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