Autodesk® Moldflow® Communicator 2012

Materials and databases

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Materials and databases 1

There are a vast range of materials that can be used to produce a plastic part, each contributing different qualities to the final product. To achieve the most accurate analysis results, it is important that the material you select for the simulation is similar to the actual material you have chosen for the part.

Autodesk Moldflow provides a wide variety of materials databases, which include thermoplastic materials, fillers, coolants, thermoset materials, and others depending upon your analysis.

Material testing and data fitting

Accurate material properties data is critical to achieving accurate simulation results. Autodesk Moldflow Plastics Labs offers material testing and data fitting services to support the material databases for Autodesk Moldflow software.

Autodesk Moldflow Plastics Labs is the leader in material characterization for plastics processing, with more than 25 years of experience testing more than 8,000 grades of thermoplastic and thermosetting materials. A comprehensive range of tests that provide complete and accurate material characterization data is available. For more information about current material testing services or to order tests, contact datafittingmoldflow@autodesk.com.

Material data must be correctly fitted and formatted for use with Autodesk Moldflow software. Autodesk Moldflow Plastics Labs accepts data for inclusion in the material database if it meets our quality and traceability standards. For more about data fitting services, contact datafittingmoldflow@autodesk.com.

Visit the Autodesk website for more detailed information about material testing and data fitting services offered by Autodesk Moldflow Plastics Labs.

Material properties

Plastics are assigned to different families, based on various properties, such as crystallinity, reaction to heat and their chemical composition.

Thermoplastic material characteristics

The important material characteristics to consider when selecting a thermoplastic material grade are described.

Crystallinity

The crystallinity of a material identifies the state of the polymer at processing temperatures, and can range from amorphous to crystalline states. Amorphous polymers are devoid of any stratification and retain this state at ambient conditions. Crystalline polymers have an ordered arrangement of plastic molecules, enabling the molecules to fit closer together.

The extent of crystallinity is a function of temperature and time. Rapid cooling rates are associated with lower levels of crystalline content and vice versa. In injected molded parts, thick regions cool slowly relative to thinner regions, and therefore have a higher crystalline content and volumetric contraction.

Mold and melt temperature

The mold temperature is the temperature of the surface of the mold that comes in contact with the polymer. Mold temperature affects the cooling rate of the plastic, and it cannot be higher than the ejection temperature for a particular material.

The temperature of the molten plastic is the melt temperature. Increasing the melt temperature reduces the viscosity of a material. Additionally, a hotter material will decrease the frozen layer thickness. Decreasing the frozen layer reduces shear stress because flow constriction is less. This results in less material orientation during flow.

Thermal properties

The **specific heat (Cp)** of a material is the amount of heat required to raise the temperature of a unit mass of material by one degree Celsius. Essentially, it is a measure of the ability of a material to convert heat input to an actual temperature increase which is measured at atmospheric pressure and a range of temperatures up to the maximum processing temperature of the material.

The **thermal conductivity** (**k**) of a material is the rate of heat transfer by conduction per unit length per degrees Celsius. Thermal conductivity is a measure of the rate at which a material can dissipate heat. This rate is measured under pressure and at a range of temperatures. The unit of measure is **W/m-C** , watts per meter Celsius.

Viscosity

The viscosity of a material is a measure of its ability to flow under an applied pressure. Polymer viscosity is dependent on temperature and shear rate. In general, as the temperature and shear rate of the polymer increases, the viscosity decreases, indicating a greater ability to flow under an applied pressure. The material database provides a viscosity index for materials in the **Rheological Properties** tab to enable you to compare ease of flow. The viscosity index assumes a shear rate of 1000 reciprocal seconds and shows the viscosity at the temperature that is specified in parentheses.

pvT data

Autodesk provides pvT models to account for material compressibility during a Fill or Fill+Pack analysis. A pvT model is a mathematical model using different coefficients for different materials, providing a curve of pressure against volume against temperature.

An analysis based on pvT data is more accurate but the iterations for temperature and pressure at each point in the model increase computational intensity. However, this suits complex models that have sudden and large changes in thickness.

Shrinkage

As plastics cool, volumetric shrinkage causes their dimensions to change significantly. The main factors that affect shrinkage are cool orientation, crystallinity, and heat concentrations.

Optical properties

Transparent plastic under stress can exhibit stress birefringence, where the speed of light through the part depends on the polarization of the light. Birefringence can result in double images and the transmission of unevenly-polarized light. Some materials are more prone to stress birefringence than others.

Composite materials

Composite materials contain fillers that are added to polymers for injection molding. Fillers increase the strength of the polymer and help ensure that good quality parts are produced. Most commercial composites contain 10 to 50 percent of fibers by weight. These are regarded as being concentrated suspensions where both mechanical and hydrodynamic fiber interactions apply. In composites that are injection molded, the fiber orientation distributions show a layered nature and are affected by the filling speed, the processing conditions, and the behavior of the material.

Environmental Impact

Different materials can have different environmental impacts. The polymer family to which a material belongs to can provide an initial indication of processibility and potential recyclability of a material. The Resin Identification code of a selected material is provided to help identify the polymer family.

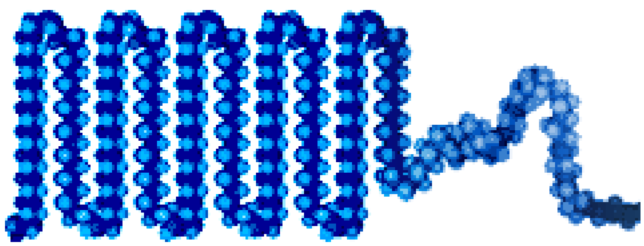
Minimizing the energy consumption of the injection molding process provides both cost and environmental benefits. Based on the predicted Injection Pressure and Cooling Time for a suite of part geometries and thickness, an Energy usage indicator has been developed for each material in the thermoplastic material database. This provides an indication of the relative energy requirements to produce a part from any given material.

The Resin identification code and the Energy usage indicator are both stored in the thermoplastic material data.

Material crystallinity

Material crystallinity is the process whereby liquid material solidifies into a transparent crystal-like state.

The molecules in plastics are long chains of atoms, as shown in the following diagram. These long molecular chains may be regularly aligned, which create a crystalline structure; or randomly arranged chains, which create an amorphous structure; or a combination of crystalline and amorphous sections which creates a semi-crystalline structure.



Shrinkage, warpage, and crystallinity

A part will not warp if it shrinks uniformly in all directions and in all areas of the mold.

Crystalline materials have a naturally higher shrinkage than amorphous materials. This means that a part with variations in crystallinity will also have variations in shrinkage, and therefore will probably warp.

How crystallinity develops

Semi-crystalline materials have a tendency to crystallize, but their degree of crystallinity present is affected by the cooling rates of the melt. The faster the melt freezes, the less time there is available for the crystalline sections of the plastic to form.

If parts of the molding cool at a slower rate, these areas will have a higher crystalline content, hence higher shrinkage.

Two main factors affect how fast the melt freezes:

Mold temperature	The higher the mold temperature, the longer the temperature will be maintained, which delays the cooling of the melt.
Mold geometry	Thick regions tend to cool slower than thinner sections and therefore have higher crystalline content and higher volumetric shrinkage than thin sections that cool quickly and so are more amorphous.Thin regions can

have a lower volumetric shrinkage than that predicted from equilibrium pvT data.

Semi-crystalline material families

Semi-crystalline materials have both crystalline and amorphous regions.

The Autodesk Moldflow materials database contains the following semi-crystalline materials:

HDPE
HTN
LDPE
LLDPE
LMDPE
PA
PA12
PA46
PA6
PA610
PA612
PA66
PA666
PA66T
PA6T
PA6T/61
PA6T/66
PBT
PE
POM
POM-HI
PP
PP/EPDM
PP/EPR
PP/PE
TPE
TPO
TPR
UHMWPE
VHMWPE

Thermoset materials

Cross-linking is a chemical process in which chemical bonds form among molecules of thermosetting materials, resulting in an interconnected network. This cross-linking process is the principal difference between thermoplastics and thermosets.

Prior to molding, the chain-like structure of thermosets is similar to thermoplastics. During processing, with the activation of heat and/or chemical means, thermosets polymerize (react or cure) into a cross-linked microstructure. Once the reaction is completed, the polymer chains are bonded (cross-linked) together to form a three-dimensional network. These cross bonds among molecules prohibit the slippage of individual molecular chains.

Consequently, a thermoset becomes an infusible and insoluble solid that cannot be re-softened and reprocessed by the application of heat, without degrading some linkages. Thermosets are analogous to hard-boiled eggs, where the yolk has turned from a liquid to a solid and cannot be converted back to a liquid.

The table below compares the structure and properties of thermosets and thermoplastics.

Material	Thermoplastics	Thermosets
Microstructure	Linear or branch molecules. No chemical bonds among the molecules.	Cross-linking network with chemical bonds among molecules after the chemical reaction.
Reaction to Heat	Can be re-softened (physical phase change).	Cannot be re-softened after cross-linking without degradation.
General Properties	Higher impact strength. Easier processing. Better adaptability to complex designs.	Greater mechanical strength. Greater dimensional stability. Better heat and moisture resistance.

Environmental impact

Users have the option to consider the environmental aspects of the materials being used.

Materials will typically be selected on criteria such as strength and functionality of the finished part. Once these primary considerations have been met, environmental factors can help finalize material selection.

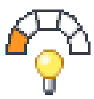
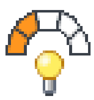
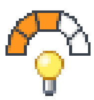
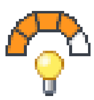
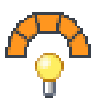
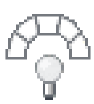
NOTE: The classifications are for the base polymer only. The effect of fillers and additives should be reviewed seperately.

Energy usage indicator

The Energy usage indicator is a relative assessment of the energy requirements of the molding phase of a part, based on the material selected. The result of this assessment is a relative value derived from the injection pressure and cooling time predictions for a suite of typical geometries and thicknessess using the material's recommended conditions and processing inputs determined by an optimization calculation.

These results were standardized and an Energy usage indicator value was applied.

It is expected that existing polymer Energy usage indicator ratings will change as more environmentally efficient polymers are developed.

Energy usage indicator	Value
	Least energy required for the production of a part
	
	
	
	Most energy required for the production of a part
	Not available

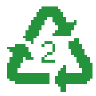
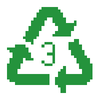
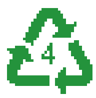
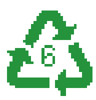
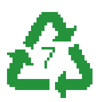
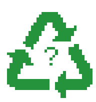
NOTE: The Energy usage indicator may not available for two reasons:

- Legacy material data from a personal database or a previous study may not include environmental information. Reload the material from the current database to view these parameters.
- The calculations for a small number of materials cannot return an injection pressure or cooling time for all the geometries tested.

Resin identification code

This code identifies the resin family to which the material belongs.

NOTE: Any materials that are a blend or contain fillers have been included in the *Other* category.

Icon	Plastic family
	Polyethylene terephthalate (PET, PETE)
	High density polyethylene (HDPE)
	Polyvinyl chloride (PVC)
	Low density polyethylene (LDPE)
	Polypropylene (PP)
	Polystyrene (PS)
	Other. Incudes any resin not specifically listed. This category also includes all materials that are blends or contain fillers.
	Undetermined, for example, legacy data

Material Quality Indicators

Because of the importance of quality material data on analysis accuracy, Autodesk Moldflow Plastics Labs have developed Material Quality Indicators.

There are three different indicators that reflect the confidence you can have in the material data, for different analysis requirements.

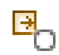
Fill Quality Indicator	Investigates the quality of the Viscosity, Specific Heat Capacity and Thermal Conductivity data.
Packing Quality Indicator	Incorporates the quality of the Fill Quality Indicator results and the pvT data. The Packing Quality Indicator cannot exceed the Fill Quality Indicator.

Warpage Quality Indicator	Incorporates the suitability of the Packing Quality Indicator along with the Mechanical Property and Shrinkage data. The Warpage Quality Indicator cannot exceed the Packing Quality Indicator.

Each indicator can be assigned a Gold, Silver or Bronze rating based on the following criteria.

- Testing method employed to generate the value of each material property.
- Completeness of the range of material properties needed for the analysis type.
- How recently the testing was completed.

Table 1: Material Quality Indicator icons

	Gold	Silver	Bronze	Unknown
Fill Quality				
Packing Quality				
Warpage Quality				

A Gold rating indicates a high confidence in the quality of the material data for the analysis type. When accurate analysis results are critical, it is recommended that a material with a Gold rating should be used.

A Silver rating can result from a combination of well tested, and supplemental[1] material data. For example, a material might have a Gold Packing Quality rating but use supplemental Mechanical Properties data. This could result in a Silver Warpage Quality Indicator rating.

Bronze ratings can reflect problems such as incomplete data sets, the extensive use of supplemental data and untested material properties. The use of Bronze-rated materials can still generate good results, but these results should not be relied upon to determine critical requirements such as precise warpage or shrinkage allowances used for the cutting of molds.

An unknown rating indicates a material that has been used in an earlier version of the software. Re-selecting the same material will update the Material Quality Indicators.

The rating for a material is displayed in the **Study Tasks** pane of a study. Hover the mouse over an icon for the rating to be displayed.

[1] Supplemental data are untested parameter values that are typical for that material family. In the Thermoplastic material dialog, any group of parameters (e.g. Mechanical properties data) that are highlighted in red, indicate that the values used are supplemental.

Materials

Autodesk Moldflow provides a variety of databases for you to select materials from. These databases include materials for parts, molds, and more.

Part materials

There are many different types and grades of plastics available. The end use of the part can help determine the most suitable plastic for a given application.

Thermoplastic materials

Different materials have different uses and applications.

Follow the links for detailed descriptions of Autodesk Moldflow generic materials.

ABS materials

Acrylonitrile-Butadiene-Styrene (ABS) offers superior processibility, appearance, low creep, excellent dimensional stability, and high impact strength.

Typical Applications

- automotive
  - instrument panels
  - interior trim panels
  - glove compartment doors
  - wheel covers
  - mirror housings
- refrigerators
- small appliance housings
- power tools applications
  - hair dryers
  - blenders
  - food processors
  - lawnmowers
- recreational vehicles
  - golf carts
  - jet skis
- telephone housings

Injection Molding Processing Conditions

Drying	ABS grades are hygroscopic and drying is required prior to processing. Suggested drying conditions are 80°C–90°C [176°F–195°F] for a minimum of 2 hours. The material moisture content should be less than 0.1%.
Melt Temperature	200°C–280°C [392°F–536°F]; Aim: 230°C [446°F]
Mold Temperature	25°C–80°C [77°F–176°F]. Mold temperatures control the gloss properties; lower mold temperatures produce lower gloss levels.
Material Injection Pressure	50 –100 MPa
Injection Speed	Moderate–high

Chemical and Physical Properties

ABS is produced by a combination of three monomers: acrylonitrile, butadiene, and styrene. Each of the monomers impart different properties: hardness and chemical and heat resistance from acrylonitrile; processibility, gloss, and strength from styrene; and toughness and impact resistance from butadiene. Morphologically, ABS is an amorphous material.

The polymerization of the three monomers produces a terpolymer which has two phases: a continuous phase of styrene-acrylonitrile (SAN) and a dispersed phase of polybutadiene rubber. The properties of ABS are affected by the ratios of the monomers and molecular structure of the two phases. This facilitates a high level of flexibility in product design and consequently, there are hundreds of grades available in the market. Commercially available grades offer different characteristics, such as medium to high impact, low to high surface gloss, and high heat distortion.

HDPE materials

High-density polyethylene (HDPE) is an odorless, tasteless, and nontoxic polymer that makes it suitable for food contact applications. HDPE has greater tensile strength, heat distortion temperature, viscosity, and chemical resistance than LDPE, but has a lower impact strength.

Typical Applications

- containers in refrigeration units
- storage vessels
- household goods (kitchenware)
- seal caps
- PET bottle bases
- blow-molding (packaging applications)

Injection Molding Processing conditions

Drying	Not normally necessary if stored properly.
Melt Temperature	180°C–280°C [356°F–536°F]; for high molecular weight grades, the suggested melt temperature range is 200°C–250°C [392°F–482°F]
Mold Temperature	20°C–95°C [68°F–194°F] The higher temperatures are for wall thickness of up to 6 mm; lower temperature for wall thicknesses greater than 6 mm.
Material Injection Pressure	70 MPa–105 MPa
Injection Speed	High injection velocity is recommended; profile injection velocity can be used to reduce warpage in the case of components with a large surface area.

Runners and Gates

Diameters of runners range from 4 mm–7.5 mm (typically 6 mm). Runner lengths should be as short as possible. All types of gates can be used. Gate lands should not exceed 0.75 mm in length. Ideally suited for hot runner molds; an insulated hot tip runner is preferred when there are frequent color changes.

Chemical and Physical Properties

HDPE is produced from the polymerization of ethylene; lower temperature and pressure conditions are used compared to the production of low-density polyethylene. The material is free from branching and this is made possible by the use of stereospecific catalysts. Because of molecular regularity, HDPE has a high level of crystallinity compared to LDPE.

Higher levels of crystallinity contribute to higher density, tensile strength, heat distortion temperature, viscosity, and chemical resistance. HDPE is more resistant to permeability than LDPE. The impact strength is lower. The properties of HDPE are controlled by the density and molecular weight distributions. Injection molding grades typically have a narrow molecular weight distribution.

When the density is 0.91 g/cm^3–0.925 g/cm^3, the material is known as Type 1; Type 2 materials have densities in the range of 0.926 g/cm^3–0.94 g/cm^3, and Type 3 materials have densities in the range of 0.94 g/cm^3–0.965 g/cm^3.

The material flows easily and the melt mass-flow rate (MFR) ranges from 0.1–28. Higher molecular weights (lower MFR grades) have better impact resistance.

Being a semicrystalline material, the molding shrinkage is high (order of 0.015 mm/mm–0.04 mm/mm [1.5%–4%]). This depends on the degree of orientation and the level of crystallinity in the part, which in turn depends on processing conditions and part design.

PE is susceptible to environmental stress cracking, which can be minimized by proper design and by using the lowest MFR material at a particular density level. HDPE is soluble in hydrocarbons at temperatures greater than 60°C, but resistance to these materials is greater than that for LDPE.

LDPE materials

LDPE (Low Density Polyethylene) is an odourless, tasteless and nontoxic polymer that makes it suitable for food contact applications. LDPE has higher impact strength than HDPE, but lower tensile strength, viscosity, and chemical resistance.

Typical Applications

- closures
- bowls
- bins
- pipe couplings

Injection Molding Processing Conditions

Drying	Not usually necessary
Melt Temperature	180°C–280°C [355°F–535°F]
Mold Temperature	20°C–70°C [68°F–158°F]
Material Injection Pressure	Up to 150 MPa
Pack Pressure	Up to 75 MPa
Injection Speed	Fast speeds are recommended; profiled speeds can limit warpage problems of large surface area parts.

Runners and Gates

All conventional types can be used; LDPE is suitable for hot runner molds. Insulated hot tip runners are preferred for frequent color changes.

Chemical and Physical Properties

LDPE is produced by the polymerization of ethylene at high pressure and temperature. The material is semicrystalline-crystalline. The crystallinity level is low because of chain branching. The material is tough but possesses moderate tensile properties and exhibits creep. However, it has good impact and chemical resistance. It is an easy flow material because of long chain branching.

Commercial materials have densities in the range of 0.91–0.94 g/cm^3. LDPE is permeable to gases and vapors. Very close tolerances are not possible with this material and its relatively large coefficient of thermal expansion makes it less suitable for long-term applications.

Shrinkage is of the order of 0.02–0.05 mm/mm [2–5%] when density is between 0.91–0.925 g/cm^3. When density is between 0.926–0.04 g/cm^3, the shrinkage is of the order of 1.5–4%. Actual shrinkage values are dependent on the molding conditions.

LDPE is resistant to many solvents at room temperatures, but aromatic and chlorinated hydrocarbons cause swelling. Like HDPE, it is also susceptible to environmental stress cracking.

PA12 materials

Polyamide 12 or Nylon 12 (PA12) is an effective electrical insulator and its properties are not as sensitive to humidity as other polyamides. PA12 has good resistance to shock and many chemicals, and is extensively modified with plasticizers and reinforcements. In comparison to PA6 and PA66, PA12 materials have a lower melting point, lower density, and much lower moisture regain. PA12 is not resistant to strong oxidizing acids.

Typical Applications

- gear wheels
  - water meters
  - business machines
- cable ties
- cams
- slides
- bearings

Injection Molding Processing Conditions

Drying	The moisture content must be below 0.1% prior to processing. If the material is exposed to air, drying in a hot air oven at 85°C [185°F] for 4 -5 hours is recommended (3-4 hours in a desiccant dryer). If the container is unopened, it can be used directly for molding after 3 hours of equilibration to shop floor temperature.
Melt Temperature	230°C–300°C [446°F–580°F]; not to exceed 310°C [590°F] for standard grades and 270°C [518°F] for flame retardant grades
Mold Temperature	30°C–40°C [86°F–104°F] for unreinforced grades; for thin-walled or large surface area components, 80°C-90°C [176°F–194°F] can be used; 90°C–100°C [194°F–212°F] for reinforced grades. Increasing the mold temperature increases the crystallinity level. It is

	very important to precisely control the mold temperature.
Material Injection Pressure	Up to 100 MPa. Low hold pressures and high melt temperatures are recommended.
Injection Speed	High; high speeds give better finish on glass-filled grades.

Runners and Gates

Runner diameters for unfilled grades can be as small as 3–5 mm because of the low viscosity of the material. Reinforced grades require larger diameters (5–8 mm). The runner shape should be the full round type. Sprues should be as short as possible.

A variety of gates can be used. To avoid highly stressed components or excessive shrinkage, small gates should not be used for large parts. The thickness of the gate should be equal to the part thickness. When using circular tapered gates, the minimum recommended diameter is 0.8 mm.

Hot runner molds can be used effectively but precise temperature control is necessary to prevent material drooling or freezing off at the nozzle. The size of the gates can be smaller when hot runners are used instead of cold runners.

Chemical and Physical Properties

PA12 is a linear, semicrystalline-crystalline thermoplastic derived from butadiene. The properties of PA12 and PA11 are similar, but PA12 has a different crystal structure.

Viscosity is determined by water content, temperature, and residence time. This material flows easily. Shrinkage is of the order of 0.005–0.02 mm/mm [0.5–2%]. This is dependent on the specific grade, wall thickness, and processing conditions.

PA6 materials

Polyamide 6, Nylon 6, or polycaprolactam (PA6) is one of the major engineering thermoplastics. PA6 is tough, has excellent abrasion resistance, good chemical resistance, fatigue endurance, lubricity, impact strength, high strength, and rigidity.

Applications

- structural applications
- bearings

Injection Molding processing conditions

Drying	Since PA6 absorbs moisture readily, care should be taken to ensure its dryness prior to molding. If the material is supplied in watertight packaging, the containers should be kept closed. If the moisture content is >0.2%, drying in a hot air oven at 80°C [176°F] for 16 hours is recommended. If the material has been exposed to air for more than 8 hours, vacuum drying at 105°C [221°F] for more than 8 hours is recommended.
Melt Temperature	■ 230°C–280°C [446°F–536°F] ■ 250°C–300°C [482°F–572°F] for reinforced grades
Mold Temperature	Mold temperature significantly influences the crystallinity level which in turn affects the mechanical properties. ■ 80°C [176°F] or greater. Glass reinforced materials are always processed at higher mold temperatures. ■ 80°C–90°C [176°F–194°F]. For structural parts, a high degree of crystallization is required. Increasing the mold temperature increases the strength and hardness, but the toughness is decreased. High mold temperatures are also recommended for thin-walled parts with long flow lengths. ■ [20°C–40°C / 68°F–104°F]. To achieve a higher and more uniform degree of crystallinity, a cold mold is recommended for parts with a wall thickness greater than 3 mm.
Material Injection Pressure	Generally between 75MPa–125 MPa (depends on material and product design)
Injection Speed	High (slightly lower for reinforced grades)

Runners and Gates

The gate location is important because of very fast freeze-off times. Any type of gate can be used; the aperture should not be less than half the thickness of the part. When hot runners are used, the size of the gates can be smaller than when cold runners are used. When using circular tapered gates, the minimum diameter of the gate should be 0.75 mm.

Chemical and Physical Properties

The molecular structure of polyamides consists of amide (CONH) groups joined by linear aliphatic sections (based on methylene groups). The toughness, rigidity, crystallinity, and thermal resistance of polyamide materials are due to the strong interchain attraction caused by the polarity of the amide groups. The CONH groups also cause a lot of moisture absorption.

Nylon 6 is produced by polymerization of caprolactam. The chemical and physical properties are similar to that of PA66. However, its melting point is lower than PA66 and it has a wider processing temperature range. Its impact strength and solvent resistance are better than PA66, but its moisture absorption is higher. Many properties are affected by moisture absorption, which must be taken into account when designing with these grades. Various modifiers are added to improve mechanical properties; glass is one of the most commonly used fillers. The addition of elastomers, such as EPDM or SBR, improves impact resistance.

For unfilled grades, shrinkage is of the order of .01–.015 mm/mm [1–1.5%]. The addition of glass fibers reduces the shrinkage to as low as 0.3% in the flow direction, but this could be as high as 1% in the cross-flow direction. The post-molding shrinkage is affected mainly by the crystallinity level and moisture absorption. The actual shrinkage is a function of part design, wall thickness, and processing conditions.

PA66 materials

Poly (hexamethylene adipamide), Polyamide 66, or Nylon 66 (PA66) is an engineering-grade thermoplastic. PA66 has higher strength but lower impact resistance than PA6.

Applications

- automotive industry
- appliance housings
- generally where impact resistance and strength are required

Competes with PA6 for most applications.

Injection Molding Processing conditions

Drying	Drying is not required if the material is sealed prior to molding; however, if the containers are left open, drying in a hot air oven at 85°C [185°F] is recommended. If the moisture content is > 0.2%, vacuum drying at 105°C [220°F] for 12 hours is recommended.
Melt Temperature	260°C–290°C [500°F–554°F] 275°C–280°C [527°F–536°F] for glass filled grades. Melt temperatures above 300°C [572°F] should be avoided.
Mold Temperature	80°C [176°F] suggested. Mold temperature affects crystallinity level which in turn affects physical properties. In the case of thin-walled parts, crystallinity

	changes with time when mold temperatures of less than 40°C [104°F] are used. In such cases, annealing may be needed to retain dimensional stability.
Material Injection Pressure	Generally between 75MPa–125 MPa, depending on material and product design.
Injection Speed	High (slightly lower for reinforced grades)

Runners and Gates

The gate location is important because of very fast freeze-off times. Any type of gate can be used; the aperture should not be less than half the thickness of the part. When hot runners are used, the size of the gates can be smaller than when cold runners are used, because premature freeze-off is prevented. When using circular tapered gates, the minimum diameter of the gate should be 0.75 mm.

Chemical and physical properties

PA66 homopolymer is produced by the polymerization of hexamethylene diamine and adipic acid (a dibasic acid). PA66 is a semicrystalline-crystalline material with one of the highest melting points among commercially available polyamides. The grades have strength and stiffness that is retained at elevated temperatures. PA66 does absorb moisture after molding, but retention is not as high as PA6. Moisture absorption depends on the composition of the material, wall thickness, and environmental conditions. Dimensional stability and properties are all affected by the amount of moisture absorption, which must be taken into account for product design.

Various modifiers are added to improve mechanical properties; glass is one of the most commonly used fillers. The addition of elastomers, such as EPDM or SBR, improves impact resistance.

Although it does not flow as easily as PA6, the viscosity of PA66 is low so it flows easily, which enables the molding of thin components. The viscosity is very sensitive to temperature.

Shrinkage is of the order of 0.01–0.02 mm/mm [1–2%]. The addition of reinforcing glass fibers reduces the shrinkage to 0.2–1%. Differential shrinkage in the flow and cross-flow directions is quite high. Mineral fillers yield more isotropic moldings.

PA66 is resistant to most solvents, but not to strong acids or oxidizing agents.

PBT materials

Polybutylene Terephthalate (PBT) has high strength and rigidity for a wide range of applications. PBT is one of the toughest engineering thermoplastics.

Typical Applications

- household appliances
  - food processor blades
  - vacuum cleaner parts
  - fans
  - hair dryer housings
  - coffee makers
- electronics
  - switches
  - motor housings
  - fuse cases
  - key caps for computer keyboards
  - connectors
  - fiber optic buffer tubing
- automotive
  - grilles
  - body panels
  - wheel covers
  - door components
  - window components

Injection Molding Processing Conditions

Drying	This material is sensitive to hydrolysis at high temperatures. It is therefore important to dry the material prior to molding. Suggested drying conditions (in air) are 120°C [248°F] for 6–8 hours (or 150°C [300°F] for 2–4 hours). Moisture levels must be below 0.03%. When using a desiccant dryer, drying at 120°C [248°F] for 2.5 hours is recommended.
Melt Temperature	>220°C–280°C [428°F–536°F]; aim: 250°C [482°F]
Mold Temperature	40°C–60°C [104°F–140°F] for unreinforced grades. For other grades, a wide range of temperatures can be used, depending on the grade (15°C–80°C [59°F–176°F]). Heat removal must be fast and uniform. Cooling channels of 12 mm diameter are recommended.
Material Injection Pressure	Moderate (up to maximum of 150 MPa).

Injection Speed	Fastest possible speeds (due to fast solidification of PBTs)

Runners and Gates

Full round runners are recommended to impart maximum pressure transmission. A guide line for the runner diameter is part thickness + 1.5 mm. A wide variety of gates may be used. Gate diameters should preferably be between 0.8–1.0 times the part thickness. When using circular tapered gates, the minimum recommended diameter is 0.75 mm. Hot runners may also be used, taking care to avoid drool and material degradation.

Chemical and Physical Properties

PBT is a polyester that is produced by the polycondensation reaction of dimethyl terephthalate an butanediol. It is a semicrystalline material and has excellent chemical resistance, mechanical strength, electrical properties (high dielectric strength and insulation resistance), and heat resistance, all of which are stable over a broad range of environmental conditions. It has very low moisture absorption.

Tensile strength ranges from 50 MPa [7,250 psi] for unfilled grades to 170 MPa [24,650 psi] for glass reinforced grades. High levels of glass fillers make the material more brittle.

Crystallization is rapid and this could cause warpage due to non-uniform cooling. In the case of glass filled grades, shrinkage is reduced in the flow direction, but in the cross-flow direction it may be equal to that of the generic grade. Shrinkage is of the order of 0.015–0.028 mm/mm [1.5 -2.8%]. A 30% glass-filled material has a shrinkage range of 0.3–1.6%.

PBT melting point (approximately 225°C [437°F]) and heat distortion temperatures are lower than that of PET. The Vicat softening point is approximately 170°C [338°F]. The glass transition temperature ranges from 22°C–43°C [71°F–109°F].

The melt viscosity is fairly low and due to fast crystallization rates, cycle times are typically low.

PC materials

Polycarbonate (PC) is an amorphous engineering material with exceptionally good impact strength, heat resistance, clarity, sterilizability, flame retardancy, and stain resistance.

Typical Applications

- electronic and business equipment
    - computer parts
    - connectors
- appliances

    - food processors
    - refrigerator drawers

- automotive
    - head lights
    - tail lights
    - instrument panels

Injection Molding Processing Conditions

Drying	PC grades are hygroscopic and pre-drying is important. Recommended drying conditions are 100°C–120°C [212°F–248°F] for 3 to 4 hours. Moisture content must be less than 0.02% prior to processing.
Melt Temperature	260°C–340°C [500°F–644°F]; higher range for low melt mass-flow rates (MFR) grades and vice-versa.
Mold Temperature	70°C–120°C [158°F–248°F]; higher range for low MFR grades and vice-versa.
Material Injection Pressure	As high as possible for rapid molding.
Injection Speed	Slow injection speeds when small or edge gates are used; high speeds for other types of gates.

Chemical and Physical Properties

PC is a polyester of carbonic acid. All general-purpose polycarbonates are based on bisphenol A. The bisphenol A component of the molecule contributes to the high glass transition temperature (150°C [302°F]). The rotational mobility of the carbonyl group within the molecule contributes to the high ductility and toughness of the material.

The notched Izod impact strength of PC is very high and mold shrinkage is low and consistent [0.1–0.2 mm/mm].

High molecular weight PCs (which translate to low MFR) have higher mechanical properties, but processibility of such grades becomes difficult. The type of PC chosen for an application should be based on the desired criteria. For high-impact properties, use a low-MFR PC; conversely, for optimal processibility, use a high-MFR PC.

The melt viscosities are typically Newtonian up to shear rates of 1000 1/s and decrease beyond that. The Heat Deflection Temperature Under Load is typically between 130–140°C [266–284°F] and the Vicat Softening Point is typically around 155°C [311°F].

PC+ABS materials

Polycarbonate-acrylonitrile-butadiene-styrene blend (PC+ABS) combines the properties of PC and ABS, that is, the high processibility of ABS with the excellent mechanical properties and the impact and heat resistance of PC. The ratio of the two components affects the heat resistance. The blend exhibits excellent flow characteristics.

Typical Applications

- computer housings
- business machine housings
- electrical applications
- cellular phones
- lawn and garden equipment
- automotive
  - instrument panels
  - interior trim
  - wheel covers

Injection molding processing information

Drying	Drying is required prior to processing. Moisture content should be less than 0.04 % to ensure stable processing parameters. Drying at 90°C–110°C [194°F–230°F] for 2 to 4 hours is recommended.
Melt Temperature	230°C–300°C [446°F–572°F]
Mold Temperature	50°C–100°C [122°F–212°F]
Material Injection Pressure	Part dependent
Injection Speed	As high as possible

PC+PBT materials

Polycarbonate and polybutylene terephthalate blends (PC+PBT) combine the properties of PC and PBT, including the high toughness and dimensional stability of PC, and the lubricity and good chemical and heat resistance of crystalline PBT.

Typical Applications

- gear cases
- automotive bumpers
- applications which require
  - chemical and corrosion resistance

- high heat resistance
- high impact strength over wide temperature ranges
- high dimensional stability

Injection Molding Processing Conditions

Drying	110–135°C [230–275°F] for approximately 4 hours.
Melt Temperature	250–280°C [482–536°F], depending on the specific grade
Mold Temperature	40–85°C [104–185°F]

PEI materials

Polyetherimide (PEI) is an amorphous thermoplastic with a high temperature resistance, strength, and stiffness.

Typical Applications

- automotive
  - engine components
  - temperature sensors
  - fuel and air handling devices
- electrical/electronics
  - connector materials
  - printed circuit boards
  - circuit chip carriers
  - explosion proof boxes
- packaging applications
- interior aircraft materials
- medical
  - surgical staplers
  - tool housings
  - non implant devices

Injection molding processing information

Drying	PEI absorbs moisture and can cause material degradation. Moisture content should be less than 0.02%. Suggested drying conditions are 150°C [302°F] for 4 hours in a desiccant dryer (6 hours for reinforced and blended grades).

Melt Temperature	■ 340°C–415°C [644°F–780°F] reinforced grades ■ 340°C–440°C [644°F–824°F] unreinforced grades
Mold Temperature	70°C–175°C [158°F–347°F] typically 140°C
Material Injection Pressure	70MPa–150 MPa
Injection Speed	As high as possible

Chemical and Physical Properties

The chemical structure of PEI consists of repeating aromatic imide and ether units, which accounts for its high temperature resistance. This structure also leads to high stiffness and modifiers are used to make the material processible. PEIs are very stiff and strong even without reinforcements, and they have excellent thermal stability so they can be used in high temperature applications. They also have good flame and chemical resistance, and effective electrical insulation properties. The glass transition temperature is high (215°C [419°F]). PEI exhibits low shrinkage and highly isotropic mechanical properties.

PET materials

Polyethylene terephthalate (PET) has excellent chemical resistance and barrier properties, good strength, rigidity, fatigue endurance, and abrasion resistance.

Typical Applications

- automotive
  - mirror backs
  - grille supports
  - head lamp reflectors
  - alternator housings
- electrical applications
  - motor housings
  - electrical connectors
  - relays
  - switches
  - microwave oven interiors
- industrial applications
  - furniture chair arms
  - pump housings
  - hand tools

Injection molding processing conditions

Drying	Drying is essential prior to molding. PETs are very sensitive to hydrolysis. Recommended drying conditions are 120°C–165°C [248°F–329°F] for 4 hours. The moisture content should be less than 0.02%
Melt Temperature	265°C–280°C [509°F–536°F] for unfilled grades, 275°C–290°C [527°F–554°F] for glass reinforced grades
Mold Temperature	■ 80°C–120°C [176°F–248°F] ■ Preferred range: 100°C–110°C [212°F–230°F]
Material Injection Pressure	30 MPa-130 MPa
Injection Speed	High speeds without causing embrittlement

Runners and Gates

All conventional types of gates can be used. Gates should be 50–100% of the part thickness.

Chemical and Physical Properties

PET is an aromatic polyester produced from polymerization of either terephthalic acid (TPA) or dimethyl ester terephthalic acid (DMT) and ethylene glycol (EG). The glass transition is approximately 165°C [330°F] and the material crystallizes over a temperature range from 120°C–220°C [248°F–428°F].

PET is highly sensitive to moisture at high temperatures and exhibits excessive warpage when reinforced with glass fibers. Promotion of crystallinity is achieved through adding nucleating agents and crystal growth accelerators. Crystalline moldings exhibit high modulus, gloss, and heat distortion temperatures. Warpage is minimized by the addition of particulate fillers such as mica. When low mold temperatures are used, transparent moldings can be obtained with unfilled PETs.

PETG materials

Glycol-modified PET and copolyesters (PETG) offer a desirable combination of properties such as clarity, toughness, and stiffness.

Typical Applications

- medical devices
    - test tubes
    - bottles

- toys
- displays and lighting fixtures
- face shields
- refrigerator crisper pans

Injection molding processing conditions

Drying	Drying is essential for PETG prior to injection molding. The moisture level must be below 0.04%. Drying temperature is not to exceed 66°C [150°F]. Drying at approximately 65°C [149°F] for 4 hours is recommended.
Melt Temperature	220°C–290°C [428°F–554°F]; the melt temperature is grade specific
Mold Temperature	10°C–30°C [50°F–86°F], recommended 15°C [60°F]
Material Injection Pressure	30 MPa-130 MPa
Injection Speed	High speeds without causing embrittlement

Chemical and Physical Properties

PETGs (or copolyesters) are glycol-modified PETs. The modification is achieved by adding a second glycol during polymerization. The resulting molecular structure is irregular and the material is clear and amorphous with a glass transition temperature of 88°C [190°F]. PETGs can be processed over a wider processing range than conventional PETs and offer a good combination of properties such as toughness, clarity, and stiffness.

PMMA materials

Polymethyl methacrylate (PMMA) has excellent chemical and weather resistance.

Typical Applications

- automotive
  - signal light devices
  - instrument panels
- blood cuvettes
- industrial
  - video discs
  - lighting diffusers
  - display shelving
- consumer

- drinking tumblers
- stationery accessories

Injection Molding Processing Conditions

Drying	PMMA is hygroscopic and must be dried prior to molding. Drying at 90°C [194°F] for 2-4 hours is recommended.
Melt Temperature	240°C–280°C [460°F–536°F]
Mold Temperature	35°C–80°C [90°F–176°F]
Injection Speed	Moderate

Chemical and Physical Properties

Pellets for injection molding are made by bulk polymerization of methyl methacrylate followed by extrusion and pelletization, or by polymerization in an extruder. Formulations vary by molecular weight and physical properties such as flow rate, heat resistance, and toughness. Higher molecular weight grades are tougher than lower molecular weight grades. High flow formulations are generally preferred for molding.

Heat deflection temperature under load varies from 75°C [167°F] for high flow materials to 100°C [212°F] for low flow (high molecular weight) materials.

PMMA has excellent optical properties and weatherability. The white light transmittance is as high as 92%. Molded parts can have very low birefringence, which makes PMMA suitable as a material for video discs.

PMMA exhibits room temperature creep. The initial tensile strength is high but under long-term, high-stress loading, it exhibits stress craze. Impact strength is good but it does show some notch sensitivity.

POM materials

Polyacetal or polyoxymethylene (POM) has a low coefficient of friction, good dimensional stability, and high temperature resistance.

Applications

- gears
- bearings
- valve and pump housings
- lawn equipment

Injection Molding processing conditions

Drying	Not usually required but the material should be stored in a dry atmosphere.

Melt Temperature	■ 180°C–230°C [356°F–446°F] for homopolymer ■ 190°C–210°C [374°F–410°F] for copolymer
Mold Temperature	50°C–105°C [122°F–221°F]. Higher mold temperatures are preferred for precision molding to reduce post-molding shrinkage.
Material Injection Pressure	70–120 MPa
Injection Speed	Medium–high

Runners and Gates

Any type of gate can be used. Circular tapered gates should be as short as possible. Insulated, hot tip runners are preferred for homopolymers. Both internally and externally heated hot runners can be used with copolymers.

Chemical and Physical Properties

Acetals are tough, resilient materials that exhibit good creep resistance, dimensional stability, and impact resistance even at low temperatures.

Acetal grades are either homopolymers or copolymers. Homopolymers have better tensile strength, fatigue resistance and hardness, but are difficult to process. Copolymers have better thermal stability, chemical resistance, and processibility. Both homopolymers and copolymers are crystalline and have low moisture absorption.

Copolymers can be used continuously at air temperatures up to 100°C [212°F]. Homopolymers have slightly higher temperature resistance. The many grades of acetal materials that are available can be tailored for different applications.

High crystallinity levels of acetals lead to relatively high shrinkage levels of 0.02–0.035 mm/mm. Differential shrinkage is observed with reinforced grades.

PP materials

Polypropylene (PP) is a widely-used, translucent, semicrystalline, thermoplastic polymer with excellent chemical resistance to a range of chemicals.

Typical Applications

- automotive (mineral-filled PP is often used)
  - dashboard components
  - ductwork
  - fans
  - some under-hood components

- appliances
  - dishwasher door liners
  - dryer ductwork
  - wash racks
  - clothes washer lids
  - refrigerator liners
- consumer products
  - lawn/garden furniture
  - lawn mower components
  - sprinklers

Injection Molding Processing Conditions

Drying	Not normally necessary if proper storage is used
Melt Temperature	220°C–280°C [428°F–536°F], not to exceed 280°C
Mold Temperature	20°C–80°C [68°F–176°F], suggested, 50°C [122°F]. The crystallinity level is determined by the mold temperature.
Material Injection Pressure	Up to 180 MPa

Injection Speed

Typically, fast injection speeds are used to minimize internal stresses; if surface defects occur, slow speed molding at a higher temperature is preferred. Machines capable of providing profiled speed are highly recommended.

Runners and Gates

In the case of cold runners, typical diameters range from 4–7 mm. Full round sprues and runners are recommended. All types of gates can be used. Typical pin gate diameters range from 1–1.5 mm, but diameters as low as 0.7 mm can be used. In the case of edge gating, the minimum gate depth should be half the wall thickness and the width should be at least double the thickness. Hot runners can readily be used for molding PP.

Chemical and Physical Properties

PP is produced by the polymerization of propylene using stereospecific catalysts. Isotactic polypropylene (iPP) is mainly produced. (The methyl groups lie on one side of the carbon chain.) This linear plastic is semicrystalline because of an ordered molecular structure, and it is stiffer than Polyethylene (PE) and has a higher melting point. The polypropylene homopolymer becomes very brittle at temperatures higher than 0°C [32°F] and for this reason, many commercially available grades are random copolymers with 1–4% ethylene, or block copolymers with higher ethylene content.

Due to crystallinity, the shrinkage is relatively high (order of 0.018–0.025 mm/mm [1.8–2.5%]). The addition of 30% glass reduces the shrinkage to approximately 0.7%. Shrinkage is fairly uniform; the difference in flow and cross-flow shrinkage is typically less than 0.2%.

Both homopolymer and copolymer polypropylene offer excellent resistance to moisture and good chemical resistance to acids, alkalis, and solvents. However, PP is not resistant to aromatic hydrocarbons such as benzene, and chlorinated hydrocarbons such as carbon tetrachloride. PP is not as resistant to oxidation at high temperatures as PE.

PPE materials

Polyphenylene ether blends (PPE or PPO) are engineering thermoplastics that exhibit resistance to high temperatures. Because of the high glass transition temperature, which is about 210°C, PPEs are often blended with other polymers to increase processability.

Typical Applications

- household appliances
  - dishwasher
  - washing machine
- electrical applications
  - control housings
  - fiber-optic connectors

Injection Molding Processing Conditions

Drying	Recommend drying before molding for approximately 2–4 hours at 100°C [212°F]. PPEs have low levels of moisture absorption and can typically be molded as received.
Melt Temperature	240°C–320°C [464°F–608°F]. Higher temperatures are for grades with higher levels of PPE.
Mold Temperature	60°C–105°C [140°F–220°F]
Material Injection Pressure	60–150 MPa

Runners and Gates

All gates can be used but tab and fan gates are preferred.

Chemical and Physical Properties

Polyphenylene Ether (PPE-also known as PPO) is poly(2,6-dimethyl-1,4-phenylene ether). PPE in its pure form is very difficult to process. To overcome this, commercially available PPEs are blended with other thermoplastic materials, such as polystyrene/high-impact polystyrene, or nylon.

A range of properties can be obtained depending on the proportion of PPE and the material with which it is blended.

Blends with nylon (PA 6/6) offer improved chemical resistance and perform well at high temperatures. The water absorption is low and the molded products have excellent dimensional stability.

Blends with polystyrene are amorphous whereas blends with nylon are crystalline. The addition of glass fibers reduces shrinkage levels to 0.2%. These materials have excellent dielectric properties and a low coefficient of thermal expansion.

The viscosity level of the blend depends on the ratio of the components in the blend; higher PPE levels increase the viscosity.

PS materials

Polystyrene (PS) is an inexpensive and hard polymer that is used extensively.

Typical Applications

- packaging
- housewares
  - tableware
  - trays
- electrical
  - transparent housings
  - light diffusers
  - insulating film

Injection Molding Processing Conditions

Drying	Not usually required unless stored improperly. If drying is needed, the recommended conditions are 2-3 hours at 80°C [176°F].
Melt Temperature	180°C–280°C [356°F–536°F]; upper limit is 250°C for flame retardant grades [19–158°F]
Mold Temperature	Suggested: 20°C–70°C [68°F–158°F]
Material Injection Pressure	20–60 MPa

Injection Speed	Fast speeds are recommended.

Runners and Gates

All types of conventional gates can be used.

Chemical and Physical Properties

General purpose PS is produced by the polymerization of styrene. Most commercial grades are clear, amorphous polymers. PS offers excellent dimensional and thermal stability, optical clarity, and very little tendency to absorb moisture. It has good dielectric properties. It is resistant to water and dilute inorganic acids, but is attacked by strong oxidizing acids such as concentrated sulfuric acid, and is swollen by some organic solvents.

Processing shrinkage is typically between 0.4–0.7%.

PVC materials

Polyvinyl chloride (PVC) is a widely used polymer. The range of additives used with this polymer can alter its physical properties to create a tough rigid polymer used for water pipes through to a pliable material used for fabric applications.

Typical Applications

- water distribution piping
- home plumbing
- house siding
- business machine housings
- electronics packaging
- medical apparatus
- packaging for foodstuffs

Injection Molding Processing Conditions

Drying	Not usually necessary as PVC absorbs very little water.
Melt Temperature	160°C–220°C [320°F–428°F]
Mold Temperature	20°C–70°C [68°F–158°F]
Material Injection Pressure	Up to 150 MPa
Packing Pressure	Up to 100 MPa
Injection Speed	Relatively slow to avoid material degradation

Runners and Gates

All conventional gate types can be used. Pin-point and circular tapered gates are used for molding small components and fan gates are typically used for thick sections. The minimum diameter of pin-point or circular tapered gates should be 1 mm and the thickness of fan gates should not be less than 1 mm.

Sprues should be as short as possible; typical runner sizes are 6–10 mm and should have a full round cross-section. Insulated hot runners and certain types of hot sprue bushings can be used with PVC.

Chemical and Physical Properties

Rigid (unplasticized) PVC, which is produced from sodium chloride and natural gas, is one of the most widely used plastic materials. The repeat chemical structure is vinyl chloride. Additives are mixed with PVC to make it processible. PVC grades produced by suspension or mass polymerization techniques are the major types used for melt processing. PVC is substantially an amorphous material.

The additives used include stabilizers, lubricants, processing aids, pigments, impact modifiers, and fillers. The features of PVC include low combustibility, toughness (designed to be virtually unbreakable), good weatherability (color and impact retention and no loss in stiffness), and excellent dimensional stability. PVC is highly resistant to oxidizing and reducing agents, and strong acids. However, unplasticized PVC is not recommended for environmental and continuous use above 60°C [140°F]. It is not resistant to concentrated oxidizing acids such as sulfuric or nitric acid, and is unsuitable for use with aromatic and chlorinated hydrocarbons.

It is very important to process the material at the correct melt temperature; otherwise, severe problems from decomposition (which produces hydrochloric acid which in turn accelerates decomposition) could result.

PVC is a relatively stiff flow material and has a narrow processing range. The molecular weight determines the flow characteristics. Materials with a higher molecular weight are more difficult to process. This can be modified by the addition of lubricants. Typically, however, relatively low molecular weight grades are used in molding.

Shrinkage is fairly low (0.002–0.006 mm/mm [0.2–0.6%]).

SAN materials

Styrene acrylonitrile (SAN) has good rigidity, strength, and toughness, and better chemical resistance than polystyrene.

Typical Applications

- electrical
    - receptacles
    - mixer bowls
    - housings

- refrigerator fittings
    - chassis for television sets
    - cassette boxes
- automotive
    - head lamp bodies
    - reflectors
    - glove compartments
    - instrument panel covers
- household applications
    - tableware
    - cutlery
    - beakers

Injection Molding processing Conditions

Drying	SAN absorbs moisture when not stored properly so drying at 80°C [176°F] for 2-4 hours prior to molding is recommended.
Melt Temperature	200°C–270°C [392°F–518°F]; 230°C–260°C [446°F–500°F] for most applications; lower end of the range is used for molding thick wall components
Mold Temperature	40°C–80°C [104°F–176°F]; SAN solidifies rapidly at higher temperatures; for reinforced grades, the mold temperatures should not be less than 60°C [140°F].
Material Injection Pressure	35–130 MPa
Injection Speed	High speeds are recommended.

Gates

All conventional gate types may be used.

Chemical and Physical Properties

SAN copolymers are produced by the polymerization reaction of styrene and acrylonitrile. They are strong, transparent materials. The styrene component imparts clarity, stiffness, and processibility and the acrylonitrile component imparts chemical and thermal resistance.

They have excellent load bearing capacity, rigidity, good resistance to chemicals, heat deformation, and cyclic temperature loads, and dimensional stability. The properties are dependent on the acrylonitrile content and commercial grades offer different acrylonitrile molecular masses. The addition of glass fibers enhances rigidity and resistance to heat deformation, and decreases the coefficient of linear thermal expansion.

The Vicat softening point is approximately 110°C [230°F] and the deflection temperature under load is approximately 100°C [212°F].

Shrinkage ranges from 0.003–0.007 mm/mm [0.3–0.7%].

Chemical and Physical Properties

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They have excellent load bearing capacity, rigidity, good resistance to chemicals and heat deformation, cyclic temperature loads and dimensional stability. The properties depend on the acrylonitrile content, and commercial grades offer different acrylonitrile molecular masses. The addition of glass fibers enhances rigidity and resistance to heat deformation, and decreases the coefficient of linear thermal expansion.

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Shrinkage ranges from 0.003–0.007 mm/mm [0.3–0.7%].

Thermoset materials

Thermoset materials have an amorphous cross-linked structure. Some typical thermosets are listed.

acrylic
alkyds
allyl diglycol carbonate
DAIP
DAP
epoxy
fluorosilicone
melamine
melamine/phenolic
phenolics
polyurethane polyols
polyurethane isocyanates
polyurethane systems
silicone
silicone/polyamide
urea
unsaturated polyesters

Mold material

Plastic injection molds can be manufactured from a variety of metal and metal alloys. The material properties of a range of different metals are listed in the Autodesk Moldflow material database so that the impact of the material that the mold is made is of can be taken into account.

Different mold materials will have different characteristics such as specific heat capacity and thermal conductivity, which could influence the behavior of the plastic within the cavity. To achieve an accurate analysis, all aspects of the molding process must be considered.

Coolants

Coolants are the fluids that flow through the cooling channels of a mold to extract heat from the system.

Coolant properties include specific heat, thermal conductivity, and viscosity.

A database of more than forty different coolants is available to help you achieve the correct analysis results. The cooling efficency of a system depends not only on the coolant specified, but also on factors such as the layout of the cooling system, the length of cooling system, and the flow rate.

Fillers

A filler is a material that can be added to a polymer for injection molding, to improve the quality of the part.

Fillers are added to polymers to alter the properties of the plastic. Fillers can be added to increase the strength, affect the cost, and alter the brittleness of the part.

Autodesk Moldflow provides a filler database from which you can select a variety of fillers.

Preforms

Preforms are fiber materials that are manufactured for inclusion in plastic molding. Fiber preforms are often manufactured in sheets, continuous mats or as continuous filaments for spray applications.

Preforms are used to enhance the strength and elasticity of plastics. The fibers used in preforms are usually glass, carbon or aramid. The original plastic material, without fiber reinforcement, is known as the matrix and is typically a tough but relatively weak plastic. The extent to which strength and elasticity are enhanced in a fiber reinforced plastic depends on the mechanical properties of both the fiber and matrix, their volume relative to one another, and the fiber length and orientation within the matrix.

Microchip encapsulation wire

Different materials can be used to attach a die to the pins on the leadframe. Traditionally the wires were gold.

The final step in semiconductor device fabrication is the packaging of the chips. This process, also known as microchip encapsulation, involves mounting the integrated circuit or die on the leadframe, connecting the die pads to the pins with wire, and sealing the die. This final step can be simulated and the effect on the wire assessed.

Leadframe materials

Leadframes are used in semiconductor device fabrication to support the die during packaging. They are made of a conducting material and provide an electrical connection between the die which is encapsulated within a plastic material for insulation and protection, and the outside world.

Historically leadframes were plated with solder, but current leadframes are lead-free. Different, non-toxic metals can be used, although copper is frequently used.