DESIGNING WITH ENGINEERING

PLASTICS

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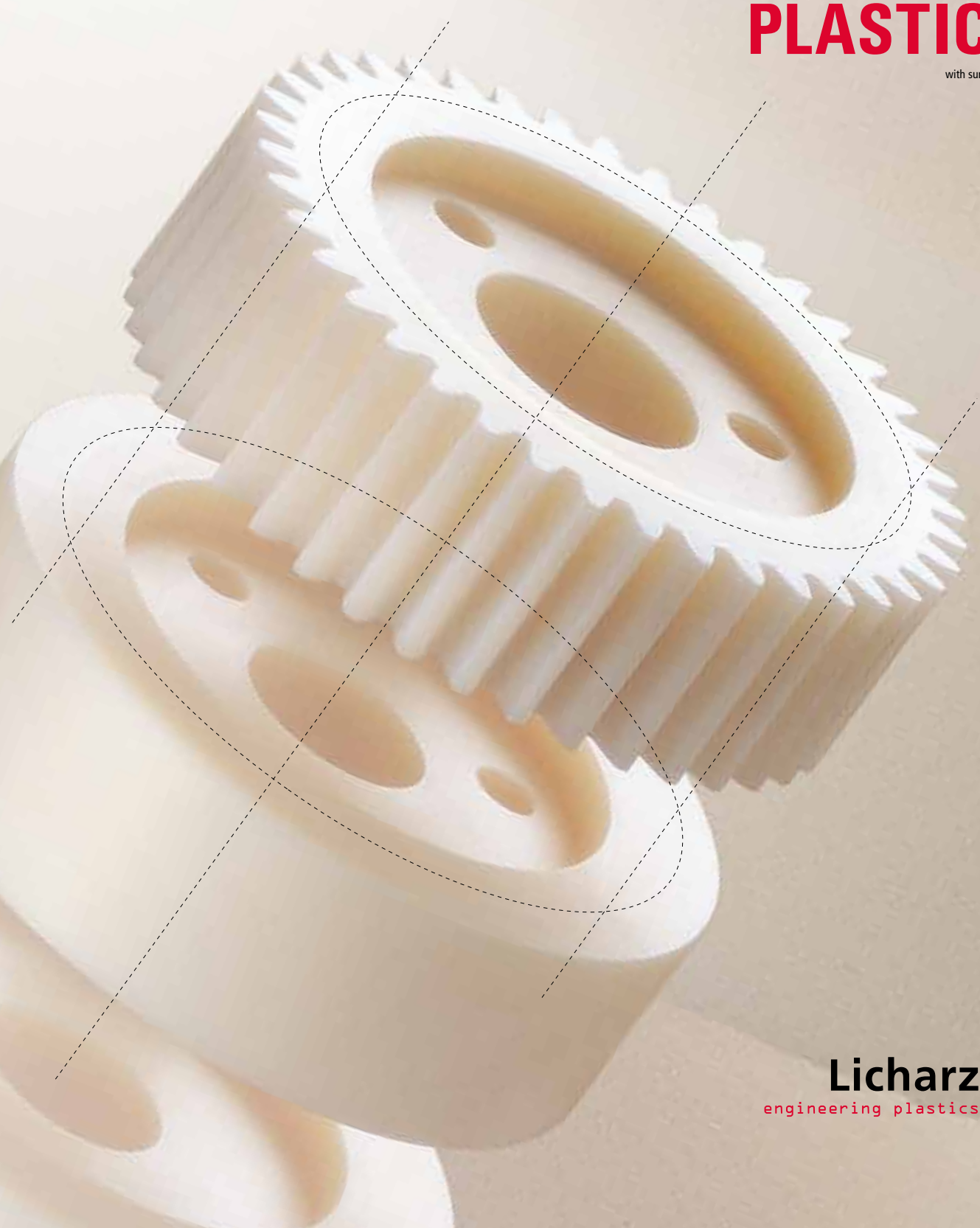

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POLYAMIDES

The competitive edge through engineered components made of plastic

The material

Polyamides are subdivided into various basic types. PA 6, PA 66 and PA 12 have established themselves as the most important for technical applications. Apart from the standard versions there are a large number of polyamides from which the basic types are specifically treated with additives for the requirements of special applications.

In the production of semi-finished products, a distinction is made between the manufacturing processes of extrusion and casting. The performance of extruded polyamide semi-finished products, however, has various disadvantages. The limits of manufacturing size are reached quickly. In addition the properties of the extruded materials are negatively affected because this process remolds the materials under temperature/pressure. The extrusion screw and tooling also cause shearing stress and breaks in the polymer matrix. Polyamides manufactured in monomer casting show a higher degree of crystallinity and thus have much better material properties than the extruded types.

In any case, all polyamides share, independently of their manufacturing process, a large number of basic properties specific to the material.

The key properties of polyamide are:
- High mechanical strength, hardness, rigidity and toughness
- High mechanical damping properties
- Good fatigue resistance
- Very high wear resistance
- Good sliding and emergency running properties
- Good machining properties

Extruded polyamides

Polyamide 6 (PA 6) is the best known extruded polyamide and offers a balanced combination of all typical polyamide material properties. Compared to the cast variants however, it absorbs more moisture, has much lower wear resistance and less dimensional strength. Furthermore, because of the manufacturing process, only a limited size range and unit weight can be produced. This restricts the design possibilities of the user.

The main properties of PA 6 are:
- Good mechanical strength
- high impact resistance
- good damping properties

Typical application examples are:
- Gears
- hammer heads
- impact and shock resistant components

Polyamide 66 (PA 66)
is used in smaller dimensioned applications and offers higher rigidity and wear resistance compared to PA 6. Compared to the cast variants, this material also displays higher water absorption. As regards to the other properties, PA 66 is comparable to the standard cast type **LiNNOTAM**, but is far more expensive. As with PA 6, the manufacturing process limits the size and unit weight which can be produced, and this restricts the user's design possibilities. Therefore PA 66 in practical application is replaced to a large extent by the more economical **LiNNOTAM**, which can also be produced in almost unlimited weights and sizes.

The main properties of PA 6 are:
- Good mechanical strength
- high impact resistance
- good damping properties
- good wear resistance

Typical application examples are:
- Friction bearings
- slide plates
- gears

Polyamide 66 + 30% Glass fibre (PA 66 GF 30)
Compared to unreinforced PA 66 an improved tensile/compressive strength, rigidity and dimensional stability are achieved due to the glass fibre as well as lower water absorption. Glass fibre reinforced Polyamide 66 is therefore particularly suitable for components where higher loads occur and/or increased demands are placed on the dimensional stability.

Polyamide 12
has very good impact behaviour, it is tough and is dimensionally stable due to its very low water absorption. It is available in small quantities as semi-finished products, but is not generally considered for construction applications due to its high price (3-4 times more expensive than PA 6).

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POM/PET

The competitive edge through engineered components made of plastic

Polyacetal (POM)

Polyacetal is a high crystalline thermoplastic with high strength and rigidity as well as good sliding properties and wear resistance with a low level of moisture absorption. Its good dimensional stability, exceptional fatigue resistance as well as excellent machining properties make Polyacetal a versatile design material also for complex components. POM satisfies high surface finish requirements.

Strength, rigidity and dimensional stability can be further improved by adding glass fibres as a filler, although this decreases sliding properties.

A distinction is made between homopolymers (POM-H) and copolymers (POM-C); homopolymers have a higher density, hardness and strength due to their higher degree of crystallinity. However, copolymers have a higher impact resistance, greater abrasion resistance and better thermal/chemical resistance.

The Polyacetal semi-finished products that we offer – from which we also manufacture finished products – are produced from copolymers in an extrusion process.

Main properties
- High strength
- High rigidity
- High hardness
- Good impact resistance, also at low temperatures
- Low level of moisture absorption (at saturation 0.8%)
- Good creep resistance
- High dimensional stability
- Resistant to hydrolysis (up to +60 °C)
- Physiologically safe

Colours
POM-C: natural/black
POM-C + GF: black.

Sliding properties
POM-C has excellent sliding properties and good wear resistance. Combined with its other outstanding properties, POM-C is well suited for use in sliding applications at medium to high loads. This also applies to applications where high levels of humidity or moisture are expected.

Due to the closely spaced static and dynamic coefficient of friction low starting torques can be implemented.
Glass filled types are the exception here as the sliding properties are significantly worse compared to the unfilled types.

Weathering effects
POM-C is not resistant to UV rays. The surface oxidizes when subjected to UV radiation in combination with oxygen and becomes stained or dull. With long-term exposure to UV radiation, the material tends to become brittle.

Polyacetal (POM)

Chemical resistance
POM is resistant to weak acids, weak and strong alkaline solutions, organic solvents and petrol, benzene, oils and alcohols.

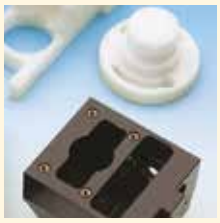
POM-C is not resistant to strong acids (pH < 4) or oxidising materials.

Behaviour in fire
POM-C is rated as normal flammable. When the source of ignition is removed, POM-C continues to burn, forming droplets. During thermal decomposition, formaldehyde can form. The oxygen index (= the oxygen concentration required for combustion) at 15% is very low compared to other plastics.

Areas of use
- General machine engineering
- Vehicle construction
- Precision mechanics
- Electrical industry
- Information technology

Applications
- Spring elements
- Bushes
- Gears
- Sliding elements
- Insulators
- Pump components
- Casing parts
- Valves and valve bodies
- Counter parts
- Precision parts





Machining
POM-C develops a fragmented chip and is thus ideally suited for machining on automatic lathes, but it is also possible to machine it on cutting machine tools. The semi-finished products can be drilled, milled, sawed, planed and turned on a lathe. It is also possible to cut threads or insert threaded parts in the material. Generally no cooling or lubricating emulsion is necessary.

To limit material deformation due to internal residual stress in semi-finished products, the parts should always be machined from the geometrical centre of the semi-finished product, removing an even quantity of material from all sides.

If maximum dimensional stability is demanded from the finished components, the parts to be manufactured should be rough pre-machined and stored for an interim period or heat treated. The parts can then be completed. More detailed information on interim storage and heat treatment, as well as other information about machining, is provided in the chapter on “Machining guidelines”.

Polyethylene terephthalate (PET)

The molecule structure of polyethylene terephthalate can be produced either as an amorphous or semi-crystalline thermoplastic. The amorphous type is crystal clear with lower mechanical stability and inferior sliding properties.

The semi-crystalline types, on the other hand, have a high level of hardness, rigidity and stability with excellent sliding properties and low sliding abrasion. Because of its good creep resistance, low level of moisture absorption and excellent dimensional stability, the material is ideally suited for complex parts with the highest demands on dimensional stability and surface finish. For the reasons mentioned above, only the semi-crystalline type is suitable for sliding applications.

The wear resistance and sliding properties of PET-GL have been improved compared to pure PET by adding a special, homogeneously distributed solid lubricating agent.

The PET semi-finished products that we offer – and from which we also manufacture all finished products – are manufactured from semi-crystalline types in an extrusion process.

Main properties
- High stability
- High rigidity
- High hardness
- Low moisture absorption (at saturation 0.5%)
- Very good creep resistance
- Very high dimensional stability
- Constantly low sliding friction
- Very little sliding abrasion
- Resistant to hydrolysis (up to +70 °C)
- Physiologically safe

Colours
PET: natural, black
PET-GL: light grey.

Sliding properties
PET has excellent sliding properties, very good wear resistance and, in combination with its other properties, is an excellent material for highly loaded sliding applications. This also applies to applications where high levels of humidity or moisture are expected.

The modified type PET-GL is especially suitable for highly loaded sliding applications in dry running operations due to its integrated solid lubricating agent. The solid lubricating agent “self-lubricates” the PET-GL, which gives it excellent sliding properties and highest wear resistance with a much higher load-bearing strength (pv limiting value) compared to pure PET. It also prevents the stick-slip effect. The other properties are equal to those of pure PET.

Polyethylene terephthalate (PET)

Weathering effects

PET is not resistant to UV rays. The material surface changes when subjected to UV rays in combination with atmospheric oxygen. If the material is to be subjected to UV rays for longer periods, a black coloured type is recommended.

Chemical resistance

PET is resistant to weak acids and alkaline solutions, salt solutions, perchlorinated and fluorinated hydrocarbons, oils, fuels, solvents and surface-active substances. Strong polar solvents have an irreversible swelling effect. PET is not resistant to strong acids or alkaline solutions, esters, ketones or chlorinated hydrocarbons.

Behaviour in fire

PET is rated as normal flammable. When the source of ignition is removed, PET continues to burn, forming droplets. The oxygen index (the oxygen concentration required for combustion) at 23% is average compared to other plastics.

Areas of use

- General machine engineering
- Vehicle construction
- Precision mechanics
- Electrical industry
- Information technology

Applications

- Ratchet wheels
- Bushes
- Gears
- Sliding elements
- Insulators
- Casing parts
- Counter components
- Precision bearings
- Cam disks

Machining

PET develops a brittle, flowing chip and is suitable for machining on automatic lathes, but it can also be machined on cutting machine tools. The semi-finished products can be drilled, milled, sawed, planed and turned on a lathe. It is also possible to cut a thread into the material or insert a threaded element. Generally no cooling or lubricating emulsion is necessary.

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