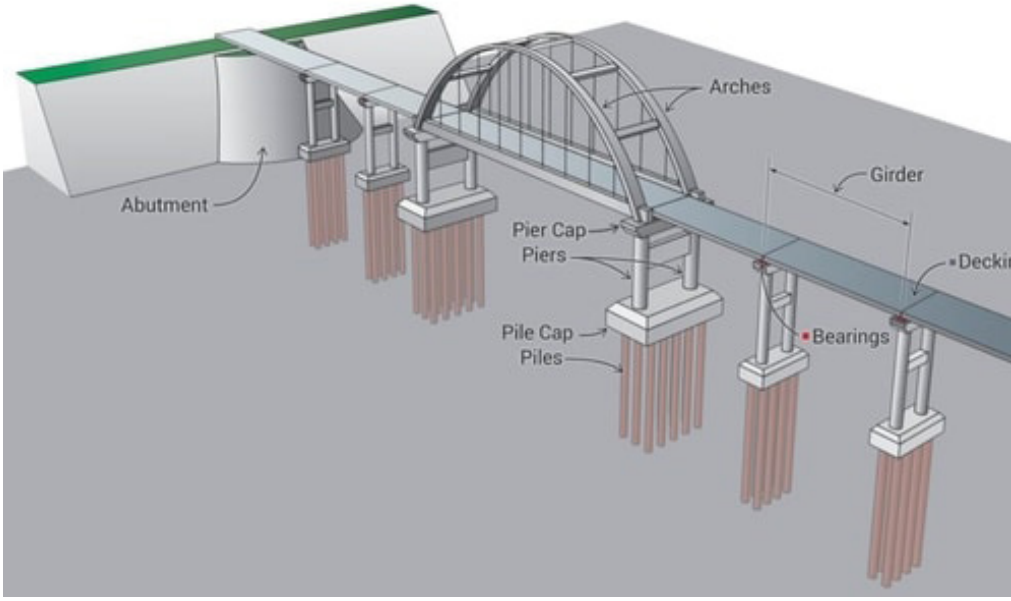
What are the main parts of a bridge? Many of us use bridges everyday, but have you ever stopped to consider what makes up the various parts of a bridge?



Main sections of a bridge © 2017 EngineeringClicks

Bridges are usually built when there is a need to cross over a road, railway, or water channel. Many large and small bridges have been built throughout history to cross over barriers and obstacles. The type of bridge that's built depends on the specific physical and design scope requirements. Hence, a bridge can be the smallest plank used to cross over a stream, or a large structural span built for traffic to travel over a wide river.

The main components of a bridge are the foundation, substructure, and the superstructure. Each of these core areas have other parts within them. Piles and pile caps are constructed as the foundation of the bridge. The sub-structure includes piers and abutments, while the superstructure includes the girders, bearings and deck.



Main sections of a bridge © 2017 EngineeringClicks

When building a bridge, the construction starts with laying the foundation. Then the sub-structure is made to give support for the heavy superstructure above it, which is actually used as the road or walkway

Main Parts of a bridge

Let's look at the main parts of a bridge in more detail and consider the components that make up the three core areas:

The Foundation

Piles: Piles are usually laid to give support to a bridge and make up the initial foundation. The piles help the weight and stresses applied by the bridge to be transmitted evenly through the ground making it stable and strong.

The material and design of a pile depend on several factors such as soil type, ground instability and load bearing capacity constraint. For bridges on rivers, scouring is also considered before the bridge is designed.

Caps: Caps provide additional load transferring capacity to the piles. They are also known as pile caps as they are placed right on top of the pile foundation. Caps are often made of very heavy concrete to give maximum strength to the upper part of the bridge.

Bents: When piles and caps are set together they are called bents. Multiple bents form the foundation for the substructure.

The Substructure

Abutments: Bridges have vertical supports at their approaching ends, functioning as retention walls for the ground. These are built from reinforced concrete and are capable of withstanding high levels of horizontal force.

Piers: When there are multiples spans in a bridge, then piers are mounted at the end of each to give sustenance from forces and vibrational effects, acting as supporting points for the bridge.

Pier Caps: Pier caps are also known as the headstock. This functions as a space for girders to transfer loads on bearings (that divide the load among all the piers), from the superstructure components on the top.

The Superstructure

Girders: Girders joins all the pile caps together by extending over them. Girders are also referred to as beams, and give support to the deck. This can be a single span, or even multiple spans joining all the bents, dependent on the length of the bridge. Girders usually have a truss design to improve stress and load resistibility. Hence, pressure is quickly passed towards the foundation. Girders are mostly made from metal or concrete.

Bearings: Bearings are structural members capable of transferring loads from the deck to the substructure. These displace stresses and load to the piers through the girders to allow movement between parts of a bridge. The movement can be linear as well as torsional. Bearings provide allowance between these parts.

Trusses: Trusses are made by joining triangular components to divide loads and bending moments through the bridge. Some types are simple trusses, suspension, and also cantilever trusses. The truss network provides a surface for transportation which can be built as a deck truss, pony truss, or through truss. Each truss differs in how the traffic will move on the bridge.

Decks: Decks get the direct traffic load. Some basic decks can be made of concrete and also from metal. These include travel or walking paths, drainage systems, curbs, expansion components, sidewalks and approach slabs.

Barriers: Mainly as a safety and protection feature, bridges have barriers on the sides of their decks. These can be specially designed fixtures, ropes, rails, fences, or concrete walls for better aesthetics.

Arches: A bridge with arches has a lot of strength. Arches can help control the safety and load bearing ability of the bridge. The quantity of arches and materials used for construction is very important. A space connecting the bridge pillars and deck beam is called the spandrel. There can be open or closed spandrels depending on the arch design.

Bridge Design

Bridges play a key role in transportation. As such, complex calculations and in-depth feasibility analysis are carried out before the design for a bridge is finalized. Aspects like the environment, load capacity, soil type and preservation, material, construction methodologies and techniques all need be taken into consideration when planning a bridge.

The Top Universities for Civil Engineering in Germany

Civil engineering is a branch of engineering that deals with the design and construction of large-scale structures like bridges and high-rise buildings. To work as a civil engineer, one must understand the basics of how static objects behave – in order to design buildings – as well as having a thorough grasp of the underlying forces inside structures like bridges and dams.

In Germany, civil engineering is called Bauingenieurwesen. Aspiring civil engineering students must complete three years of an undergraduate degree in engineering and then go through an accreditation process before they can use the professional title of an engineer legally. Below are the top ten civil engineering universities in Germany for those interested in becoming civil engineers.

1. Technical University of Munich

Established in 1868, the Technical University of Munich is a research university that is also one of the largest universities in the country. It has a noble history and has connections with 17 Nobel laureates. The university´s Department of Civil Engineering is home to numerous research institutions and laboratories, while the university has over 40,000 students from around the world.

To complete a civil engineering undergraduate degree here, one must go through three years of courses in which the fundamentals of natural and civil engineering sciences are taught. Upon the completion of an undergraduate program, the student can choose to complete a Master's program where they can specialize in a chosen field of civil engineering.

To apply to the Technical University of Munich, interested applicants must go online at the TUMonline portal. Once the online application form has been filled out, a paper application must be printed, signed, and mailed to the main enrolment office of the university before the application deadline.

2. Karlsruhe Institute of Technology

This is another large public research university in Germany and is the result of a 2009 merger

between The University of Karlsruhe and the Karlsruhe Research Center. It is one of the best universities in Europe for science, engineering, and technology. The university's civil engineering department is split into ten branches of civil engineering, which include the institute for structural analysis, the institute for concrete structures, the institute of mechanics, and the institute of transport studies.

The Bachelor's program at the Karlsruhe Institute of Technology is split into two parts. The first part of the program teaches the student the necessary scientific foundational knowledge to understand the problems faced in engineering work. The second part of the program teaches students the practical components of engineering work, such as relevant fieldwork. A Bachelor's thesis is also required from the student in order to graduate, which should be completed over a duration of three months.

3. Berlin Institute of Technology

The Berlin Institute of Technology, also known as the Technische Universität Berlin, was founded in 1879. It is one of the largest and most notable German institutes of technology and belongs to the prestigious TU9.

The school's civil engineering department offers a Bachelor's and a Master's degree in civil engineering. In fact, civil engineering students make up the largest group of students at the university. Students with both German educational certificates and foreign ones can apply to study here. The application process can be completed online on the TU Berlin website.

4. Technical University of Dresden

Located in the eastern German state of Saxony, the Technical University of Dresden is one of the top ten largest universities in Germany. The school was established in 1828 and is a member of TU9. The founding of the school is tied to the founding of the German empire, and as a result, many of the buildings on campus are over 100 years old.

The faculty of civil engineering at the Technical University of Dresden offers different types of civil engineering degrees to meet the needs of students. A diploma program is available for those not interested in obtaining the full degree. A distance-learning Bachelor's program is also available. Once admitted, the student will also complete eight weeks of practical work experience that is required for graduation.

5. Technische Universität Darmstadt

This is another TU9 university located in the south-eastern city of Darmstadt. It was established in 1877 and was one of the first universities in the world to have an electrical engineering department. In fact, Albert Einstein even recommended this university!

The civil engineering department at this university offers two majors, which are civil engineering and

geodesy. To obtain an undergraduate civil engineering degree, the student must complete general courses, specialized courses, optional generalized and specialized courses, and a Bachelor's thesis. Both German and international students can apply, with the application process being conducted online.

6. University of Stuttgart

The University of Stuttgart is one of the oldest TU9 universities in Germany and has the best engineering programs in various disciplines of engineering. The faculty of civil and environmental engineering is made up of 14 different institutes and employs over 400 people.

Students interested in studying at the University of Stuttgart can complete Bachelor's programs in German, and Master's programs in English. Specializations offered include computational mechanics, structural engineering, transportation systems, and water and the environment.

7. Ruhr University Bochum

The Ruhr University of Bochum was founded in 1962. The school's civil and environmental engineering department offers a Bachelor's and a Master's degree. The Bachelor's degree can be completed over six semesters while the Master's degree can be completed over four semesters.

Interested applicants can apply online with the deadlines being July 15th and January 15th. Once admitted, the student can take advantage of the school's many programs, research facilities, and workshops where they can learn to use engineering software such as Revit and LaTeX.

8. Technical University of Braunschweig

The Technical University of Braunschweig is another TU9 university, with a history that dates back to 1745. The university is known for its interdisciplinary research, and has a research focus on 'smart future' cities.

The civil engineering course at the University of Braunschweig is designed to meet both current and future demands in civil engineering knowledge. Both a Bachelor's and a Master's program is offered here, with the Bachelor's degree occupying six semesters. During the Master's degree, students can specialize in numerous subjects such as waste management, building materials, fire protection engineering, and more.

9. University of Duisburg-Essen

Founded in 1654, the University of Duisburg-Essen is home to 40,000 students and is one of the

top ten largest universities in Germany. The school's civil engineering department offers specialized studies in 14 different disciplines.

Interested applicants can apply to complete a Bachelor's or Master's program. Some subjects of civil engineering in which students can specialize include construction management, geotechnical engineering, concrete structures, mechanics, urban water and waste management.

Top US Civil Engineering Conferences in 2020

The civil engineering profession is dynamic; it continually changes and expands. Civil engineering conferences are great events to keep abreast of these changes, including learning the latest requirements, news, tools, and techniques. These gatherings are also good opportunities to meet professionals and share experiences with other civil engineers.

1. 2020 Construction Institute Summit

- February 20-22, 2020
- The Westin Los Angeles Airport Hotel
- Los Angeles, CA

With the theme of "Our Vision Is 20/20: Challenge the Past and ENGINEER TOMORROW", the 2020 Construction Institute Summit aims to provide comprehension on the latest strategies, techniques, and technologies that are being used by owners, engineers, and contractors in terms of managing risks for the successful delivery of projects.

It is spearheaded by the Construction Institute (CI) of the American Society of Civil Engineers (ASCE), the first national organization created to meet the needs of workers in the construction industry. CI has an active membership that offers both individuals and groups the opportunity to network with other professionals and enhance their skills. It offers technical activities, civil engineering conferences, and the development of internationally recognized standards.

Participants will be able to join industry experts and innovators in a wide range of discussions on finding solutions to top problems in the construction industry. They can also observe firsthand an overview of high-performance projects from the project teams' perspectives and

have the option to participate in insider tours. For potential participants, registration starts on November 6, 2019, and ends on January 15, 2020.

2. Structures Congress 2020

- April 5-8, 2020
- St. Louis Union Station Hotel
- St. Louis, MO

The Structures Congress 2020 is a conference offered by the Structural Engineering Institute (SEI) of the ASCE. The SEI is an organization established in October 1996 to serve the needs of the structural engineering community. It is committed to advancing and serving the structural engineering profession, while influencing change on issues faced by civil engineers.

The event aims to inspire, connect, and present knowledge from industry experts in structural engineering. Participants can also earn Professional Development Hours (PDHs) from sessions on buildings, bridges, natural disasters, seismic issues, risk management, and professional practice.

Attendees can gain knowledge on cutting-edge applications as well as visit the Exhibit Hall for the latest tools and resources that they can use in their job roles. Corporate sponsors include Autodesk, Computers and Structures, Inc., and UPS. Registration starts on October 28, 2019. There will also be onsite registration starting on March 5, 2020.

3. World Environmental and Water Resources Congress 2020

- May 17-21, 2020
- Green Valley Ranch Resort, Spa & Casino Hotel
- Henderson, NV

The 20th World Environmental and Water Resources Congress theme is “Be Smart and

Sustainable: Don't Gamble with your Infrastructure." The 4-day conference features 13 concurrent technical tracks. The Environmental & Water Resources Institute (EWRI) of ASCE is expecting approximately 1,200 leading engineers and scientists to join the discussions on the latest case studies, research, and best practices in water resource and environmental issues.

The EWRI was created in 1999 to serve as a technical source for issues related to the environment and water. Its members are professionals whose areas of focus are on the environment, surface water, groundwater, irrigation and drainage, hydraulics and waterways, and urban water sources, among others.

Participants will be able to attend technical workshops at no additional cost. They can also join in on the policy dialogue on water resource and environmental issues as well as learn about the latest trends and techniques in the industry. Aside from the opportunity to network and meet qualified potential employees, civil engineers attending the conference can earn up to 34.5 PDHs. The participants to the EWRI Congress can also join the Watershed Management Conference on May 20-21 in the same venue.

4. International Conference on Transportation and Development (ICTD 2020)

- May 26-29, 2020
- Hyatt Regency Seattle
- Seattle, WA

Another civil engineering event to look forward to is the International Conference on Transportation and Development. Its theme is "Showcasing Collaborative, Smart, and Integrated Mobility Solutions." It is organized to encourage the exchange of information among practitioners, researchers, public infrastructure owners, engineers, and planners.

The event is spearheaded by the Transportation & Development Institute (T&DI) of ASCE. The T&DI is one of the ASCE's specialty institutes with a focus on the transportation and development professionals and industry. Members of the organization help in the promotion of professional excellence in urban planning and development as well as transportation engineering.

Some of the topics to be discussed in the conference are transportation safety, freight and logistics, transportation economics and finance, rail and transport engineering, workforce and development, and airfield pavements. Advance registration for this civil engineering conference starts on December 18, 2019, and ends on May 1, 2020.

5. UESI 2020 Surveying & Geomatics Conference

- May 31 - June 2, 2020
- Doubletree Hilton Hotel & The Lawrenceburg Event Center
- Lawrenceburg, IN

The UESI 2020 Surveying & Geomatics Conference is a civil engineering showcase organized by the Utility Engineering & Surveying Institute (UESI) of ASCE. The organization is the global leader in the generation of products and services which promote and reward planning, operations, engineering, designing, asset management, and construction excellence. It was established in October 2015 and is the first national organization that meets the needs of professionals working within the pipeline, utility, and surveying industries.

The event's theme is on, "Surveying: The Road to Successful Engineering." The conference covers various topics like innovative technologies, integration of data for 3D modeling or 3D data fusion, risk in utility modeling, UAS in surveying, geomatics in climate changes, and geospatial technologies for smart cities. Participants will be able to get insights from professional surveyors, engineers, and academics who are practicing and researching professional geomatics and surveying.

Engineers joining this civil engineering conference will be able to earn up to 19 PDHs. Advance registration starts on January 15, 2020 and ends on May 29, 2020.

To find more upcoming research and academic conferences see the Conference Monkey Directory.

Engineering Careers / General Discussions

How to write an engineering motivation letter for a PhD

Ok, so the time has come to write your engineering PhD motivation letter. The cursor is blinking on the blank page. Your mind races. What do I write? How do I start? How do I phrase it? It can be a challenge, especially for us engineers who may not enjoy the written word as much as other academics do. But competition for some PhD places can be fierce, especially at good universities. Getting the motivation letter right is one of the most important parts of your application, so don't leave it until the last minute.

To help you out with what can be a stressful part of the application procedure, we've compiled a list of the essential components of an engineering motivation letter, including the structure, the format, and the nitty-gritty of the content.

Basic Structure and Style

The first thing to realise is there's a big difference between the PhD motivation letter you should write for universities in North America and European universities. Typically, American universities expect to hear more about your general life, whereas European ones prefer to keep things mainly focused on your academic and work achievements. As a general rule of thumb:

- **America** – 70% life skills, accomplishments, 30% academic/practical/work
- **Europe** – 30% life skills, accomplishments, 70% academic/practical/work

The format

Your letter should follow a standard formal letter format and should:

- be no more than 500 words (approx. one typed page of A4)

- be written in a clear font such as Arial or Calibri
- have a font size of 11 or 12
- consist of short easy-to-read and understand paragraphs
- use sub-headings and bullet points to break up the text
- be polite and formal, but not too wordy

Readability is a key factor in writing a successful motivation letter. Even though you're addressing academics, it's best to keep the language as simple as possible. Remember, this is a letter, not an essay. The professors may have to read dozens of these letters and want to find out about you as easily as possible, without having to wade through waffle, clichés or pompous-sounding sentences. Microsoft Word has a handy built-in readability checker (based on the Flesch-Kincaid test) and you want the "reading ease" score to be between 60 and 70 points to hit the right spot.

The structure

A recommended overall structure for the letter is as follows:

- A brief (1 or 2 sentences) introduction
- Your motivation for applying to do a PhD (personal statement)
- Your academic achievements and relevant life experiences
- The impact you hope to make with your research
- Your future career plans

Before we move on to looking at the actual content of your letter, just a quick note that should really go without saying – stick to the facts. Never be tempted to make things up or "embroider the truth". It's not only unethical but if you're accepted on the course and your dishonesty is revealed at a later date, you could waste all that time and effort, not to mention your reputation will be in tatters. It's not worth it.

Content of the Engineering Motivation Letter

Don't underestimate practical experience

Let's face it, engineering is a hands-on subject, no matter which branch you specialise in. The single biggest mistake that graduates make when applying for an engineering PhD, is focussing entirely on their academic achievements and neglecting any practical or "in-the-field" experience. Make a list of

any relevant work experience, field trips, projects, etc. Anything that had an engineering element to it can be included. A good tip is to go back as far as possible. Joined a robotics club in secondary school? Write it down. Helped a neighbour build their house extension? Write it down. Had a summer job with a construction company? You get the picture. Even if you decide not to use half of it, listing all of these things out will give you some ideas of relevant skills you can mention.

Be specific

Another mistake people commonly make is to list their skills without providing any evidence, or just generally making vague statements. Don't simply state: "I work well in a team". Give an example: "During my time at XYZ Construction Ltd, I worked closely with various team members to plan and build a gherkin-shaped tower block". Don't say: "I enjoyed my Environmental Engineering undergraduate degree". Be very specific about what you enjoyed: "As part of my degree course, I studied the spread and effect of subsoil pollution, which I found really interesting. So interesting in fact, that I spent my summer working for a soil remediation company."

Show a bit of personality

It's ok to add a bit of character to the letter. Avoid jokes and sarcasm, but you can phrase things in a way that adds some sparkle. Include some "insider" references that only a fellow engineer would understand, for example. A great way to get your letter to stand out from the crowd is to highlight how your personality has helped you to overcome difficulties or achieve things related to engineering. A good example of this could be if you have worked on any relevant community or voluntary projects.

Show them that you're perfectly suited to the rigours of a PhD

A PhD is very different from undergraduate and postgraduate studies and requires different skills. You need to be self-motivated, disciplined, industrious, resourceful and focussed. Try to think of events in your life that demonstrate these qualities and make sure to mention them.

Talk about your plans

Towards the end of your letter, make sure you mention what your long-term plans are. This shows that you are focused on engineering as a career and that you'll work hard to achieve results.
Talk about any relevant work experience you've had to date – paid or unpaid. Also, mention any engineering societies or institutions that you're a member of or plan to join.

Gentle Persuasion Techniques

We're not going to go in-depth into the psychology of persuasion here, but there are some little-known copywriting (i.e. advertising) "secrets" that you can employ to influence them to accept you. First of all, come up with a concrete idea of what they are looking for in a student. Once you have this fixed in your mind, include a sentence or two that shows you understand this and that you're the person they've been waiting for. For example, if you think they're looking for somebody creative with good design skills and also demonstrates people skills, you could include something like this in your introduction: "You're looking for a high-calibre student with a keen interest in design. During my undergraduate studies, I took part in several extracurricular design projects which involved coordinating and working with a small team of engineers."

Another copywriting "trick" is to use powerful verbs to inspire or evoke an emotional response – think Nike's slogan "Just Do It". We're not suggesting you include a cheesy slogan, but try to use powerful verbs such as:

- I did...
- I made sure...
- I focused...
- I endeavoured...
- I innovated...

Also, if you remember your school English lessons, they may have mentioned passive and active voice. Make sure that the majority of your phrases use the active voice. Here's an example:

- Passive voice: "I was able to make a difference."
- Active voice: "I made a difference."

Finally, try to end with an upbeat message. In advertising, this is known as a call to action – a rousing final pitch that encourages the person to take a specific action. In a motivation letter, it's a good idea to summarise the key things that make you suitable for the course, then close with something like: "Please don't hesitate to contact me if you need any more information and I look forward to your response."

How to present your mechanical design to the team

- This article details how to present your mechanical design to your colleagues in an engaging way.
- It's useful to learn public speaking skills and how to communicate clearly. We also offer tips on how to pitch your presentation to different audiences.
- Don't forget the importance of getting those fine details right beforehand!

Newbies to engineering often underestimate the 'soft skills' they will need to develop for the job. Being able to present your mechanical design effectively involves much more than just knowing the technical details inside out.

Tips to help you present your mechanical design

Whether you need to present your mechanical design to your peers, a boss, or a client to pitch for new business; there are certain skills and tips that can make things a little less daunting. Here are some ideas to help you on your way:

Public speaking skills

If you find speaking in front of groups intimidating or very difficult, it is imperative that you learn techniques that will help you gain confidence. Developing confidence in this area will help when the time comes for you to present your mechanical design.

The most comforting thing to realise is that almost everybody feels a certain degree of nervousness when making a presentation to others. When it's time to present your mechanical design to people within your team, just remind yourself of this fact, and expect to feel at least slightly uncomfortable.

If you find the anxiety is too much to bear, it is probably worth learning some relaxation techniques that you can practice before the presentation. If you can get this right and deliver a clear, relaxed and calm presentation, then that is half the battle won.

We will discuss some other ways to prepare for public speaking later on in this article.

Understand your audience

Gauging your audience's level of expertise is critical in delivering a successful mechanical design presentation. The technical information you are presenting may seem very straightforward or trivial to you, but it may not be so to members of the finance department, managers or even those with an engineering background that have been away from the design process for many years.

Generally, you will have to decide between presenting your mechanical design in broad strokes, without including detailed technical information or getting into the nitty-gritty of the engineering aspects. The last thing you want to do is overwhelm or intimidate those listening, as that will undo all the hard work you have put into the project.

Also, the objectives of your presentation will differ depending on the audience. For instance, if you are presenting to a group of your engineering peers, the emphasis may be on improving the design and sharing ideas, whereas if presenting it to the board of directors you may be more focused on things like the durability of the materials and the cost-effectiveness.

Getting the details nailed down

Any mechanical engineer worth their salt will have a very detailed understanding of the technical aspects of the design. Before presenting your design, however, you need to anticipate the kind of questions your audience will ask.

Again, this depends very much on your audience, but generally speaking, certain types of questions will arise more often than others. You may be asked about alternatives to your design, material choices and supplies, manufacturing processes, safety considerations, fabrication timescales, etc. If you don't have answers to these prepared in advance, they could trip you up, leaving you fumbling and floundering,

Having said that, there are always going to be questions that you won't have the answer to, at least without referring to other documentation, so how do you deal with those? Simply reply that you don't have the information to hand, but you will get back to the person as soon as possible after the meeting.

Presentation tips

You must have experienced it before, a speaker that relies too heavily on detailed slides, in other words 'death by PowerPoint'. If you are just standing up there reading from a PowerPoint displaying an occasional image of your design, with arrows pointing here, there and everywhere, the experience can quickly become either too confusing or excruciatingly boring for those listening.

That's not to say that slideshows can't be used, but don't be tempted to just read from them parrot fashion. It's much better to have a rough narrative mapped out with short bullet points or prompts that you have prepared in advance. One way to engage the audience is to project your computer screen to give a live demonstration, maybe showing active 3-D visualisations that you can rotate and pan around, giving them a real feel for your design concept.

The live display element also makes it far easier when fielding questions as you can zoom in on areas of interest and highlight unique design features when asked.

Rehearse, but don't over-rehearse

Our final tip is to make sure that you rehearse what you are going to say at least once, preferably twice. If you can find a willing person, present it to them to get some feedback. This is especially useful if it is your first design presentation, as you will gain confidence. You don't want to suffer the soul-destroying humiliation of not being well-prepared enough early on in your career. It's equally important not to over-rehearse, as there's a good chance you will come across as either too stilted or overly confident, i.e. arrogant.

Despite everything we've said, it's important to realise that most people will not be judging you entirely on your speaking skills. They are likely to be far more interested in the mechanical design. So, go easy on yourself and keep things in perspective.

How to get a mechanical engineering job at NASA

- This article will help you decide if you've got what it takes to work at NASA!
- We've got some guidance for you on how to apply for and land a mechanical engineering job at NASA.
- We'll cover details on what qualifications and skills you need to succeed. We'll even provide examples of some typical interview questions you might expect.
- On a side note, did you know that NASA use AI to sift through initial job applications?

If you were one of those kids that spent their whole childhood fantasising about working at NASA, then this article is for you. So, without further ado, let's take a look at how you can land that dream mechanical engineering job at NASA.

What do NASA Mechanical Engineers do?

Mechanical engineers are vitally important to NASA's operations and space projects; whether it's designing mechanical ground support equipment, developing shutter mechanisms for space telescopes, or testing engine components, there are literally hundreds of jobs you could be asked to work on.

If you like variety, NASA is a great place to work as once one project finishes, you'll start work on another that may be in a completely different department. You certainly won't get bored, and you'll also get a chance to work with cutting-edge technology and be exposed to the latest materials, research, and engineering concepts.

What skills and qualifications do I need?

Let's start with qualifications. You need to either be working towards or have completed a bachelor's degree in an appropriate field of engineering from an accredited college or university. Obviously, a mechanical engineering degree is the best bet, but they will accept applications from graduates of degree courses that are closely related to the type of work and that demonstrate the relevant knowledge, skills and abilities.

The main skills required for a mechanical engineering job at NASA are problem-solving, communication, team-work, perseverance and adaptability. As with all engineering jobs, you'll need a keen eye for detail and the ability to act on feedback or criticism.

What training programs does NASA offer?

There are various routes to getting a mechanical engineering job at NASA. If you're a student who is interested in working and studying at the same time, the NASA Pathways Intern Employment Program (IEP) is ideal for you. For people that have graduated within the past two years, the Pathways Recent Graduates Program (RGP) offers the best opportunity to get started on a career at NASA. The Presidential Management Fellows (PMF) program is for applicants that have completed a doctorate, masters, or professional degree within the past two years.

Upon successful completion of any of the NASA programs, there is a good chance of permanent or fixed-term employment of up to six years.

How to apply for a mechanical engineering job at NASA

NASA has their own automated recruiting system called NASA STARS. You set up an account on their website, and you can then upload a maximum of 5 resumes, with a character limit of 32,000 for each. You will also have to answer some screening questions at this stage.

NASA's (as you would expect) highly advanced AI system then sifts through the applications to find the most promising candidates. You will be notified of whether you have been successful at reaching the next stage or not once the decision has been made. If your credentials fit the requirements, your information will be passed on to a hiring manager, and you will be called to interview.

Therefore, it is very important to get your resume(s) top-notch before applying. Make sure you make yours stand out and include extra-curricular skills and abilities you have that may be applicable to the job.

NASA's interview process

NASA don't publish too many details of their interview process. Anecdotal evidence suggests that interviews for potential engineers are fairly casual. Do expect to answer some fairly challenging questions, however. Here are a few interview questions that candidates have reportedly been faced with, that with a bit of homework you should be able to answer with no problems.

- How do you stay up to date on aerospace-related current events?
- What has been the biggest breakthrough in aerospace engineering in the past decade?

- Give us an example of a time when you applied your ability to use analytical techniques to define problems or design solutions.
- Describe any projects or coursework which equip you to work on design issues for rocket propulsion systems.

Think outside the box

The most important quality that NASA look for in a mechanical engineer is ingenuity. You need to be able to demonstrate how you can solve problems that others can't, and how you can apply yourself to coming up with innovative ideas and solutions. Be sure to include any details of projects, events, competitions, etc. where you have demonstrated these abilities. Ask yourself this, what is going to make me stand out from a crowd of potentially hundreds of other applicants?

Top 6 Companies for Automotive Engineers to Work for 2019

Automotive engineers tend to be highly passionate about their jobs, as most started their careers spending their free time modifying or repairing old petrol-powered cars, that often broke down if we're being honest with each other. The automotive industry is moving rapidly towards a market where internal combustion engines are beginning to be actively phased out. Major cities around the world are placing ever more severe deadlines and penalties on vehicles that pollute the air. Vehicles are losing their complex, noisy and often dirty mechanical hearts and being replaced with simple, silent and clean electric motors.

What's more is that these vehicles are being set up for autonomous operation, completely removing the driver from the equation. For the petrol heads among us this all seems very boring, you will no longer be the one piloting the machine and feeling the rumble of the engine as you drive on those long winding roads but rather just a passenger in a silent, very fast, super intelligent machine of the future. However, clinging to the past will not serve any purpose other than to make you irrelevant in this rapidly changing field. The list below aims to give some guidance on where you should aim your sights if you want to find an automotive job.

Tesla

This is an obvious one. Tesla is continuously in the news for both good and bad reasons. The good being beautifully designed vehicles that look more like an Apple product than a car. The bad being missed production goals, questionable autonomous features and the oft borderline bizarre twitter antics of its visionary leader Elon Musk. Tesla set out with the goal of making electric cars mainstream and have in large part succeeded in achieving that, their cars now a familiar sight on the high street. Electric cars are definitely not a new technology, but they have long been in the shadow of internal combustion powered vehicles due in part to the limited energy storage capabilities of batteries. However, Tesla battery technology has progressed exponentially making these types of vehicles not only feasible but also relevant. Despite a few reports to the contrary, Tesla is known as a challenging, but also, rewarding place to work and offers a front row seat in the coming electric car revolution. The recent success of the model 3 and the upcoming Tesla truck and pick up truck, make working for Tesla very interesting indeed. Some of the advantages of working for Tesla are indicated below:

Employment Advantages

- Cutting edge technology on the leading edge of electrical and autonomous vehicles.
- Challenging work environment.
- Elon Musk has stated from the start that he wants to force the world into transitioning into a greener and cleaner future. Not many companies can boast such altruistic goals. At Tesla, you can truly feel that you are changing the world.

Interesting Projects

Tesla is no stranger to interesting projects, some of the key ones are listed below:

1. Tesla is taking a giant leap into the world of trucking with their Semi, it has been spotted around town during testing and if all the hype is to be believed it will take the trucking industry by storm.
2. An all-electric pick-up truck is in the works by Tesla and is set to take the market by storm. Initial renderings of the pick-up look very interesting indeed.
3. The final vehicle in Musk's line up, the model Y, will be an SUV with a whole range of interesting features.

General Motors

General Motors is part of the old guard. With classics like the 1969 C Chevrolet Camaro and the 1963 Chevrolet Corvette, it has no doubt been the dream working place of many automotive engineers. GM is a massive player in industry and owns multiple brands. Their focus is still primarily on IC powered vehicles but they're keeping their finger tightly on the pulse of electric vehicles with models such as the Chevy Bolt. Their disadvantage lies in the fact that they are too big to react quickly to a changing market as they have immense amounts of capital invested in their manufacturing processes and tooling. However, don't despair, despite the coming EV revolution there will still remain a market for IC vehicles for many years to come. If your goal is to gain experience in a large, established company, then GM is a good start.

Employment Advantages

- General motors are a titan of industry and as such, promise a stable working environment as far as car companies go.
- Progressive gender inclusion initiatives.
- Moving gradually into the electric market, since companies that do not make a serious move into this space will be made irrelevant in a few decades.

Interesting Projects

General motors own many brands and each of these brands has some or other new technology under their sleeves. The only truly interesting project is the Bolt;

- The Chevy Bolt is the flagship EV vehicle from the GM line up, this vehicle is no tesla but gives an idea of the how the future of electric vehicles will look. The bolt seems like it will disappear in a crowd. A nice sensible vehicle.

Ford

Where GM was part of the old guard, Ford is the King of the castle. Henry Ford brought automobiles to the masses by making use of innovative manufacturing techniques that are still used today. They have come a long way since the model T with classics like the Ford Mustang. Ford has made a massive move to electric cars by investing 11 billion USD into their electric program and have committed to having 20 new electric cars on the market by 2023. Unfortunately, at their core, they are still a company that makes amongst other things, overpowered “gas guzzling” trucks such as the F150. It must be noted that Ford is turning these mean machines into clean machines with hybrid and all electric versions of this vehicle. So, if this is what you thrive on then Ford is the place to be. You also have relative job security as Ford is preparing itself for the surge in electric cars.

Employment Advantages

- Ford has been around since the beginning and has a certain prestige in industry.
- They have invested heavily in electric vehicles

Interesting Projects

- Ford is developing a driver assist system called Co-Pilot360, this system does not allow for completely autonomous driving but is rather designed to assist the driver with lane changes, emergency braking and lane keeping.
- Full electric and hybrid F150's that will apparently not be short on power.
- Not much is known about Ford's new "mustang inspired' EV. This definitely sounds interesting but without the roar of an IC engine, there won't be as much thrill involved. This vehicle is set to debut in 2020.

Toyota

Toyota is known for its die-hard attitude; it just keeps rolling forward regardless of the torture it's subjected to. The company's reliability is legendary, and, having been around since 1937 it is now the largest automaker in the world. Toyota makes sensible vehicles that get the job done every time. If you want to learn the art of making vehicles that last, then Toyota might be where you want to take up residence.

Employment Advantages

- If its job security you're looking for then you don't get more stable than Toyota with their massive global reach.
- A huge range of vehicles and products make Toyota an interesting and fulfilling place to work.
- If you're a die-hard IC fan then Toyota will take you to the cutting edge of this technology.

Interesting Projects

- This one is a bit of a long shot, but Toyota has recently patented a design for a flying car with pop out rotor blades. Now it must be noted that this is still just a patent and not a guarantee that Toyota will pursue the idea. It definitely sounds interesting though.
- Like all other major car companies, Toyota also has a horse in the EV race. This vehicle is called the iQ EV. A small compact EV for city driving.

McLaren

This is a bit of a departure from the rest of the more sensible options mentioned above, but it would not be fair to leave out a company that most engineers could only dream of working for. If you follow F1 you will know that McLaren is one of the top teams in the competition. You might also know that they make some of the most beautiful vehicles currently on the market. Not only that, these cars are marvels of automotive engineering, crafted to incredible levels of performance and perfection. There will always be a market for IC vehicles as nothing compares to the deep rumble of a 4-litre twin-turbo V-8. It is any engineers' dream to work for a company that produces such perfection and continues to do so with an ever-increasing line up of amazing vehicles.

Employment Advantages

- If you have ever seen a McLaren then you will most likely understand that just being able to work on such an engineering marvel is a privilege all on its own.
- On the forefront of IC supercar design, testing and optimising.
- McLaren has an F1 team and working for their road car division just might give you a shot at joining their team as an engineer.

Interesting Projects

- McLaren is in itself an interesting project, as the vehicles designed and manufactured are incredible supercars.
- McLaren has a relatively large range of vehicles from the Speedtail all the way to the stunning P1, each of the vehicles in their range is a marvel of design and engineering.

Fisker

Are you a fan of sleek and futuristic looking electric vehicles but don't buy into the Tesla hype? If your answer was a resounding yes, then Fisker might be right up your alley. The chairman and CEO of Fisker has designed various top of the range vehicles in the luxury vehicle market. Despite only having two vehicle models in the pipeline, this company has a very real chance of growing in the market as EV vehicles become more prevalent.

Employment Advantages

- Fisker's goal is to create a truly environmentally friendly vehicle. One feature, for example, is

using reclaimed wood on the interior. If this aligns with your moral compass then this will be the ideal place for you.

- Fisker is currently going through a growth phase and there is an uptake in available positions at the company. If you want to be part of their journey - now is the time.

Interesting Projects

- Fisker has an ambitious luxury electric vehicle in the pipeline called the Emotion, it stands toe to toe with Tesla as it claims to include autonomous driving and a massive range of capabilities.
- The orbit shuttle is a very futuristic looking electric vehicle for the masses. It does not have a driver and is designed to shuttle people around cities taking the place of existing mass transit options.

What's your destination?

As an engineer, there are many opportunities in the automotive industry. Furthermore, this is probably the most important era in vehicle design as there is a shift taking place in the way vehicles are powered, to the way they are driven. Electrically powered autonomous vehicles are the future of the industry. There are many small startups wanting to take on the big hitters, and this will result in many jobs becoming available. We are on the cusp of an evolution in mobility.

8 of the Greatest Challenges Facing Engineering

Engineers are, by definition, problem solvers and innovators. Whether it's to do with transportation, buildings, medical devices or energy sources, engineers are always looking for ways to make everyday life better for their fellow human beings. With the rapid rate at which changes are taking place in the world today, we all have to keep on our toes to stay ahead of the curve, and this is especially true in the engineering world. To this end, here are 8 of the greatest challenges engineers can expect to face in the next decade.

1. The climate crisis

With climate change becoming a growing topic that demands immediate attention, engineers are going to have to up their game to help mitigate potential catastrophe. The problems of climate change are becoming ever clearer, with scientists linking things like food shortages (of which more later) and even the 2018 California wildfires to the fact that we haven't been treating our world as we should have been. Engineers will be at the forefront of this life-or-death struggle, be it by helping offset pollution created by large companies and corporations, finding sustainable solutions to the energy problem, or ensuring future generations of engineers are more environmentally conscious than any who have come before. This is top of our list of the challenges engineers will face because it's not something that only affects a portion of society - it's something we will all have to deal with. Because we are all a part of the problem, it's only fair that we all become part of the solution.

2. Making water clean and accessible

Water remains one of our most pressing needs and the shocking truth is that the lack of clean water causes more deaths worldwide than wars. According to statistics more than 16% of the world's population still does not have sufficient access to clean water every day. It's not that there isn't enough water available – it's more a matter of how to channel the water where it is most needed. Some countries (like Canada) have abundance, while others (in Africa or the Middle East) never have enough. And then there is the question of all the salt water in the oceans, waiting to be desalinated.

3. Providing enough food

After the need for water comes the desperate need for a steady food supply. This challenge facing engineers of the present and future is an ongoing one which tends to grow along with the expanding world population. As the number of mouths to be fed increases, so does the need for nutritious food. Through effective bioengineering and agricultural innovations, engineers can look forward to making a difference in this everyday challenge of alleviating hunger and malnutrition.

4. Personalised and relevant education

Without a doubt, the kind of education our children and grandchildren receive is going to determine the way they will shape and influence the world when they grow up. The days of one-method-for-all are long gone in the world of learning. Whether it's learning to read or learning to do long division calculations, each child is unique and has a personal style. The challenge for engineers would be to develop more personalised and relevant methods of learning, whether it is computer programs or modular work that caters for the individual needs and preferences of the learner.

5. Improving health care

Medicine and healthcare is another challenging area that is always going to be with us. Engineers have an open invitation when it comes to developing new systems of processing genetic information. More understanding is needed regarding how individuals differ in response to drugs and treatments. Personalised medicines and strategies for overcoming drug resistant infections are just two of many important challenges for engineers to face in the next decade.

6. The refugee crisis

An overwhelming percentage of the world's population is displaced, living in conflict zones, or constantly fleeing from danger. This is as a result of political conflicts and wars as well as natural disasters, droughts and famines. Increasing refugee populations calls for engineers to find new and improved ways of meeting the unique challenges of relief work by working with both host governments and organizations seeking to provide humanitarian aid.

7. Cyber security

The use of computer systems is now so pervasive to every area of our daily lives that most of us cannot imagine how we would manage without them. Those who have been victims of cyber crime have felt the crippling effect that this can have, especially at a business or government level. Certainly engineers would do well to tackle the challenge of cyber safety and find the best ways of securing both data and wealth from unscrupulous cyber criminals.

8. Enlisting the youth

One of the greatest challenges that engineers will face in the next decade is to ensure that their honourable profession is continued into future generations. It is essential to attract and enlist youngsters into engineering careers in order to leave a legacy that will keep on improving the standard of living for all the inhabitants of this world.

As you can see, the opportunities are endless. With hard work, focus and dedication in these areas and others, engineers stand to make a big difference in the world. The challenges are there to be solved, and the role of the engineer in society certainly isn't going away anytime soon.

Top 7 Online Aerospace Engineering Degrees

To keep pace with the growth in commercial aircraft production and global military spending, the global aerospace and defense (A&D) industries are expected to continue their growth trajectory in the coming years. According to Deloitte's 2019 Global Aerospace and Defense Outlook, more than 38,000 aircraft are expected to be produced worldwide over the next 20 years. Aerospace engineers are well-placed to take up roles in one of the most in-demand industries in the world today. For engineers who are looking for a career shift or trying to increase their chances of landing higher positions, an aerospace engineering Master's degree may be the golden ticket. Enrolling full time can be an issue for some though. That is why, enrolling at top universities with online aerospace engineering degrees can be a good option.

1. Georgia Institute of Technology

Georgia Institute of Technology (Georgia Tech) is a research university committed to the improvement of the human condition through science and technology. It is a top-ranked college that provides technologically-focused education in the fields of engineering, computing, science, business, design, and liberal arts. Georgia Tech's College of Engineering consistently ranks among the US' top engineering schools and is known as a global leader and innovator.

Its Daniel Guggenheim School of Aerospace Engineering ranked as the #1 aerospace engineering school in the world according to the Shanghai Ranking of World Universities. Their online aerospace engineering degrees for Master of Science in Aerospace Engineering option gives its students the same training and learning as those who get the degree on campus. Courses follow the Georgia Tech Academic Calendar, allowing students to work on assignments during hours that work best for them but within the required time frame. Some of the available courses include turbulent flows, rotary wind aerodynamics, electro-optics, and robotics.

2. Johns Hopkins University

Johns Hopkins University is a research university with campuses in Baltimore, Maryland, and Washington, D.C. It is the country's first research university and prides itself on being a leader in federal research and development funding since 1979 through its Applied Physics Laboratory.

The university is proud of its history, having launched the fields of water purification and genetic engineering. It also authenticated the dead sea scrolls.

Its Whiting School of Engineering is a global leader in innovation and research. It is home to award-winning faculties, including some awarded with NSF CAREER Awards, DARPA Young Faculty Awards, and Office of Naval Research Young Investigator Awards. The college offers an online aerospace engineering degrees with a Master of Science in Space Systems Engineering that aims to equip students with the tools to become technical leaders within the aerospace industry. Students are required to complete a total of 10 courses within 5 years. Some of the courses offered are satellite communication systems, space mission formulation, spacecraft propulsion, modern navigation systems, and physics of remote sensing.

3. University of Alabama

Founded in 1831, the University of Alabama (UA) is the state's oldest public college. It was established under the statutory mandates and authorizations of the constitution. The university is often referred to as the 'The Capstone' for being the top stone or highest point of the Alabama public school system.

UA was the first university in the state to offer engineering classes, starting in1838. Its college of engineering has more honors students in engineering than any other single college in the state. The college of engineering has been offering distance and online aerospace engineering degrees for MS degrees in Aerospace Engineering and Mechanics for more than 20 years. Students are required to complete a total of 30 credit hours with either a non-thesis or thesis option. Some of the courses that can be taken are orbital mechanics, continuum mechanics, the theory of elasticity, and intermediate fluid mechanics.

4. University of Colorado-Boulder

The University of Colorado-Boulder (CU Boulder) is a public research institution that has developed 229 energy and clean technologies since 2006. Its annual economic impact on the state economy amounts to $3.85 billion. It has over 200 campus and community organizations that take part in the 'Be Involved Fair'. The College of Engineering and Applied Science was founded in 1893 and ranks among the top engineering schools in the nation.

CU Boulder's Ann and H.J. Smead Aerospace Engineering Sciences Department is internationally recognized for its research and education leadership in earth- and space-sciences as well as in aerospace engineering. The online aerospace engineering degrees program in Aerospace Engineering is a 2-year program with two options: thesis and non-thesis. Some of the focus areas are astrodynamics and satellite navigation systems, autonomous systems, and bioastronautics.

5. University of Florida

University of Florida (UF) is a top-ranked public research university entrusted with land, sea, and space grants. UF attracts over $700 million in research every year, and 2/3 of the research funding comes from the federal government. The UF Herbert Wertheim College of Engineering is home to one of the most dynamic and biggest engineering programs in the country. It is the largest professional school, the second-largest college, and among the top three research units in the university.

The department of mechanical and aerospace engineering is an internationally recognized group that conducts exciting research and offers both undergraduate and graduate programs. Its online aerospace engineering degrees program offers a Master's of Science in Aerospace Engineering which requires the completion of 30 credit hours for both thesis and non-thesis options. Some of the available courses are analytical dynamics, finite element analysis and application, and continuum mechanics.

6. University of New South Wales

University of New South Wales (UNSW Sydney) is one of Australia's leading research and teaching universities. It prides itself on being the most comprehensive research-intensive university in Australia with a 7,000-strong research community. The UNSW engineering faculty works in partnership with several industries and organizations for projects and research. These include Intel, Kimberly-Clark, Boeing, Rockwell Collins, and the Australian Department of Defence.

The UNSW Sydney's Master of Space Engineering is an online aerospace engineering Master's program designed to develop a high-level understanding of engineering principles and practices related to space systems. It can be completed in 1 year by full-time students and requires the completion of 48 units of credit. Some of the courses that can be taken are space operations, global navigation satellite systems, space systems engineering management, and satellite communications.

7. University of Washington

University of Washington (UW) is one of the world's preeminent public research universities. It confers over 12,000 Bachelor's, Master's, and Doctoral degrees annually. Its college of engineering has a solid 117 years of engineering innovation and has awarded $11.5 million in student scholarships. UW is a proud contributor to the economic growth of the numerous startups launched each year by UW students and faculty.

Its online aerospace engineering degrees for Master of Aerospace Engineering is a technical engineering degree that requires applicants to have a minimum GPA of 3.0 to be eligible for admission. The Master's program is a terminal coursework-only degree that can be completed part-time in 3 years. Areas of concentration include controls, fluids, structures, and composites.

Electrical

What is Electrical Resistivity?

Electrical resistivity is a property unique to every material, which is essential to understand before creating and designing electrical and electronic systems. Knowledge of how materials differ in resistivity provides information for selecting appropriate materials used for building motors, electrical circuits, dielectrics, resistive heating, and superconducting applications.

What is the electrical resistivity of a material?

Electrical resistivity, represented by the Greek letter ρ (rho), is a measure of the resistance of a specific material of a given size, to the electrical current conduction that flows through it. It is also referred to as the specific electrical resistance or volume resistivity [1]. The SI unit of electrical resistivity is expressed in ohm-metres (Ωm). It is also found in units of (μΩcm). Insulators have high values of electrical resistivity in the range of 1010 Ωm or more, whereas metal conductors have very small resistivity values in the range of 10-8 Ωm.

What is the formula of electrical resistivity?

The electrical resistivity (ρ) of a solid object is determined by passing an electric current through a specimen and then measuring the resultant voltage drop over a certain length. It is expressed by the relationship between the electrical field inside the material and the flowing electric current.

The fundamental relationship between a material's opposition to electron flow is represented by Ohm's law [2]:

where,

V = I . R

V is the applied voltage, (volts: V)

I is the electrica

l current flow (amperes: A)

R is the resistance of the material (ohms: Ω)

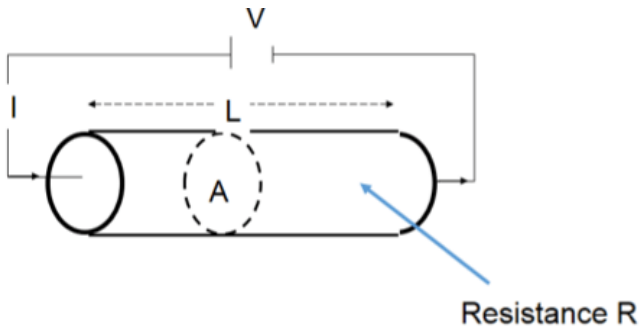


Image 1 Source for reference - https://www.subsurfaceinsights.com/images/ohmslaw.png

By dividing the voltage by the specimen length L resulting in an electric field E and the current by the cross-sectional area A resulting in a current density J, electrical resistivity can be described as an intrinsic material property, as follows:

$$\rho = \frac{E}{J}$$

ρ is the electrical resistivity of the material (ohm-metre: Ωm)

E is the magnitude of the electric field in the material (volt/metre: V/m)

J is the magnitude of the electric current density in the material (ampere/sq.m: A/m2)

For an ideal resistor or conductor that has a uniform cross-section, physical composition, and uniform current flow, the electrical resistivity formula can be written as:

$$\rho = (R \cdot A) / L$$

where,

R is the electrical resistance of a uniform specimen (ohms: Ω)

A is the cross-sectional area of the specimen (square metres: m2)

L is the length of the specimen (metres: m) [2]

Conductivity, in contrast to resistivity, is a material property that relates to the ease at which electric current could flow in a material. It is the reciprocal of resistivity and is given by 1/ρ with a unit of Siemens/metre (S/m). A superconductor has virtually zero ohmic resistance and infinite conductance [3].

Resistivity vs Resistance

Resistivity and resistance must not be confused with each other. Resistivity is a material property with an intrinsic value just like thermal conductivity, while resistance is influenced by the shape, geometry, and resistivity. Consider two rod samples of a conducting material with the same composition and length but of different diameters. The resistivity is expected to be the same in both, yet the one with the smaller cross-sectional area will have a relatively greater resistance. If, however, the diameters were the same and the length of one rod is increased, the longer rod will have a greater resistance. Therefore, we could say that for a conductor, resistance is proportional to its length (R □ L) [4].

Resistivity and temperature

The electrical resistivity is dependent on temperature and, for most materials, the tabular values are normally given at room temperature (20°C). Metallic conductors usually have increasing resistivity in proportion to temperature, whereas the resistivity of semiconductors, such as silicon, decrease with rising temperature. That makes semiconductors ideal for electronics applications [2].

Resistivity and material selection

Electrical and electronic systems use electrical resistivity as a key parameter for material selection. This enables designers to determine the right material to be used for a given application. Power distribution systems, for example, rely on electrical resistivity in order to assess transmission lines, earth grounding, and soil material.

Materials that serve as conductors need a low resistivity level despite being drawn into long, thin wires. Knowledge of the electrical resistivity of various materials provides information on the practicality of their usage and allows for the exploration of suitable alternatives. For example, while silver and gold have low resistivity values and are excellent conductors, they are expensive compared to copper. Copper has high ductility and high electrical conductivity properties, as well, so it serves as a better option. Resistivity is also important in identifying materials that are required to act as insulators to host wires and connections.

Top Universities for Electrical Engineering in Australia

Electrical engineering is often described as a difficult but rewarding job. Tasked with designing and developing new electrical systems, an electrical engineer can expect to pull in an average gross weekly salary of AUD$1,927. In Australia, they can be employed across many industries such as aerospace, rail, facilities management, and telecommunications. For engineers who wish to land jobs as consultants, managers, or project leaders, however, a Master's degree can be very helpful. Below are the top Australian universities that offer Master's degrees in electrical engineering.

1. Curtin University

Curtin University is a culturally diverse school in Western Australia. Founded in 1966 as the Western Australia Institute of Technology, the university is now ranked among the top 1% worldwide according to the Academic Ranking of World Universities. Additionally, engineers with postgraduate degrees from Curtin are the highest paid in Western Australia based on the 2018 Quality Indicators for Learning and Teaching (QILT) report.

Curtin offers a Master of Professional Engineering major in electrical engineering with three specializations: embedded systems engineering, emerging power systems engineering, and telecommunications and networking engineering. The completion of this course indicates that graduates have completed the Stage 1 Competency Standards for Professional Engineers as required by Engineers Australia. This Master's degree requires 400 credits and can be completed in two years.

2. Queensland University of Technology

The Queensland University of Technology (QUT) is a major Australian university with roots going all the way back to 1849 under the name Brisbane School of Arts. It officially became the Queensland University of Technology in 1989 with the passing of the Queensland University of Technology Act. Today, QUT offers more than 400 courses and extensive research opportunities at its two campuses in Gardens Post and Kelvin Grove. It ranked #244 in the 2019 QS Global World University rankings.

QUT offers a Master of Engineering degree with a specialization in electrical engineering, a program that can be completed in one year for full-time students or two years for part-time students. Students are required to complete 96 credits of course units. These break down as 60 credits from core engineering postgraduate units and 36 credits from advanced disciplines and electrical specialization. The latter can focus on power system modeling, power electronics, and power systems management with renewable and storage resources

3. RMIT University

The Royal Melbourne Institute of Technology (RMIT) is a QS 5-star-rated university founded in 1887. It is a global university with campuses in Australia and Vietnam as well as a research and industry collaboration center in Spain. RMIT is ranked 238th out of the top 1000 universities in the world according to the 2019 QS Global World University rankings. To ensure that students are updated with the most relevant education that meets industry needs, RMIT partners with global organizations like Deloitte, Adidas, and BMW.

Admission to RMIT's Master of Engineering (Electrical Engineering) program requires a GPA of at least 2.0 out of 4.0. The program is offered at the Melbourne city campus and can be completed by full-time students in two years while part-time students may take up to four. Areas of focus are renewable energy, high-voltage and protection systems, building services, and power electronic converter systems.

4. Australian National University

The Australian National University (ANU) is a national research school in Canberra. Discussions to build a national university began in 1944, and by 1946 the government enacted the bill that established ANU. The university is ranked #1 in Australia and #24 in the world according to the QS World University Rankings in 2019. It has three campuses located in the Australian Capital Territory (ACT), New South Wales, and Northern Territory.

The Master of Engineering in electrical engineering degree at ANU is a two-year program for full-time students. Students must have a minimum GPA of 5.0/7.0 in a cognate discipline to be admitted to the program. Among the acceptable cognate disciplines are electrical/electronics engineering, telecom/communication engineering, and power and information engineering. To be awarded the Master's degree, students must complete 96 units, of which 48 will come from compulsory courses and 36 from electives in electrical engineering, computing, and breadth.

5. University of Melbourne

The University of Melbourne is a public research university established in 1853. It is a public-spirited institution that consistently ranks among the top universities, standing at #39 in the world according

to the QS World University Rankings in 2019. The university has a total of seven campuses, namely: Parkville, Southbank, Burnley, Creswick, Dookie, Werribee, and Shepparton.

Its Master of Engineering (Electrical) degree is offered at the Parkville campus and can be completed by full-time students in two to three years, while part-time students are allowed to take up to six years. Students must complete a total of 300 credit points to graduate. Among the classes that students may choose are electrical network analysis and design, electrical device modeling, advanced motion control, and electronic system implementation.

6. University of New South Wales

The University of New South Wales (UNSW Sydney) is one of Australia's leading research and teaching universities. Established in 1949, it ranks 45th in the QS World University Rankings 2019. The university is also a member of a coalition of the country's leading research-intensive institutions known as the Group of Eight. UNSW has invested a total of $250 million in research infrastructure since 2015.

The university offers Master of Engineering and Master of Engineering Science degrees with specializations in electrical engineering. Both Master's programs can be completed in two years for full-time students and are accredited by Engineers Australia. Students are required to complete a total of 96 units of credit (UOC) for both. The Master of Engineering requires

18 UOC in core courses, 36 in Level 4 electives, 30 in Level 5 electives, and 12 in engineering and technical management electives. The Master of Engineering Science, on the other hand, requires 18 UOC of inquiry-based courses, 30 of advanced disciplinary courses and 6 of engineering and technical management courses.

7. University of Queensland

The University of Queensland (UQ) is a research and teaching institution founded in 1909. It is among the world's top universities, ranking at #48 in the QS World University Rankings 2019, #32 in the CWTS Leiden Ranking 2018 and #54 in the Academic Ranking of World Universities. UQ has two campuses in Brisbane (Herston and St Lucia) as well as one in the town of Gatton in the southeast part of the state.

UQ's postgraduate programs include a Master of Engineering and a Master of Engineering Science for electrical engineering. Its Master of Engineering program requires 32 units worth of practice-focused and advanced technical courses, professional experiences, and research projects. The program can be completed in three years at the St Lucia campus. The Master of Engineering Science program, on the other hand, can be completed in one year for full-time students, requiring only 16 units for those who have an Honors degree or 24 units for students who want to do both project work and general engineering courses.

8. University of Sydney

Founded in 1850, the University of Sydney was Australia's first university. It regularly places among the top 50 universities, ranking #3 in Australia and #42 in the world according to the QS World University Ranking 2019. The university's graduates are ranked #1 in the country and #4 in the world for employability based on QS World Rankings. The University of Sydney has a total of 11 campuses and research locations including Cumberland, Camden, Surry Hills, and Westmead.

Its Master of Engineering (Electrical Engineering) is offered at the Camperdown/Darlington location, the university's largest and most diverse campus. The program requires students to complete 72 credit points. Full-time students can complete the program in one and a half years, while part-time students can expect to take two to three years. Among the available subjects are high-voltage engineering, power system dynamics and control, model-based software engineering, and the Internet of Things for critical infrastructures.

GUIDES / EBOOKS / PILLAR ARTICLES

The Kingsbury guide to

Industry 4.0

Kingsbury

What is Industry 4.0?

Industry 4.0 refers to the act of optimising manufacturing through digitisation and factory automation.

Industry 4.0 is the next major advance in the manufacturing industry. The Industry 4.0 meaning isn't tied to any specific technology or software but is rather an all-encompassing term used for the integration of physical and cyber technology in industrial automation. The ultimate goal of Industry 4.0 is the creation of smart factories that are optimised and integrated with emerging technologies or systems like machine learning, sensors, IoT (internet of things) and IIoT (industrial internet of things). These factories will be able to self-monitor and optimise themselves based on data gathered both from human operators as well as integrated sensors.

How Industry 4.0 works

The German institute of technology defines 4 design principles that accurately characterise how Industry 4.0 works as indicated below.

1. Interoperability

Communication between human operators and machines is made easier by making use of a range of sensors and devices. These sensors can communicate directly with human operators via mobile phones or to a centralised computer system. Machines can also communicate directly to each other without any human involvement; these systems are known as M2M (machine to machine). The communication is often handled over IoT architecture.

2. Virtualisation

In a smart factory, a virtual copy of the factory is made via data gathered from sensors/ devices. The virtual factory can store and display all the data related to specific machines and manufacturing processes. If the various systems detect failures, safety concerns or any anomalies, a human operator can be notified or the problem can be solved without human intervention. The more sensors integrated into the factory the more accurate the virtual model.

3. Decentralisation

Low-level decision making on the factory floor by a human operator is reduced or eliminated by using M2M communication. This allows the plant to self-configure in order to adapt to changes in manufacturing requirements. This is ideal in a manufacturing environment that is becoming more focused on producing individual, customer-specific configurations of products.

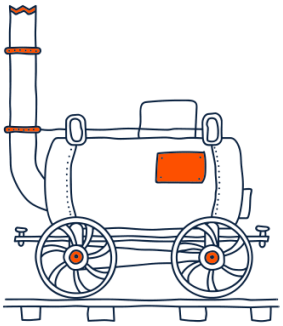
4. Real-time capability

In order for a smart factory to operate efficiently, data needs to be gathered and analysed in real time. This allows unmatched flexibility in the manufacturing process. For example, if a certain machine fails, the system can react by transferring the workload to another, underutilised machine to reduce downtime. These decisions can be made before a human operator has even realised that a fault occurred.

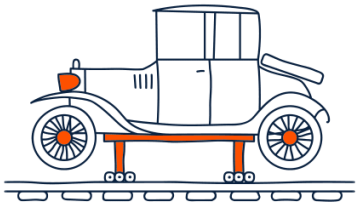
When did Industry 4.0 start?

The Industry 4.0 origin can be traced back to 8 April 2013, the date when the final version of a German government memo was released. The memo was a strategy document that outlined the need to automate the manufacturing industry to remove human intervention where possible.

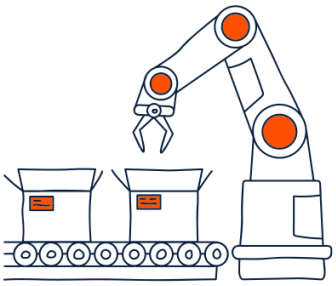
In 2015 the German chancellor spoke of the concept at the World Economic Forum in Davos. Thereafter the term became more prevalent in industrial circles and the implementation thereof was beginning to be adopted by large industry players in an attempt to get ahead of the curve and realise the benefits of Industry 4.0 in their operations.



1. The first industrial revolution was characterised by the movement from an agricultural society to a more mechanised society that harnessed steam energy.



2. The second industrial revolution was characterised by the advent of the assembly line to efficiently produce large quantities of consumer goods for an ever-growing market.



3. The third industrial revolution was characterised by the use of computerised systems such as robotics.

4. Did Industry 4.0 start in the new millennium? The answer is yes and it is characterised by the integration of cyber-physical systems to optimise manufacturing.

Benefits of Industry 4.0

Increased productivity

Due to the fine level of optimisation, resources are precisely allocated and tracked. This allows for highly efficient operations in which any inefficiencies are immediately evident and can be quickly handled.

Improved customer experience

The higher efficiency of a smart factory will result in a higher level of customer satisfaction. Orders will arrive on time in good condition as there is little room for human error. Furthermore, a smart factory is able to produce a single, custom product just as easily as a batch of a million products.

Cost reduction

The reduction of cost can be attributed to a few key drivers, these are listed below;

1. Efficient allocation of resources.
2. Higher pace of manufacturing.
3. Reduced production downtime.
4. Reduced waste through improved quality control.
5. Lower labour and operating costs.

Industry 4.0 challenges

Data security

Data security is one of the most significant risks to smart factories. This risk is potentially even more detrimental to large corporations who rely on their intellectual property to maintain a market advantage. However, with Industry 4.0, even machinery is at risk of being damaged by security breaches.

Skills

As factories evolve so will the jobs required to operate them. Unskilled labour will be replaced by robots, and even some administrative jobs will be lost as a result of AI and machine learning being implemented.

Infrastructure

The sensors and equipment needed to maintain the functionality of a smart factory need to be robust, as any unexpected failure can result in significant downtime and financial loss.

Capital

The capital investment required to transform a modern factory to a smart factory is significant. The benefits are well understood but the actual financial analyses of the economic benefits are not well published as yet. It would be very easy to over-automate and be worse off than when you started.

Key Industry 4.0 technologies

Big data analytics

A natural by-product of transforming a factory into a smart factory is terabytes of data. This data can reveal a wealth of valuable information that can indicate where there are inefficiencies and issues in the factory. However, to extract this information, Industry 4.0 data analytics methods must be used. Machine-learning algorithms can be used to learn which patterns are normal in the data and which are anomalous. The more data being fed into the algorithm, the more accurate it will become at predicting machine failures, raw material bottlenecks and possible cyber security breaches. This is the data-driven future of the digital Industry 4.0.

Robotics and automation

Where big data is the brains, Industry 4.0 robotics are the muscle. It is the robots that will be doing the work in the automation-driven smart factory and they will be doing so more efficiently than ever before. This is down to Industry 4.0 robotics being different from their current counterparts due to their ability to communicate both to each other and to a centralised control. It is this ability which will enable the next evolutionary leap for industrial automation and robotics. Robotics will continue to get faster and more accurate, but it is their integration with communication systems that will truly transform the manufacturing industry and industrial automation companies. Robots will be able to communicate their operational status to a central control or even to a localised control which will then use that feedback to decide whether maintenance is required, or if the machine needs to be taken offline immediately and its task delegated to another robot.

Additive manufacturing

Industry 4.0 additive manufacturing will be one of the defining technologies of the fourth industrial revolution. Due to its versatility, additive manufacturing plays a key role in Industry 4.0 as it saves time and reduces cost.

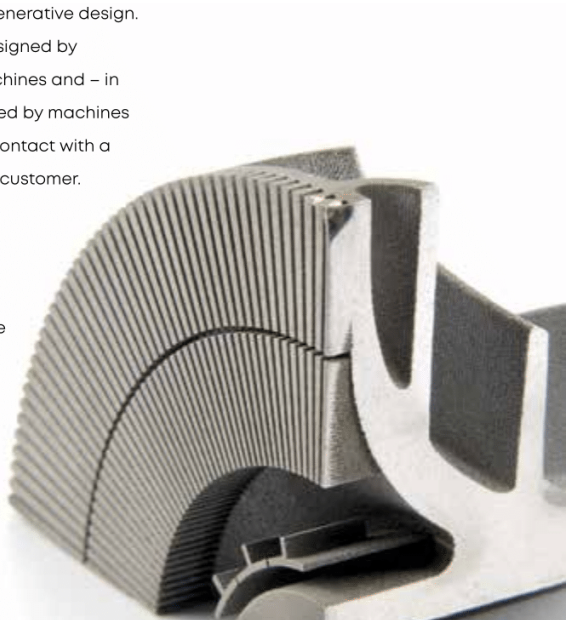
Sharing some key parallels with Industry 4.0, it's decisive for process efficiency and reduces complexity as well as being highly customisable and energy efficient. All of which allow for rapid prototyping and a decentralised production process.

Additive manufacturing technologies integrate seamlessly with the internet of things. A part can be designed and set up for 3D printing, the file can be sent over the network to the printer and the part will be made with minimal human interaction.

Additive technologies are also unique in their ability to manufacture parts generated entirely from computer algorithms, like generative design. This means that parts can be designed by machines, manufactured by machines and – in the near future – even be delivered by machines without ever coming into direct contact with a human... until in the hands of the customer.

Thanks to the Internet of Things, smart factories of the future will be interconnected, have all the processes in place to incorporate greater flexibility and allow for individualization of manufacturing processes.

This is the future of manufacturing.



Horizontal and vertical integration

Vertical integration is about controlling manufacturing from the most basic level of raw materials all the way to the final assembly of the product. Vertical integration is notoriously capital intensive and sometimes it is easier to leverage the skills and expertise of an existing vendor instead of trying to bring the manufacture of those components in-house. However, a well-implemented vertical integration strategy has many benefits such as supply chain security and cost savings. Industry 4.0 vertical integration eliminates some of the risks involved by means of efficient and flexible controls.

Horizontal integration is basically the spreading out of a company by having multiple business units that develop the same type of components. This allows large cost savings due to marketing, R&D, production and delivery synergies. Industry 4.0 horizontal integration can leverage the data gathered and efficiencies gained from other smart factories in the network. Even machines that are in different factories can be utilised across factories.

Cyber security

As mentioned previously, cyber security is one of the biggest concerns in an Industry 4.0 environment. This is due to risks from putting sensitive company data onto potentially vulnerable networks that can be accessed. Not only can the data be accessed but so can actual hardware such as production-line machinery. Cyber attacks on these systems can cause untold damage to a company through production loss, defective products and the resulting financial losses of these types of attacks. As such, new cyber security technologies and regulations are needed to protect industry from the cyber security threats unique to Industry 4.0.

Which sectors should embrace Industry 4.0?

Energy industry

The energy industry can be broadly classified as industries which are involved with the technologies and systems that directly impact the production and distribution of energy. Industry 4.0 can be easily applied to the highly regulated oil and gas industry. This is due to the fact that many of the technologies required for full Industry 4.0 implementation are already used in this industry. All that is required for Industry 4.0 oil and gas is the merging and integration of all these technologies in a homogenous system.

Medical industry

The medical industry is known for pushing the boundaries of material science, engineering and manufacturing. The increasing need for patient-specific medical devices and medication puts strain on traditional manufacturing techniques because medical products are rarely a one-size-fits-all affair. Certain products must be manufactured to integrate seamlessly with the patient's body and still maintain extremely high levels of quality. The flexibility of Industry 4.0 enables the manufacture of highly customised devices without the hefty price tag that characterises these types of components, resulting in a new-age Industry 4.0 pharma.

Transport industry

The transport industry is probably the fastest moving towards industry 4.0. A good example of this high pace of adoption is Tesla. With the rising popularity of electric vehicles, there is a complete shift in the traditional workflow of manufacturing a vehicle; factories need to be completely retooled to be able to efficiently make electric cars. This is what has kept some of the larger companies out of the EV race for so long. Tesla built their production line from the ground up and thus were able to incorporate Industry 4.0 transportation principles into their process seamlessly. Many other automakers are following this example, so expect the auto industry to be at the forefront of Industry 4.0 development and implementation.

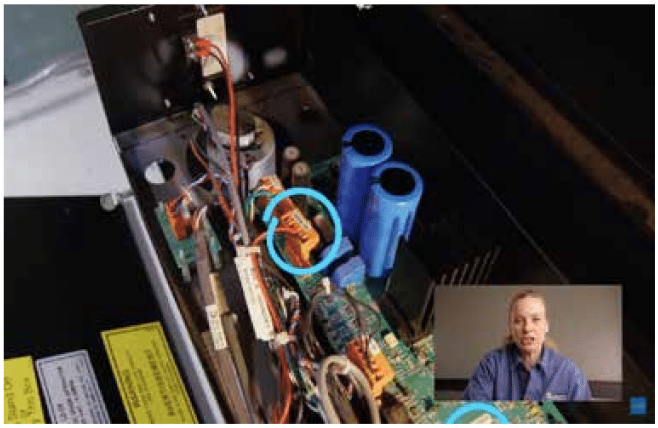
Aerospace industry

The aerospace industry is highly complex as there are millions of components in a modern airliner. Each of these components is designed to a high level of precision and repeatability. The monitoring of these complex projects can benefit massively from Industry 4.0 technologies like big data, smart component tracking and smart inventory management systems. Industry 4.0 aerospace can dramatically improve manufacturing quality and repeatability.

Industrial manufacturing

Industrial manufacturing refers to the fabrication of parts or products from raw materials using various manufacturing technologies and machinery. The impact of Industry 4.0 in manufacturing is very easily observed in an industrial manufacturing plant. A typical facility can benefit from Industry 4.0 manufacturing in a large number of ways. CNC machines can have raw materials loaded into them by robots. Once the parts are complete, these items can be removed from the CNC by the same robot, loaded onto automated carts which then take these parts to the next step in the manufacturing process. Manufacturing 4.0 technologies can decide which parts are the most in need upstream, and the CNC can be tasked with producing these parts until a predetermined condition is met.

Burkhardt-Weber – Hololens



Future trends for Industry 4.0 for 2019 and beyond

The future of Industry 4.0 is continuously evolving as existing technologies mature and new technologies emerge. There is no doubt that Industry 4.0 is the next logical step for manufacturing.

Many large companies are already making use of Industry 4.0 techniques. The rest of the market will be forced to implement these techniques or risk being left behind and becoming irrelevant in their industry. The benefits from Industry 4.0 are just too significant to ignore despite the risks identified earlier. Some of the key Industry 4.0 trends are listed below.

Increased adoption of Industry 4.0

Companies that are not able to make the jump to complete Industry 4.0 will begin to implement chunks of these systems in areas of their businesses that can most easily produce immediate financial benefit. Companies that make use of ERP (Enterprise Resource Planning) and MRP (Material Requirements Planning) systems can already see the benefits of automating their administrative processes and will therefore be in a position to implement similar methods on the shop floor.

Improved human-machine cooperation

Human to machine interaction will be further improved to allow for an almost seamless integration. Technologies that will enable this integration include augmented reality, better sensors that allow machines to sense humans working around them and improved AI systems that enable machines to anticipate human movements and actions, allowing these machines to better work alongside humans.

Industry 4.0 consultants

Companies that offer Industry 4.0 consultation services will be on the rise. There is still a fair amount of confusion regarding Industry 4.0 and how to cost-effectively implement it into existing businesses. This is where consultants will fill the gap, providing services that analyse existing companies and advising how they can implement Industry 4.0 systems into their factories without damaging their business.

Accessible sensor technology

Industrial sensors will continue to drop in price. Consumer sensor technology has become extremely cheap and this will continue trickling down into the industrial space as more competition in the market appears.

Machine self-analysis

Machines will be augmented with sensors that will allow them to monitor their state and be able to measure key machine performance markers. This data will be analysed by machine-learning algorithms, and predictive maintenance plans will be developed from this data. This will drastically reduce downtime due to unplanned maintenance and as a result increase company profit and production efficiency.

Internet of systems

The internet of systems will enable companies to leverage vast amounts of data gathered from all their factories. Lessons learnt and optimisations made can be shared across smart factories. Even machines can be shared on the network to truly create an autonomous supply chain. For example, if one factory is not able to meet production demand for a certain product, another factory that is underutilised can be autonomously roped in to assist with production. The logistics network can also be reconfigured to account for the change in manufacturing location.

Artificial intelligence

Although true artificial general intelligence is still far off, rudimentary AI and machine-learning systems will become more common in smart factories due to the large amounts of data that needs to be collected, analysed and presented in a clear and concise format. This will allow a human to further optimise processes within the factory. AI systems will be able to point out inefficiencies in the system and will even be able to autocorrect those efficiencies with limited human interaction.

The ultimate **CNC machining** guide

with everything you need to know in just 12 minutes

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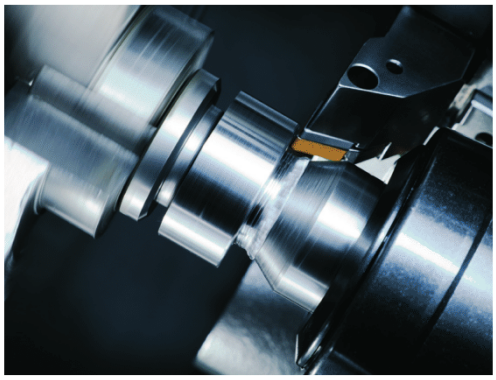
WHAT IS A CNC MACHINE?

CNC machining stands for computer numerical control and basically means that a machine is controlled by a set of commands from a controller. This code normally comes in the form of a list of coordinates known as G-code. Any machine controlled by this code can be referred to as a CNC machine, be it a milling machine, a lathe or even a plasma cutter. In this article we will focus on different types of CNC mills, lathes and the combination of these. The movement of CNC machines can be defined by their axes; these are X, Y and Z with A, B & C axes for more advanced machines. The X, Y, Z axes refer to the main cartesian vectors and the A, B, C axes refer to rotation about these axes. CNC machines typically operate in up to 5 axes. Typical CNC machines are listed below.

CNC Lathe

A lathe works by spinning the material in the chuck of the lathe. A tool is then moved in 2 axes into the work to cut out cylindrical parts. A CNC lathe can create curved surfaces that would be difficult if not impossible on a manual lathe. The tool is usually non-rotating but can also move as in the case of live tooling.



CNC Mill

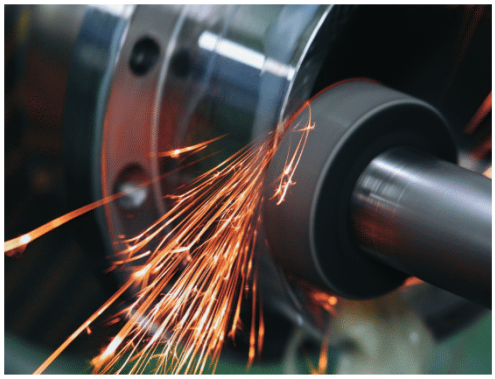
A CNC mill is typically used to manufacture flat parts, however more complex machines with more degrees of freedom can create complex shapes. The material is held stationary and the spindle rotates with the tool, which is moved along 3 axes to cut into the material. In some cases the spindle is stationary and the material moves into it.

CNC Drill

These machines are similar to CNC mills, but they are specially designed to only cut along one axis, i.e. the drill only moves down the Z-axis into the material and never cuts along the X and Y axes.

CNC Grinders

These machines move a grinding wheel into the material to create high-quality surface finishes. They are designed to take off small amounts of material on hardened metals; they are thus used as a finishing operation.



SUBTRACTIVE MANUFACTURING

CNC machining creates parts through subtractive manufacturing. This is basically the process of removing material from a solid billet to eventually get to the desired shape. This can be done via any of the previously mentioned methods like milling, turning, grinding or drilling. Additive manufacturing is the opposite process, in which material is added from nothing to create the part, for example with 3D printers.

TOOLING

The tooling does all the cutting work. Tools are typically mounted in a tool holder and loaded into the spindle when needed. Many different types of tools are needed to make a complete part — there is no "one size fits all" approach to manufacturing. The most common tools used in a typical machining set up are listed below:

MILL TOOLS

End Mill
An end mill is the most common type of tooling and can typically cut in 3 directions. They come in various styles such as flat, corner radius, roughing, ball and taper to name a few. They are characterised by the number of flutes, helix angles, base material and coating material.

Face Mill
A face mill is designed to cut across a large surface area, i.e. facing. Its cutting edges are typically on the edge of the tool and the teeth are usually carbide inserts.

Thread Mill
A thread mill is designed to create threads, it works by rotation around the shank in a helical pattern to cut in the thread shape.

Slotting Cutter
These types of cutter are used to create t-slots along the length of a part. The tool must enter and exit from an open side of the material due to its geometry.

LATHE TOOLS

OD Turning
As the name suggests, this tooling is designed to cut on the outer diameter of the part. It can either take the form of solid tooling that is ground to the required shape, or carbide inserts.

ID Grooving & Threading
These tools are typically slender to allow them to reach inside the part to bore out the inner diameter after drilling as well as to thread the inside.

Parting
A parting tool is used to cut off the part as a final operation after all other operations are complete.

Drilling
These are used to drill out holes longitudinal to the part, the holes still need to be reamed or bored out to reach final tolerances.

TOOLING MATERIAL

The different tool types can be subdivided into materials. The materials typically used for tooling are listed below:

200°C	**High Carbon Steel** These are the cheapest type of machine tool but do not have a long tool life. They also lose their hardness at around 200°C.
600°C	**High-Speed Steel (HSS)** These are more common than carbon steel tools as they have longer tool life and only lose their hardness at 600°C, meaning they can cut at higher speeds.
900°C	**Carbide Inserts** Cemented carbide tools are harder than HSS but are less tough and can fracture if not handled correctly. They can withstand temperatures of up to 900°C.
🔥	**Ceramics** These cutting tools are extremely hard and are usually reserved for cutting hard materials at very high temperatures. There are two common variants namely alumina and silicon nitride.
max	**Cubic Boron Nitride** These tools are ideal for hardened steels and superalloys and have excellent abrasion and thermal resistance.

PROS & CONS OF CNC MACHINING

CNC machining has slowly taken over the manufacturing industry as it is simply more efficient than using manually operated machines. Some of the pros and cons of CNC machines are listed below.

+ Faster than Manual
No human can match the speed, precision and accuracy of a CNC machine. In high production environments, using a manual machine will simply result in financial loss.

+ Reduced Production Cost
A CNC machine can essentially run non-stop if the loading and unloading of materials and parts is further automated, this means the machine can run overnight with no supervision. Also, one operator can run multiple machines, offsetting higher labour costs.

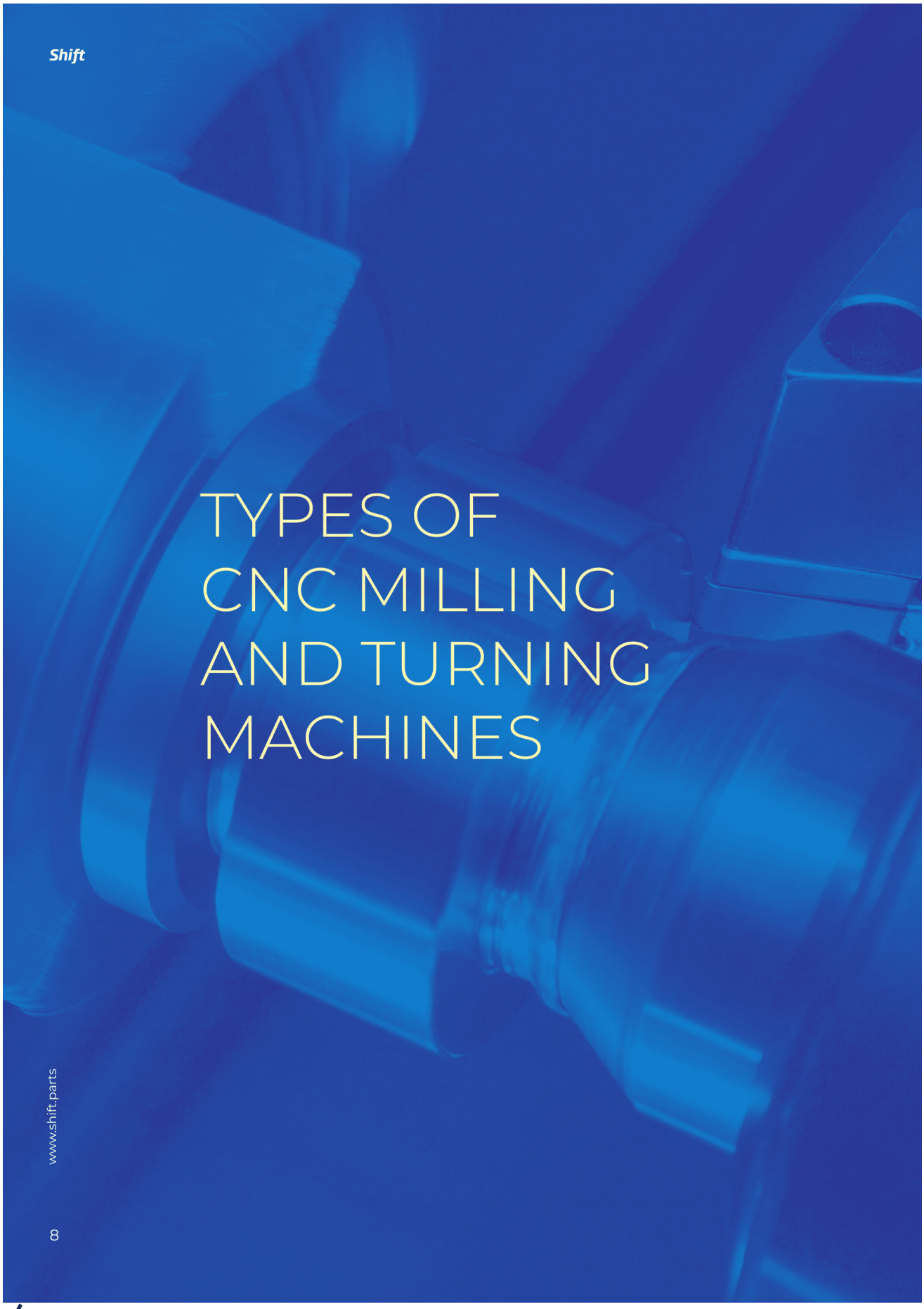
+ Higher Efficiency
A CNC machine can move from one operation to the next in a fraction of a second. Tool changes can happen very quickly as some machines have a turret with many tools pre-fitted or a tool library that loads a new tool into the spindle when needed.

+ Increased saafety
Manual machines are incredibly dangerous, even highly skilled operators can make mistakes that could cost them a limb or their life. CNC machines are very safe: the worst case is likely to be the machine getting damaged due to bad coding.

– Expensive
A CNC machine is an extremely advanced piece of equipment. It is manufactured to very high tolerances and rigidity. This is to allow it to manufacture millions of parts and still produce a quality result. This quality translates directly into cost; the more advanced the machine the higher its cost.

– Higher Skilled Operators
Despite needing fewer operators, a CNC machine requires highly skilled operators, which will result in a higher labour cost.

– Higher Maintenance Costs
Due to the complexity of CNC machines the cost of maintenance is much higher when compared to manual machines.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CNC Milling Machines

Vertical Machining Centre (VMC)
The spindle in a VMC remains in one position and the table moves underneath it. In some cases the table moves up to meet the spindle or the spindle can move up and down on the Z-axis. These machines are very rigid and can therefore produce highly precise components. They have the disadvantage of a relatively small work area. VMCs can have 3 axes (X, Y, Z), 4 axes (X, Y, Z & A) or even 5 axes (X, Y, Z, A & B).

Horizontal Machining Centre (HMC)
An HMC is a machine whose spindle is oriented horizontally instead of vertically. These types of machines are ideal for long production runs as they can machine up to 3 times as much as a VMC, provided there is enough work to keep the machine busy. An HMC is also much more expensive than a VMC. A block of material can be fixtured on the bed of the machine while another part is being manufactured. This is why continuous production is possible, as the spindle can easily move to the next block of material that is ready and change out is very quick.

CNC Lathe

Engine Lathe
This is basically a standard lathe that is relatively versatile. The 'engine' in the name is a relic from when lathes used to be powered by pulleys from an engine that was not on the machine. An engine lathe would then be a lathe with the motor on the lathe.

Turret Lathe
A turret lathe allows for much faster production times as all the required tools are loaded into the turret prior to manufacture. When a new tool is needed it is simply rotated into position.

Tool Room Lathe
A tool room lathe is used for high precision, low volume work. As the name suggests, these styles of lathes are used to create tools and dies. It is also set up to be highly versatile.

CNC Turning Centres
These types of lathes are very advanced and have a wide range of features which include milling, turret tool posts and even a second spindle. There are also both vertical and horizontal turning centres. A horizontal lathe results in all the chips falling away from the part and into the chip conveyor, and a vertical lathe allows gravity to assist when a part is seated into the chuck. Horizontal lathes are easier to automate. It is the application which will determine which style is more applicable.

Speed Lathe
This type of lathe is used primarily for light work, it has a simple setup with headstock, tailstock and tool post.


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MATERIALS
CNC machines can handle a wide array of materials from aluminium all the way to superalloys like Inconel. Each material has its own set of challenges and requires specific tooling, speeds and feeds.
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Aluminium

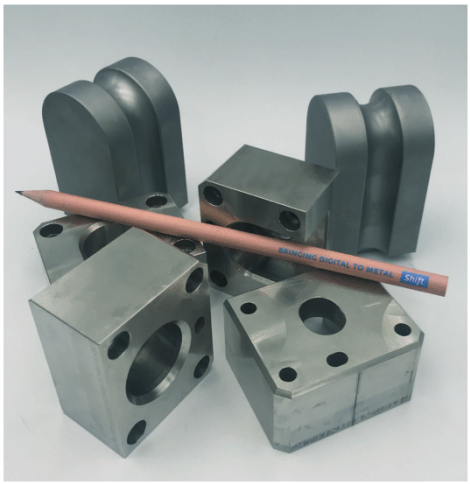
Because aluminium is a very soft material, there is the risk of the aluminium gumming up the cutting tool. This is because of aluminium's low melting temperature. Harder tempers of aluminium can be used to improve machinability.

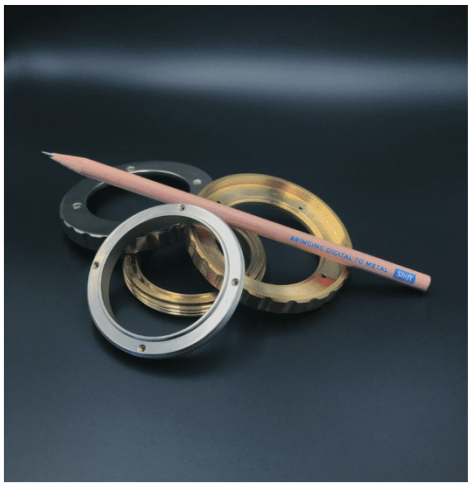
Carbon Steel

Due to the large number of grades of steel, there are many factors that contribute to the overall machinability of the material. These factors may include; cold work, chemical composition and microstructure. Generally, elements like lead and tin can improve cutting speed due to their lubricating actions, and sulphur will reduce strain hardening of the chip.

Titanium

Titanium has a wide array of alloys that each has its own challenges. Ideally the tool must be kept engaged to the material, as stopping in an area will cause rubbing, heat build-up, work hardening and tool wear. Pure titanium behaves much like aluminium and can also gum up the cutting tool whereas its alloys are usually much harder and can cause heat build-up and tool wear. Lower rpm and higher chip load can result in better tool life due to decreased temperatures.





Superalloys

Superalloys are designed to have very high strength at high temperatures, because of this they are very difficult to machine. Higher power machines are also required to machine these materials. Superalloys have a tendency of work hardening very quickly making future machining operations more difficult. Lower cutting speeds are typically recommended.

Copper

Copper is a notoriously difficult material to machine due to its malleability and its tendency to flow around tools instead of cutting. It is used primarily for electrical components and heat exchanger components that require high conductivity and heat transfer coefficients. High Speeds and feeds tend to work well with pure copper. Copper alloys machine a lot easier than pure copper.

Plastics

Plastic has thousands of different forms from thermosetting plastics to normal thermo plastics. There are also an incredibly wide range of hardness's and mechanical properties. Only rigid plastics machine well and can be held within tolerance, while softer plastics tend to deform past the cutting tool and result in parts that are not dimensionally on spec. Heat tends to build up at the cutting edge due to plastic being an insulator, and if not careful, the plastic will melt.

WHAT CAN GO WRONG?

Despite the wide range of uses and functionality achievable by CNC machines, there are risks involved. Some of the most common mistakes made in CNC machining are listed below.

CNC Crashes

CNC machines are unthinking; they only do what they are told. If programmed incorrectly the machine can drive a cutting tool into itself in a millisecond. Machines will typically detect a crash and the machine will stop, but the damage would have already been done. There are various software tools that can mitigate this risk. Tool paths can be simulated before the code is uploaded to the machine. More complex, 5-axis machines are very difficult to simulate using standard computer-aided manufacturing (CAM) software and require additional software between the CAM coding and loading the code onto the machine.

Incorrect Speeds & Feeds

Speeds and feeds are critical to creating quality machined components. If the wrong settings are used there will be accelerated tool wear and substandard surface finishes and tolerances. This is a complex topic as each material and its alloys have different settings for the ideal cut. It will often take a few iterations to reach the perfect set up.

Lack of Maintenance

As with any piece of complex machinery, a lack of maintenance can quickly destroy it. Machines must be kept clean and the OEM maintenance plan must be strictly adhered to.

KEY INDUSTRIES USING CNC

Any industry that requires the manufacture of components is impacted by CNC machining either directly or indirectly. Some of the key industries and their uses of CNC machining are listed below.

Aerospace
The aerospace industry requires components with a very high level of precision and repeatability, these can include turbine blades in the engine, tooling used to create other components and even combustion chambers used in rocket engines.

Automotive and machine building
The automotive industry requires the manufacture of high-precision moulds used for casting parts like engine blocks or the machining of high-tolerance parts like pistons. On a larger scale, gantry-style machines can carve out clay moulds used in the design phase of a car.

Military
The military makes use of high-precision components with very high tolerances from missile components to gun barrels. All machined parts in the military can benefit from the accuracy and speed of CNC machines.

Medical
Medical implants are often designed with very organic shapes and need to be made from advanced alloys. As such CNC machines are a must because no manual machine can create these shapes.

Energy
The energy industry covers all spectrums of engineering from steam turbines to more exotic technologies like fusion. Steam turbines require highly precise blades to maintain balance in the turbine and the R&D plasma containment chambers in fusion have highly complex shapes of advanced materials that require CNC machines.

CURRENT TRENDS OF CNC

With the accelerating pace of technological development in recent years, there has been the perception that additive manufacturing will overtake CNC machining, however the more likely scenario is the emergence of more and more manufacturing centres that combine multiple technologies into one machine. These can take the strong points of both subtractive and additive machines to create a machine that's capabilities are greater than the sum of its parts. Some early iterations of these machines can already be found.

Furthermore, the relentless march of automation through the fourth industrial revolution will result in more automated systems that can self-diagnose, self-optimise and run with minimal human intervention. Products can be made based on the personal requirements of individual consumers and this will be possible because of the level of flexibility offered by CNC machines.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CASE STUDIES

How Matmatch Increased Organic Traffic Growth With Regular Content

SUCCESS STORY

Ben Smye, Head of Growth at Matmach.com, talks about organic traffic growth and developing a library of educational content with the help of Engineering Copywriter.

BEFORE	WORKING WITH ENGINEERING COPYWRITER	RESULTS
Matmatch had grand publishing ambitions but their team was small. Managing freelancers and even finding qualified writers proved a struggle, and used up far too much of their precious time.	After forging a partnership with Engineering Copywriter, Matmatch was able to consistently publish quality content. The removal of the writing workload freed up Matmatch's employees to focus on other aspects of the business.	Twelve months of consistent publishing has generated substantial organic growth. Current stats show: - 400,000+ Google Impressions per month - 11,000+ page views each month (and growing) for educational content - 7:00 min average time on page Several posts are now ranked #1 in Google for key terms.

"We had ambitions to publish a lot of content but were a small team. It was tough to find external writers who could meet our requirements of writing quality educational content for a discerning engineering audience."

A brand's authority plays an important role when ranking online for search terms. Any company that's serious about expanding their reach and attracting loyal followers needs to have a solid marketing strategy, one that includes publishing high-quality, relevant, and engaging content on a consistent basis.

Matmatch.com helps engineers, product designers, and procurement teams find the best material suppliers for their job through an extensive material database platform. The marketing team wanted a library of educational pieces to attract readers, but struggled to find qualified writers to produce articles on schedule.

How did Engineering Copywriter Help?

Engineering Copywriter offers technical writing services specifically for an engineering audience, and all their writers have engineering backgrounds. That meant they had the necessary expertise to deliver what Matmatch needed, both in terms of content and schedule. This collaboration has made for an enduring partnership that allowed Matmatch to meet their content goals.

"Engineering Copywriter was able to deliver quality content on a regular basis. We agreed on the target of a specific number of articles per month, and we knew they would always deliver the content on time, and as promised."

The two companies have been working closely for over a year, and Matmatch has been able to release weekly content consistently. *"Working with Engineering Copywriter helped us develop our library of educational content much more quickly than we otherwise could. It also took pressure off the in-house team and freed up our time, as we didn't need to spend time managing freelancers."*

Engineering Copywriter's systems and processes ensures that all articles meet the same high standards. That turned out to be critical in helping Matmatch achieve their content goals and increase their organic traffic.

What Were the Results?

Matmatch's articles have seen an impressive increase in organic performance, especially in recent months.

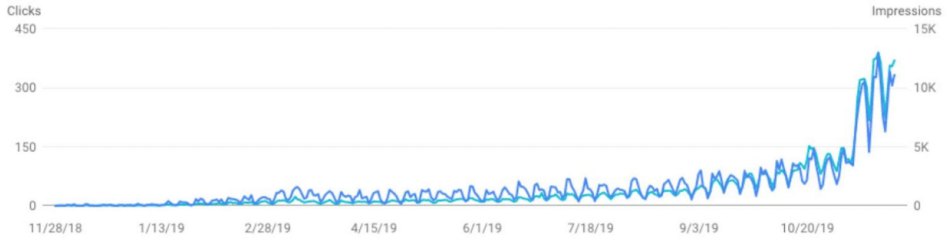


Figure 1: *Analytics showing the impressive increase in organic traffic to the 'Learn with Matmatch' content as a result of the consistent publication of high-quality content with the help of Engineering Copywriter, even without promotion.*

"As we built up the library, we didn't do much to promote it, so it took time for us to see results. However, in recent months we have seen a big increase in organic performance from the articles. For example, in the last three months they have attracted ***over 1 million impressions in Google****. Traffic is still 'catching up', but in the last month or so we've seen an average of* ***400-600 visits per day on the articles****. Some are ranked* ***#1 in Google*** *for key terms like 'wrought aluminium'."*

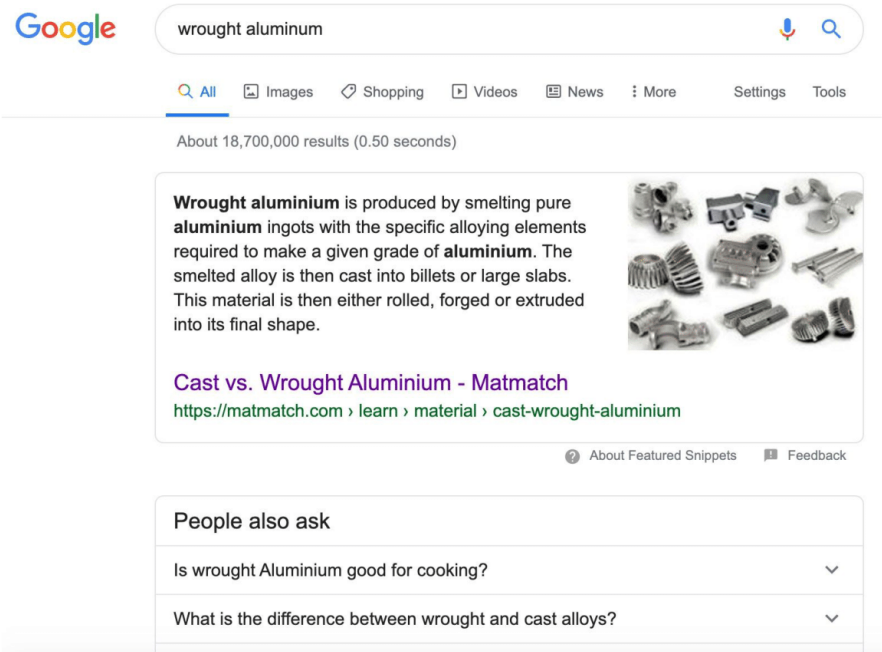


Figure 2: *Screenshot of Matmatch's post on wrought aluminum which appeared as a featured snippet in Google with almost 19 million search results to contend with.*

Whereas Matmatch's previous efforts had been restrictive, partnering with a professional writing team made their output run like clockwork. The steady flow of articles has resulted in an accelerating growth trend in terms of website traffic and views. Like all young blogs, the change took time to materialize, but the statistics bear out Matmatch's confidence that they're on the right track and that their readership will continue to grow.

Continuing to work closely with Engineering Copywriter, Matmatch's analytics from December 2019 alone showed:

- 400,000+ impressions on Google
- 11,500+ page views
- An average session duration of over 7 minutes

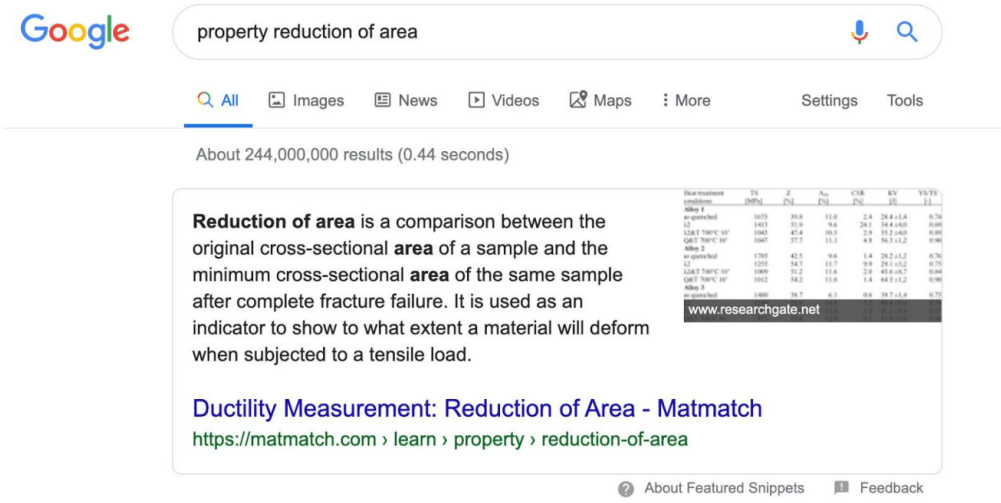


Figure 3: *Screenshot of Matmatch's post on property reduction of area appearing as a featured snippet in Google out of over 224 million search results.*

“Engineering Copywriter understands what it takes to bring results. If you are in the engineering niche and need a reliable, consistent, and helpful content creator, I would certainly recommend them.” - Ben Smye, Head of Growth.

This all goes to show that a long-term content plan pays off in terms of organic SEO results. Matmatch’s experience has proven that high quality content posted on a regular basis can really help grow web traffic and increase reader engagement.

How Golder Used Machine Learning to Help a Gold Mine Optimize Operations

Project Info

Client	Location
Confidential Mining Client.	US

Description

As a subset of Artificial intelligence (AI), the capabilities of Machine Learning (ML) have improved significantly, allowing companies to optimize and improve a wide range of business operations. Mining companies are no exception and are taking advantage of ML to improve their operations and production — from predictive maintenance to achieving interoperability within different operational teams. Successful ML programs most commonly result in huge efficiencies in both time and resources. Ultimately, this produces financial savings, so it's little wonder why ML is so desirable for the mining industry.

The project challenges

For the past 12 months, Golder has been working on an innovative ML project to assist a client in their gold-mining operations. In fact, the project was the first of its kind to be awarded Golder Innovation Project funding. (Golder's Innovation Program is aimed at supporting innovation in all its forms, from breakthrough technologies to incremental improvements to existing services we provide to our clients.)

The project focused on solving a common problem in mines — the sorting of materials into appropriate categories for processing and waste. A client who was commencing operations at a mine in the US approached Golder for assistance. The client and Golder personnel had common connections in academia, and when the client realized that Golder had integrated ML into other mining clients' operations, they reached out.

The client wanted assistance developing a more efficient and accurate method for grade control using hyperspectral minerology – a form of spectral imaging that senses the electromagnetic spectrum and detects minerals. Specifically, the client wanted to know whether Golder could build an automated workflow for the classification of scanned core based on the images produced from hyperspectral scanning. They were interested in three classifications:

- Heap leach material for gold extraction
- Materials for further mill processing
- Waste materials
- A collaborative effort

The Golder team was confident in their ability to create successful ML solutions to help the client improve efficiency with the use of image processing and computer vision. In order to access the top expertise and achieve the best cutting-edge solutions for the client, Golder worked alongside other innovative companies as well.

Software stacks and teams of people worked closely to support the project:

- Golder deployed their machine learning team with programming expertise and made available subject matter experts (SMEs) in geochemistry, geomechanics, minerology, and others.
- Microsoft brought support and knowledge from their AI teams, as well as access to the Microsoft Azure cloud platform, combined with Databricks distributed cluster computing and Custom Vision Service.
- TerraCore supported with in-depth geospectral-imaging expertise

With this collaborative approach, Golder was able to deliver the best possible solution to the client.

The ultimate solution

A common challenge, well-known across the industry, stems from depth registration issues in core boxes. Although field engineers and technicians follow standardized procedures to meet the relevant quality requirements, inconsistencies often arise. These inconsistencies often come from the variable lengths of rock column samples, drilling cores getting washed out or lost, or inconsistent spaces within the core boxes. With a strong collaborative team across respective industries, however, Golder and their collaborators were able to come up with novel processes to resolve these registration issues. The resulting data was much more consistent.

In the end, the project team led by Golder subject-matter experts were able to:

- Upload hyperspectral images of material samples to Azure Cloud
- Merge the images with other metadata such as elemental assay, mineralogy, and lithology for classification
- Train neural network algorithms to analyze all data for classification
- Build a cloud-based workflow for the ingestion, processing, and analysis of hyperspectral core scanned images leading to predictive grade control

Through these learnings, new core logging procedures have been developed for Golder's ongoing and future drilling programs where use of digital core scanning and image processing is foreseen for automation process. This helps to avoid significant efforts required to fix the depth registration and other associated issues for further data analysis.

A positive outcome

Images and data were divided into training and testing sets, and the team was able to successfully use machine learning to classify materials. As a result, the client will save time and resources on their material classification process, resulting in significant financial savings. In addition, the ML classification process is consistent and more accurate than a similar process done by hand, resulting in a more valuable product with far less wasteful labor. Ultimately the solution is a true win-win scenario.

Virtual Reality Prototype Supports Permitting by Allowing Decision Makers to Experience Project Plans

Project Info

Client	Location
Confidential.	Europe

Description

Companies in the energy sector often face difficulties and delays when seeking permitting approval for the construction of large infrastructure with potential to affect the environment.

Seeking approval for new project facilities poses a challenge when it comes to both the landscape and social aspects of the facility's location and visual impact. Photorealistic images and sketches are subjective and lack a "first-person perspective," leading to potential misinterpretation that results in project opposition and costly delays.

For the last two years, the MediaLab team at Golder has collaborated with select clients to develop a 360°, fully immersive, virtual reality (VR) solution to present project plans to decision makers. Working with clients, Golder has evolved this service concept, carrying out software architecture and development, and specifying the most suitable VR devices.

In one example, our team employed a newly developed, innovative VR prototype for a European energy client who had already experienced a one-and-a-half-year delay at the permitting stage of a transmission line upgrade. Current structures were experiencing bottlenecks and improvements were needed for more efficient delivery of services to the area. Asset security was a critical factor but concerns and questions over the changes, and the impact to the surrounding environment, were resulting in delays.

A moderator from Golder acted as a guide, using purpose-built sync software from a tablet, allowing for easy interaction with the person wearing the VR headset.

Golder personnel worked alongside our client's employees in a close partnership for more than three months on the VR solution. Cameras were taken into the field and a 360° scene, complete with sound, was recorded. Our client's engineering design materials were translated into photorealistic, immersive content that clearly depicted how the project facilities would modify the existing landscape. Older structures were removed from the scene and new structures put in place.

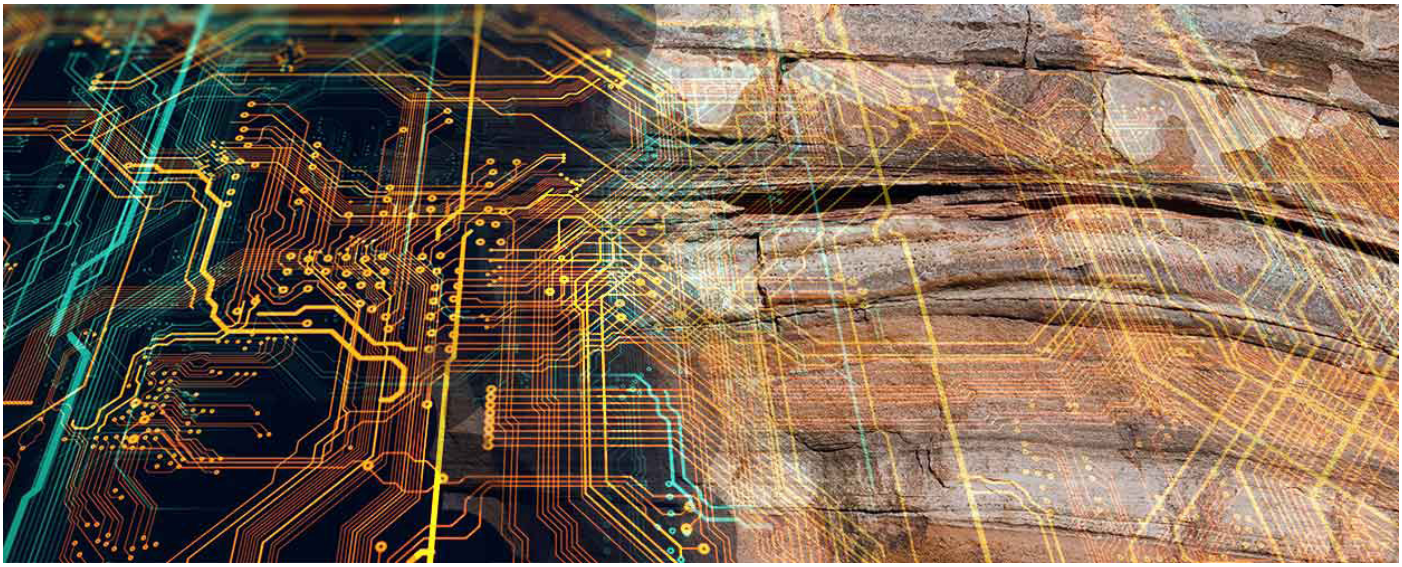
Instead of viewing traditional 2D and 3D models, sketches and pictures in an effort to imagine what changes would look like, decision makers were transported via a compelling and immersive VR experience. Users wore VR goggles to experience the sights and sounds of the proposal and virtually explored the changes to the space.

With no prior experience of VR, our client's Head of Engineering was able to experience the demonstration, with no need for training. A moderator from Golder acted as a guide, using purpose-built sync software from a tablet, allowing for easy interaction with the person wearing the VR headset.

The platform developed by Golder allows simultaneous collaboration with multiple users located anywhere in the world. After donning a VR headset, users can log in and virtually experience the site together, discussing areas of interest in real time, pointing to objects, and even making annotations for others to see. Software for the VR system also gives clients the ability to tailor the product to their own needs, company designs, and specifications.

The results from this proof-of-concept demonstration with our client have been positive. Golder has received buy-in to further develop the technology to experiment with augmented-reality (AR) capabilities. In addition, we have been tasked with incorporating the VR solution to support additional areas of our client's business, such as training, health and safety, and engineering design.

How Golder Implemented Machine Learning to Predict Rock Classification and Reduce Costs for Mine Permitting



Project Info

Client	Location
Confidential.	Central USA

Description

As larger datasets become increasingly common, many companies struggle to manage and analyze it to their advantage. Artificial intelligence (AI) and its sub-field Machine Learning (ML), can help. Machine Learning takes data samples, processes them through statistical analysis programs, and predicts future outcomes.

This strategy can be extremely valuable to companies in the environmental sector. It can save time and money on a wide set of applications, from mine material management to evaluating locations for well-monitoring stations.

For example, the Golder team worked with a client to explore how ML could assist with material classification and regulatory requirements for permitting. The client's waste-material segregation process had been wasting time and money. The process was intended to separate waste into three

classes: benign, moderate, and special handling. Although the client had a rich dataset with their assay database, they were only using two or three parameters to segregate and sort. Aside from the upfront time spent sorting so much material, the client was forced to spend additional time resorting materials that had been incorrectly classified. To top it off, excessive amounts of time and money were devoted to processing benign materials that had been misclassified as special handling.

Golder's subject-matter experts (SMEs) worked with the client to use their assay database with ML tools to identify more useful parameters for sorting other than the current ones they were using. The solution created predictive insights with outstanding results. The client saw that ML can provide insights in how to better manage their material, which can lead to substantial financial savings for the company.

The same client retained Golder SMEs to help reduce the time and costs associated with obtaining mining permits. Often a cripplingly long and expensive ordeal, the permit process usually involves massive expenditures on exploration and reporting, to include geological mapping, geochemical and geophysical surveys and so forth.

With Golder's help, the client developed a stockpile and associated cover system to minimize ground and surface water impacts from a sulfide-bearing overburden project. In conjunction with this, Golder performed water balance, infiltration modelling, and geochemical impact assessments to optimize cover design, and assist with permitting in a challenging regulatory climate.

Among the technical challenges were changing groundwater flow conditions and the need to account for a damaged rock zone in the pit shell (which provided storage). Various tools were used, such as Hydrologic Evaluation of Landfill Performance (HELP) for the water balance and infiltration modelling, The Geochemist's Workbench for geochemical modelling of sulfide overburden materials, and GoldSim for mass balance modelling. The impact assessment evaluated operational conditions through the end of mining to include post-closure scenarios.

Current permitting in the client's region remains challenging, so permit costs can quickly become excessive. The latest partnership between Golder and this client involves the use of ML to predict the neutralization potential for mine expansion. The plan is to take existing data to create a model that predicts neutralization potential, thus saving costs on lab tests. Golder SMEs will be working closely with the client and regulatory bodies as planning begins to ensure all requirements are met.

These are just some examples of the work that Golder has been doing in environmental projects with Machine Learning. Given its predictive power and ability to provide savings in both time and money, more companies are expected to adopt this solution for their data.

WEBSITE COPYWRITING

Conductive, Pre-cured Polyurethane Gasket Systems for Constructing, Maintaining, and Repairing Airplane Structures, Assemblies, and Systems.

The integrity of aircraft surfaces, joints, and assemblies are determined by design, as well as the protective or sealing measures used. Therefore, choosing appropriate industrial-grade gaskets is a key consideration for aircraft manufacturers, service organizations, and overhaul shops. In situations where inadequate sealants are used, corrosion and surface damage will occur. These factors negatively affect the structural integrity of an airplane and could lead to critical safety issues.

If the user requires a diverse range of gaskets to meet specific application needs, Av-DEC is the one-stop shop. Av-DEC flexible, pre-cured, and conductive polyurethane gaskets have been used by the majority of aerospace manufacturers, air carriers, and maintainers.

Av-DEC's versatile gasket systems have been successfully applied in the aviation industry for two decades. The reasons for their successful application by stakeholders are due to:

- Lightweight, low-density build which makes the gasket systems flexible for easy application.
- An eco-friendly, durable sealant which is non-hazardous when used.
- Simple, quick application which speeds up installation, as well as repair and maintenance procedures.
- Excellent cohesion which ensures complete protection of a component's surface.
- High-level protection from corrosive elements.
- Pre-cured "Apply and Fly™" gaskets - which ensures quick application and eliminates messiness.

Learn More About How We Can Help with Your Sealing Challenges Today

The Av-DEC inventory of gaskets consists of products that will satisfy your specific requirements. The gasket equipped with system features handles majority of gasket applications in aviation. These features are due to the use of polyurethane and the implementation of industry-specific standards when developing Av-DEC gasket systems. Av-DEC high-performing systems include:

- HI-TAK Conductive & Non-Conductive Antenna Gaskets
- HI-TAK Specialty Gaskets
- HI-TAK Fuel Panel Gaskets

Why Choose Polyurethane Gaskets?

Polyurethane serves as the base material for Av-DEC's gasket systems due to its inherent properties. The flexibility of polyurethane makes it easy to install Av-DEC gasket systems, which can be installed on metallic surfaces such as aluminum and steel alloys. The benefits gained from using an Av-DEC gasket made from polyurethane sealant include:

- High resistance to heat, abrasions, solvents, aviation fuel, and other environmental factors
- No messy greases

Electrically Conductive Gasket Systems

A conductive gasket must be used when maintaining the electrical conductivity of user assemblies which is critical for optimal function. Electrically conductive gaskets ensure excellent electrical continuity in aviation systems. The benefits of an electrically conductive gasket include:

- Ensures electrical continuity in assemblies, allowing the gaskets to transfer current as intended
- Provides conductive pathways for lightning strikes, to help protect assemblies from excessive electrical surges
- Enhances safe operation ensuring no negative effects on the normal function of the sealed surface

The Benefits of Pre-Cured Gasket Systems

Pre-cured gaskets eliminate the messiness that comes with using cure-in-place sealants. Av-DEC's pre-cured gaskets make use of compression when sealing a surface or the area of application. Some of the benefits of pre-cured gaskets include:

- A simple "Apply and Fly" installation process
- Applicable on both rigid and flexible assemblies
- Easy removal and no residue after removal
- Eliminates the waiting time associated with curing polysulfides

Pre-Cured Gaskets vs. Cure-in-place Gaskets

The deciding factor to consider when choosing between both options is the application. The surface or assembly the gasket is intended to protect plays an important role in the decision. Pre-cured gaskets are generally used when structural integrity and ease of use are the primary considerations. This is usually the case in the aviation industry.

Av-DEC conductive gasket systems are pre-cured, polyurethane gaskets that are electrically conductive. Depending on the user's application needs, one can choose the HI-TAK Polyurethane Conductive Antenna Gasket, the HI-TAK Conductive Specialty Gasket, or the HI-TAK Panel Gaskets, Conductive">Fuel Access Panel Gasket.

Av-DEC® Success Stories on Various Product Uses

U.S. Navy Prevents Corrosion by Adopting Av-DEC Gaskets

To reduce the effects of corrosion on aircraft parts and components, maintenance and repair departments perform routine inspections. The standard procedure for one of Navy aviation customers was to inspect lower antennas on aircraft every 28 days and all other antennas every 56 days for signs of corrosion. The inspection process was time-consuming. It involved removing the antenna, conducting the inspection, treating corrosion, reinstalling the antenna and finally, resealing the perimeter. The resealing process generally took more than a day because the sealant required 24 hours to cure.

Upon discovering and applying Av-DEC gaskets, the customer found that there were no signs of corrosion during their regularly scheduled inspections. This led to a re-evaluation of their inspection schedule and a new 90-day interval being adopted. During the rescheduled inspection the antenna interfaces remained free of corrosion and further re-evaluations using data collected thereafter eventually allowed for an inspection schedule to be set for every 546 days.

With Av-DEC gaskets our customer exponentially improved inspection timelines. This caught the attention of the Original Equipment Manufacturer (OEM). Today, the OEM makes use of Av-DEC gaskets in the building and assembling of its military products.

The Benefits in Detail:

- Lower maintenance and replacement cost.
- Increased inspection interval
- Complete sealing against corrosion for the long-term
- Increase in the lifespan of the associated equipment

Successfully Preventing Corrosion on the High Seas

The sea provides a harsh environment for ships, barges, oil rigs, and other equipment. This environment produces corrosive agents that negatively affect the structure and components of ships. To prevent corrosion of ship antennas, Naval Sea Systems Command (NAVSEA) sought the aid of Av-DEC gaskets and performed an experiment to determine the effectiveness of the gaskets. The experiment involved installing Av-DEC gaskets on antennas on one side of a ship while the current approved method was installed on the other side. Three ships were outfitted in this configuration for a fifteen-month test.

At the end of the test, a comprehensive inspection discovered that Av-DEC gaskets completely protected the antennas from corrosion for the full fifteen-months. On the other side, the antennas had succumbed to corrosion and needed either refurbishment or replacement. As a result, NAVSEA approved Av-DEC gaskets to prevent corrosion on ships.

The Benefits in Detail:

- Prevention of corrosion in extreme environments
- Drastic reduction in costs associated with antenna refurbishment and replacement

A Bespoke Corrosion Prevention Solution That Saved Time

The installation of aircraft electrically bonded connectors has always been a painstaking and time-consuming exercise. Our customer was installing 40 connectors on a pressure bulkhead, making the process even more taxing. Av-DEC was approached by an Original Equipment Manufacturer (OEM) to develop a faster installation solution for connectors on the pressure bulkhead. The installation process included sealing the perimeter to ensure the connectors were airtight and electrically bonded. Previously, the OEM had used conductive polysulfide to accomplish this task, which was extremely time consuming.

On assessing the difficulties the OEM faced, Av-DEC designed and built a customized gasket for this particular project. The gasket was designed for easy installation while simultaneously eliminating cure times. On application, the custom connector gasket ensured the OEM's needs were met in record time. The quick installation time cut 48 hours of labor down to 6 hours for the entire installation.

The Benefits in Detail:

- Quick application with no cure time to plan for
- Easy application which reduces labor during difficult installation tasks

An Inquiry Leads to Preventing Corrosion in 3D Printed Components

As with most sales cycles, this started with a call. The call was from a customer looking for a sprayable sealant which could be applied on 3D-printed aircraft components. After an internal consultation to determine which sealant would work best, TufStuff® (TS1228) was recommended to the customer for testing. Weeks later, the customer confirmed that the TS1228 had been successfully applied to the 3D-printed component and met the performance specifications they required from the seal. This meant the seal would continuously be used alongside the 3D printed component as needed.

The Benefits in Detail:

- Av-DEC sealants can be used to prevent corrosion in 3D printed aircraft components
- Av-DEC offers diverse products with a wide application range

The Referral That Solved Multiple Corrosion Challenges

The success of Av-DEC sealants or products when used by Original Equipment Manufacturers (OEM) and larger aviation service bureaus has been covered in great detail. Small- to medium-sized businesses have also taken advantage of the corrosion-prevention features of Av-DEC products. A perfect example was the application of HI-TAK Polyurethane Rolled Sealant (PRS®) (HT3935), Thixoflex® Gray (TG8498), and Thixoflex® Black (TG3212) products to fix corrosion on an aircraft's windscreen. In this case, the customer was a small charter company and the application was made with great success.

The engineers at the hangar next door noticed the success achieved with Av-DEC products and proceeded to use it as a sealant on their own aircraft. Once again, the TG3212 delivered and was referred to another engineering outfit that repaired rotorcraft. Av-DEC TG3212 was applied as a sealant in the rotorcraft to even greater success and since then, the series of hangars have continued to use Av-DEC corrosion prevention products.

The Benefits in Detail:

- A durable sealant that can be used for diverse applications to prevent corrosion
- A simple application procedure that helps engineers solve their sealing challenges

Reducing Flight Deck Window Removal Rate by Applying Av-DEC Thixoflex® Black

A commercial airline had a high flight deck window removal rate because of the environment its aircraft operated under. The airline installed new flight deck windows and used sealants to help prevent corrosion and keep the installation in place. The sealant they used had to be covered with speed tape until the sealant gelled. The process was time-consuming and ineffective in the long run as the high removal rate remained.

The customer chose to try Thixoflex Black (TG3212) and conducted tests to determine its effectiveness as a sealant. After the tests, the commercial airliner submitted a request to the aircraft manufacturer to use the Av-DEC sealant. The request was granted and after a year its success was so encouraging that the TG3212 was applied across the airline's fleet whenever installing flight deck windows.

The Benefits in Detail:

- Fast gel times allow the dispatch of aircraft 30 minutes after application
- Less downtime when replacement flight deck windows need to be installed
- Clean and easy sealant removal with almost no residuals to clean up, unlike polysulfide sealants
- A durable bond that experiences no visible corrosion, shrinkage, or cracking in extreme conditions

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Av-DEC® Company History

The Av-DEC Story

Av-DEC – The World Leader in the Science of Corrosion Prevention.

Preventing aircraft corrosion is what Av-DEC does. The prevention of corrosion can be done using non-hazardous, durable, and easily applied products. This is the reason the company's engineers have continuously sought out better solutions to ensure corrosion is comprehensively eliminated and the aircraft is protected for the long haul. The Av-DEC story is one of constant improvement to help the aviation industry enhance aircraft safety through corrosion prevention.

Av-DEC Founding

1997 was the year that two engineers in Fort Worth, Texas, came together to start a great journey. The goal was to help the commercial & defense aerospace industry discover and eliminate corrosion challenges regardless of their complexity. This led to the design and development of the HI-TAK Antenna Gasket, which became the first Av-DEC commercial product for corrosion prevention. Since the beginning, a culture of staying close to the customer and showing up has been ingrained into the organization.

What's in a Name?

Av-DEC is an acronym for Aviation Devices & Electronic Components, a name that showcases the initial intent of the company's founders. Today, Av-DEC provides corrosion-prevention products and devices built for the aviation industry. The name Av-DEC highlights a commitment and dedication to the continuous development and improvement of corrosion-prevention solutions specifically for aircraft structures and components.

Early Growth & Developing New Products

Breakthroughs come with great effort. The wide-scale adoption of the Av-DEC antenna gasket by a major airline was a sign of things to come. The experience gained from viewing and understanding the corrosion problems the airline faced sent Av-DEC back to the lab. The result was the design and development of the HI-TAK polyurethane rolled sealants, a product the aviation industry greatly needed. These products helped original equipment manufacturers, airlines, and aircraft operators address level-2 corrosion problems underneath galleys, lavatories, and cargo areas.

An Expected Journey

Success, they say, begets success, and the adoption of early Av-DEC products led to the creation of more custom solutions to meet other corrosion-related challenges. Today, Av-DEC has thousands of antenna gaskets, polyurethane rolled sealants, injectable sealants, and sprayable sealant-solutions in its product catalog. Av-DEC products have been used to prevent corrosion on all types of aircraft across commercial, defense, and corporate aviation.

To Infinity and Beyond

For two decades and counting, Av-DEC has been making dramatic improvements to its diverse product line and adding new products to its ever-expanding catalog. The future of Av-DEC will be defined by its passion to understand the science of corrosion and to perfect high-performing corrosion-prevention solutions for the most complex of corrosion challenges.

Interested in the Latest Innovations?

Learn More About Av-DEC Products

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Av-DEC Offers Many Training Options

From installation guides to on-site training, Av-DEC will provide the information and support needed from the Av-DEC Training Center to start using sealants, gaskets, and Polyurethane Rolled Sealants to their greatest potential.

Av-DEC Training Center offers access to all the resources needed to get started with our corrosion-inhibiting technologies. The provided resources come in different formats to ensure maintenance, repair and operations (MRO) service providers, original equipment manufacturers (OEMs), and third-party installers are all properly informed on how to get the best out of every Av-DEC corrosion prevention solution.

Av-DEC Training Formats

Av-DEC training programs are diverse and are delivered using different mediums. Choose from the following options to best fit your organization's needs.

Classroom Training

Learn how to install sealants, gaskets, and PRS on realistic models of aircraft components and assemblies. In Classroom Training, mock-ups of aviation components - seat tracks, panels, antennas, etc. - are used to give engineers and technicians a detailed, practical simulation of every installation procedure. Along the way we provide guidance and answers to common challenges our clients face while installing Av-DEC solutions.

On-Site Training

Av-DEC offers on-site training to MROs and OEMs interested in educating their in-house engineers and maintenance technicians on the use of Av-DEC sealants, gaskets, and PRS. As part of this training we instruct mechanics on the installation of Av-DEC solutions on-site, on your own aircraft, to ensure knowledge is transferred in real time without interrupting the production flow.

On-Line Training

The Av-DEC virtual training platform makes use of visual instructions, PowerPoint slides, and online computer based training (CBT), developed for interactive eLearning to train mechanics on installation procedures and common installation challenges. The videos use mockups and models of a physical hangar floor for demonstrations.

Av-DEC Training and Certifications

Certifications are a great way for aviation engineers and mechanics to highlight their ability to prevent corrosion before it becomes a problem. Av-DEC certifications test a candidate's understanding of Av-DEC products and sealing solutions, as well as the ways they should be applied. The certification program provides prospective candidates with learning resources and computer-based tests to determine the candidate's readiness level. Organizations may also use these resources to create internal review systems or tests for engineers.

Av-DEC Training Resources Are Free

Av-DEC offers these training resources for free. The instructions and learning resources attached to training programs may be downloaded at no cost. Av-DEC educators are available on a flexible schedule to best meet your organizations unique scheduling requirements.

Contact us Today for Your Free Training Resources

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Self-Leveling® Green (HT3326-5) and Self-Leveling® Green FR (HT3326-5FR)

- Two-component fast-cure polyurethane material that applies easily and self-levels while curing for use as a watertight, flexible sealant
- Fills gaps and voids between surfaces to create a flexible, watertight environmental seal
- Removes easily and with no residue thanks to excellent cohesion
- Aviation industry's benchmark for protecting surface, voids, and connector backshells from corrosion.
- FR formulation passes 12-second Vertical Burn Test per 14 CFR, PART 25-Subpart D, § 25.853 Compartment interiors & § 25.855 Cargo or baggage compartments Appendix F, Part I, (a)(1)(ii) (12 sec vertical test)

COMMON USES: • Antenna Connector Base • Seat Tracks • Wet Areas • Lavatories Areas • Galleys • Cargo Bays • Electrical Connector Backshells • Nutplates

Request a Sample or On-Site Demo Today

Two-component self-leveling sealant for waterproofing and sealing aviation components and surfaces from corrosion and abrasions.

Av-DEC Self-Leveling Green is formulated for sealing surfaces from moisture and electrolytes that cause corrosion. Self-Leveling Green integrates a self-leveling two-part corrosion-inhibiting formula that serves as the optimal environmental seal when applied. The application process ensures a semi-solid seal that is impervious to moisture, water, and humidity. Self-Leveling Green can also be used to complement Av-DEC gasket systems to provide a complete environmental seal. This combination is great for waterproofing and preventing corrosion, and it can be installed during aircraft production or during regular maintenance and repair activities.

The user can apply this two-part corrosion inhibitor for the following purposes:

- To protect avionics and aircraft surfaces from corrosive agents.
- To protect commercial and military aircraft from moisture which can degrade internal structures.
- As a complementary sealant to secure the voids and spaces left after applying a gasket for all-around protection.
- To protect surfaces and assemblies from the expected wear and tear that comes with constant use.
- As a quick, environmental sealing solution when immediate repairs must be performed.

Contact us to Find out More on Self-Leveling Green

A High-Performance Injectable Sealant for Quick Applications

Av-DEC Self-Leveling Green injectable sealant was formulated to handle the speedy maintenance and repair tasks that occur before take-off. The gel forms the required semi-solid environmental seal within 10 to 15 minutes of application. The Self-Leveling Green application technique is straightforward:

1. For proper application, follow the installation instructions included with the delivered product.
2. During application, the two-component gel is thoroughly mixed in the mixing straw delivered with the product.
3. Apply Self-Leveling Green to surfaces or assemblies. The Self-Leveling Green can be injected into voids or brushed onto surfaces.
4. Wait for 10 to 15 minutes and the semi-solid environmental seal will be formed.

The advantages of using Av-DEC Self-Leveling Green are:

- Its quick cure rate speedily protects application surfaces, helping to both speed production rates and reduce maintenance downtime.
- Self-Leveling Green can be easily removed when real-time repairs are needed.

A Waterproof Polyurethane Two-Component Corrosion Inhibitor

Av-DEC Self-Leveling Green is a polyurethane-based formulation which offers the advantage of the flexibility and durability of its base material. On proper application, Self-Leveling Green will provide a moisture-free environment under varying degrees of pressure and temperature. The benefits from using this two-component polyurethane corrosion-inhibiting sealant include:

- A non-hazardous sealant which eliminates the possibility of volatile organic compounds (VOCs) emissions which means the sealant is always safe to use.
- Eliminating the need for hazardous materials paperwork for transportation, storage, or use of the sealant because Self-Leveling Green is non-hazardous.
- A flexible environmental seal.
- Easy to remove when the need arises.
- An aesthetic green-colored gloss which is pleasant to look at when applied.

A Two-Part Polyurethane Formula for Diverse Applications

Av-DEC Self-Leveling Green is designed for diverse applications within the aviation industry. Self-Leveling Green will protect the following components from the long-term effects of moisture:

- Antenna Connector Bases
- Seat Tracks
- Galleys and Cargo Bays
- Electrical Connector Assemblies
- Voids and Spaces
- Nut and Bolt or Fastening Systems

The wide range of applications is the reason why Av-DEC Self-Leveling Green can be used in other industries outside aviation. The two-component corrosion-inhibiting sealant is provided in the standard 50cc cartridge and a larger 200cc cartridge. Click FREE SAMPLE below and leave contact details if you would like to receive a 50cc cartridge of Self-Leveling Green to evaluate this fantastic product absolutely free-of-charge.

Try a Self-Leveling Green Sample Today

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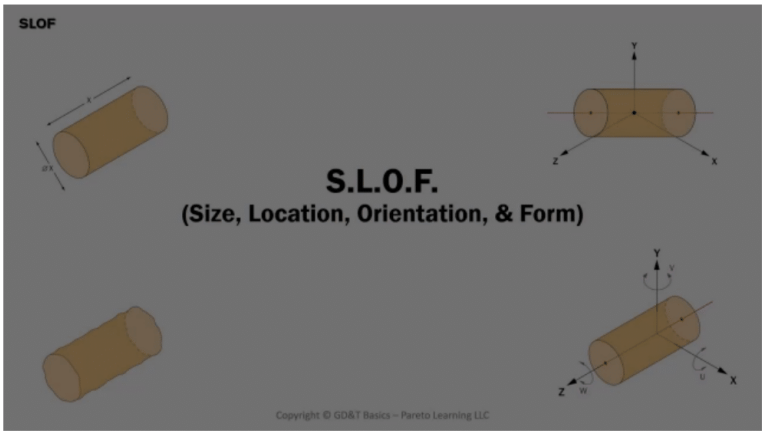
GD&T BASICS
FUNDAMENTALS COURSE

Announcing: Part 2 of your Exclusive FREE Video Tutorial!

How did you like Part 1?

No doubt you're a GD&T expert now on Size & Location. If you missed our first video, you can watch it here:



S.L.O.F Part 1 - Size and Location

Sure, GD&T can seem overwhelming in the wrong hands.

We know that.

That's why we've worked overtime to simplify things for you and take the sting out of it.

Have you considered sending your friends and colleagues our way? Learning together is always better…

Go ahead and forward them this email so they can catch up!

"I am a MET student and this is WAY better than my book. Clean, functional, and with good explanations! You all rock! Thanks for a great resource! "

- Christopher W. – Engineering Student

Check Out the Features of the Full GD&T Course

FREE Video Series Part 2 – What's it all about?

In Part 1 you gained a good foundation on Size & Location when considering features on your drawings and your design. Now it's time to take things a little bit further.

In Part 2, we explain:

- How you can ensure your ORIENTATION is controlled, even on features that might not seem like they need it.
- How to make sure your FORM is refined on an engineering drawing. (And how your size already controls your form in most cases.)

Form and Orientation are both refinements of Size and Location respectively. When you control an object's size, you control its form - and when you control an object's location, you control its orientation as well (IF controlling the proper datums). Every feature on your drawing must have S-L-O-F to be fully constrained - even if the tolerances are huge.

Remember: GD&T is more than just symbols. It is the best method for technical communication on a drawing among your Design, Manufacturing, and Inspection departments.

****Before we get to the video, we just want to remind you of something very, very important JUST FOR SUBSCRIBERS!****

YOU HAVE 2 WEEKS to grab this bargain for our amazing GD&T course...

***Snap up the course* now for only $275. For this low price you will receive 180-day access under our Premium Plan!**

*That's a huge **45% discount ($225 off)!***

Note: This is the lowest price this course will ever be, and time is running out. When it's over, it's over - so don't miss out!

AND...This is even less than our Standard Plan (60-Day) course. So, you get the course for an extra 4 months - with full access to the incredibly helpful forum and instructor question line (not included in our Standard Plan).

To benefit from this offer, simply click the button below and sign up. At the checkout, enter the code: **gdtsubscriber45%**

Also, contact us at info@gdandtbasics.com ***for information on special group or company rates today.***

Here's a reminder of the benefits of taking the GD&T Basics Fundamentals Course (individual or group):

- **Full 24/7 Access** – Review the GD&T course for a full **180 days at your convenience.**
- **Access Anywhere** from **Any Device.**
- **Direct Email** with Instructors to get **all your questions answered.** *(Premium Plan only)*
- **Student Forum** you can access 24/7 to **work with other students.** *(Premium and Gold Plan only)*
- **Convenient** – No need to take time from work. Take the course at your leisure **when you have the time.**
- **Real World Knowledge** you can **immediately apply to your job.**
- **Premium Wall Chart** - All GD&T concepts from the course are presented in the same order as on this chart, with references taken right from the course. **This is the best GD&T Chart you will find anywhere!**
- **Cost Effective –** Save thousands of dollars while getting the best GD&T training **you can actually use!**

We focus on simplifying things for you and taking the complexity out of the ASME Y14.5 standard by teaching you the critical concepts of GD&T. The information covered is what you need to carry out the vast majority of the engineering tasks you will complete.

Note: We understand that purchasing a course at your company may take some time. So if that's the case, simply let us know by contacting us at info@gdandtbasics.com and we can discuss extending our offer.

Don't delay. Grab the course quickly at this rate before it's too late.

Sign Up For The Course Today

Good friends stick together. AWESOME friends pass on the link to the best GD&T offer available on the web today!

Be an awesome friend!

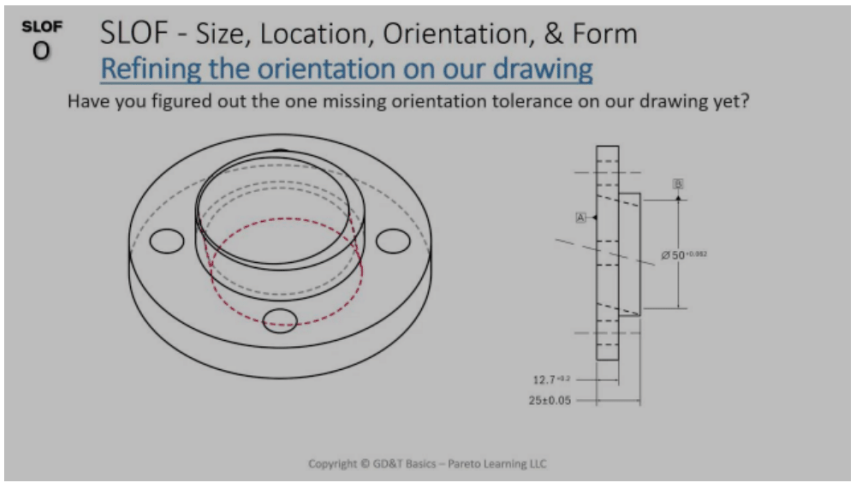
If you know someone who would benefit from this amazing special offer on our GD&T Basics Course, please pass on this link.

It's always better to learn together.

Who knows?

With the money they can save, they may even buy the next round of coffee!

So...Here's Part 2 of the FREE GD&T Video to take your knowledge to the next level.



S.L.O.F Part 2 - Orientation and Form

Be sure to get in touch at info@gdandtbasics.com if you have any questions or comments for us. We'd love to hear from you.

Remember, to use your special discount **gdtsubscriber45%** and sign up for the GD&T Basics Course before time runs out!

And stay tuned to www.gdandtbasics.com for more in-depth information on all things GD&T.

Thanks again for subscribing!

Website Features View this email in your browser

GD&T BASICS
FUNDAMENTALS COURSE

FINAL DAYS:
Learn the inside secrets of GD&T, save money and advance your career – TODAY!

Hello *|NAME|*,

For some reason, you haven't taken advantage of this amazing offer yet!

We can't believe it!

Ask yourself WHY?

- Perhaps you've been sitting on the fence?
- Maybe you just haven't gotten around to it?
- Are you unsure about something?

Rest assured this course has been designed to make it:

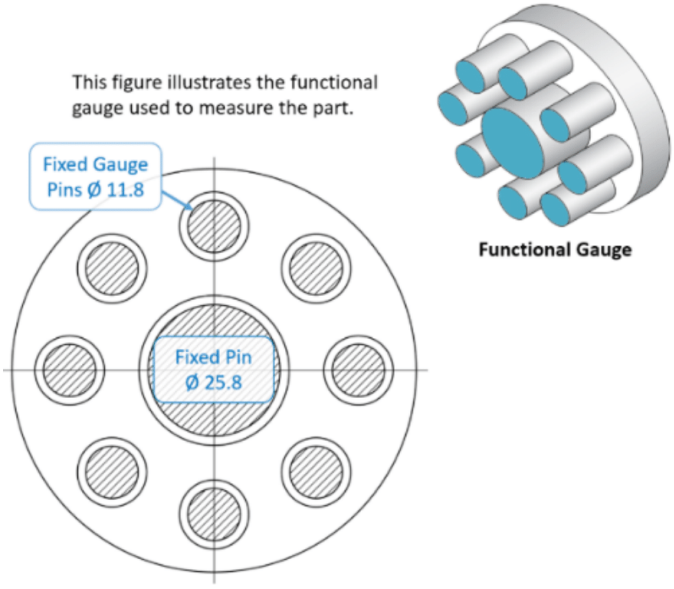
- Simple for you to understand GD&T
- Clear for you to follow the lectures
- Easily accessible for you anytime, anywhere

If you have any questions whatsoever, please drop us a quick e-mail at info@gdandtbasics.com – we're only too happy to help put your mind at ease.

Use Coupon Code: gdtsubscriber45%

Enroll Today for the GD&T Basics Course

"The course was extremely well-taught and made difficult concepts as easy as possible to grasp. Even after just 14 hours of this course I'm already one of the more knowledgeable people at my company with GD&T, because this course is thorough and leaves no gaping holes in knowledge. I'm looking forward to the advanced course."
- Logan V. – Machine Shop Owner



Here are 7 realistic reasons to take the plunge and sign up for the GD&T Basics Course NOW!

1. You're sick and tired of not understanding engineering drawings.
2. You panic when your boss asks you to sign off on the latest revisions.
3. You worry that a mistake in GD&T may cost you your job.
4. You're fed up with not being able to join in on GD&T discussions with peers.
5. You just can't get your head around all the symbols and features.
6. You narrowly miss out on job promotions again and again.
7. You think GD&T is way over-complicated.

Don't worry. We've got you covered, so get ready for a change! We've designed our courses to help you learn all about GD&T with the ***simplest***, most ***straight forward*** and ***easy to follow*** lectures on the entire web.

We focus on the 20% of GD&T that will allow you to complete at least 80% of your day-to-day tasks. We don't waste your time and energy with unnecessary information that will only confuse you and complicate things. We keep it simple. Trust us to guide you through.

Note: This is the last chance to get this special offer before the price goes up!

Discount for Subscribers Only

Only 2 Days Left!

We are offering you this special discount for our popular GD&T Training Course. Only for subscribers!

With this offer you will receive 180-day access to the course now for only $275

That is $225 off the retail price and the best offer your will find on our Premium Plan (180-day Access) anywhere! That's more than a 45% discount off our incredibly effective course!

Note: We understand that purchasing a course at your company may take some time. So if that's the case, simply let us know by contacting info@gdandtbasics.com and we can discuss extending our offer. We want to help in any way we can!

To benefit from this offer, simply click the button below and sign up. At the checkout, enter the code: **gdtsubscriber45%**

Last Chance to Sign Up For This Price!

Also be sure to contact us at info@gdandtbasics.com *for information on special group or company rates.*

Finally, do you want to be a great friend and colleague?

Learning together can be a real confidence booster and a lot more fun. Why not go ahead and forward this e-mail to your friends and colleagues. *We don't mind!*

And remember to *speak with your manager or professor* about the opportunity to benefit from even better group and company rates.

That's it for now folks.

Please get in touch at info@gdandtbasics.com if you have any questions or comments for us. We'd love to hear from you.

Remember to use your special discount code, **gdtsubscriber45%** and sign up for the course before time runs out!

Stay tuned to www.gdandtbasics.com for more in-depth information on all things GD&T.

Thanks again for subscribing!
- The GD&T Basics Team

BROCHURES

Deployment Wheel

For the safe and steady deployment of tools to subsea, look no further than the DECK Engineering deployment wheel with a lifting capacity of up to 9000 kg. This unique deployment system helps to avoid the need for large, heavy vertical towers or derricks.

DECK Equipment

Developed together with Norwegian and American experts, you can be certain of a quality system that's been meticulously designed for the best user experience. The DECK Engineering deployment wheel has been tested in the North Sea under demanding conditions. The rigorous design and testing procedures mean that you can rely on this product to deliver.

The DECK Engineering deployment wheel is an excellent solution for well decommissioning. It has proven time and again to be an effective substitution to regular deployment systems that require very heavy and very large derricks. The deployment wheel can be manufactured with the capability to work in explosive areas, such as drill floors for example, and delivered as Atex zone 1 or zone 2 certified.

Key features include:

- In addition to deployment tasks, the DECK Engineering deployment wheel can feed tools with power for operations on the sea bed.
- Its compact and mobile design mean it can be moved from ship to ship or from platform to platform resulting in more flexibility for your operation.
- The deployment wheel can be used on board of the ship or on the deck of the drilling platform, offering various solutions from one product that can serve many functions.

General technical parameters:

Lifting capacity	9 000 kg
Dimensions	2,6m x 1,8m x 2,4m (LxWxH)
Gross weight	4 800 kg
Drive	Hydraulic
Power consumption	External HPU, 65 kW
ATEX	Zone 1
Working temperature	From -20°C to +40 °C
Certification	DNV GL

To discuss the DECK Engineering deployment wheel in more detail, please contact our team of experts today.

DECK Engineering provides Engineering services and EPC deliveries for Oil&Gas and Marine industries.

Our experienced management and personnel execute projects from study phase through to completion, covering all stages and providing exceptional support. Therefore, our conceptual engineering has strong practical influence. DECK Engineering is committed to continuous quality improvement and is certified to ISO 9001:2008.

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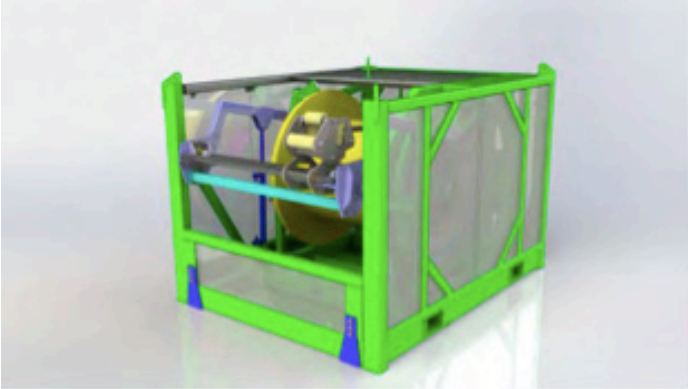

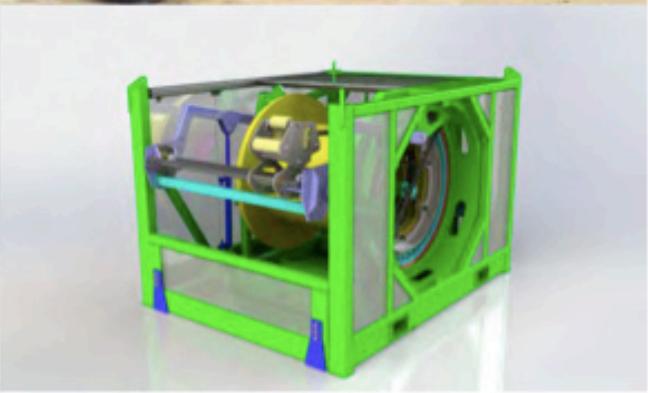

Modular Reel for Umbilical

If you need an umbilical reel that can deploy and store an umbilical, while offering flexibility, then the DECK Engineering modular reel won't disappoint. Developed together with Norwegian and American experts in the industry, this reel has excellent functionality, and its modular design provides you with more options.

DECK Equipment

The reel can be manufactured with the capability to work in explosive areas, such as drill floors for example, and delivered as Atex zone 1 or zone 2 certified.

The DECK Engineering umbilical reel has been tested in the North Sea in harsh conditions to ensure that it offers the reliability you expect, and that it remains robust and operational even in varying weather conditions.

Key features include:

- The modular system allows quick and efficient drum replacement. This means that you don't need several reels, but can simply stock extra drums with varying types of umbilical.
- Replacement of the drums can be performed on board the vessel, without the need for specialized equipment.
- The DECK Engineering umbilical reel is compact and mobile, which means it can be easily moved from ship to ship or platform to platform.
- The reel versatility means that it can be used on board of the ship or on the deck of the drilling platform to suit your requirements at any given time.

General technical parameters:

Load capacity	8 000 kg
Transporting dimensions	2,6m x 1,8m x 2,4m (LxWxH)
Gross weight	4 800 kg
Drive	Hydraulic
Power consumption	External HPU, 65 kW
ATEX	Zone 1
Working temperature	From -20°C to +40 °C
Certification	DNV GL

To discuss the DECK Engineering modular reel and how it can assist on your vessel, then please contact our team of experts today.

DECK Engineering provides Engineering services and EPC deliveries for Oil&Gas and Marine industries.

Our experienced management and personnel execute projects from study phase through to completion, covering all stages and providing exceptional support. Therefore, our conceptual engineering has strong practical influence. DECK Engineering is committed to continuous quality improvement and is certified to ISO 9001:2008.

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NEXT STEPS

Contact us to discuss your project today, and let us know how we can help you with great engineering content.

Send your email to:
info@engineeringcopywriter.com