KAYSUN

INJECTION MOLDING & ENGINEERING SOLUTIONS

An Overview for OEMs

HIGH-TEMPERATURE & HIGH-PERFORMANCE PLASTICS

Manufacturers in industries ranging from automotive and advanced manufacturing to aerospace, medical, electronics, telecommunications, and consumer products find the improved part integrity and durability that result from using high-temperature plastics beneficial for their complex injection-molded applications.

As performance and functionality requirements continue to evolve across industries and applications, transitioning away from other materials — including traditional plastics — to high-temperature options is quickly becoming the norm.

Popular High-Temperature Plastics

High-temperature plastics are extremely versatile. They can be used on their own, or combined with fillers or alloys to enhance certain properties such as:

- Strength
- Flexibility
- Temperature resistance
- Chemical resistance
- Wear and abrasion resistance
- Fire/smoke/toxicity emissions control
- Lighter weight

POPULAR HIGH-TEMPERATURE PLASTICS INCLUDE:

- **Polyphthalamide (PPA)**. A member of the polyamide (nylon) family, PPA's dimensional stability makes it a preferred plastic for replacing metal parts in high-temperature applications. Key characteristics include mechanical strength, chemical resistance, and superior creep resistance.

- **Polyphenylene sulfide (PPS)**. This organic polymer resists corrosion, heat, abrasion, and UV radiation. It is a favorite among injection molders because it is relatively easy to mold, maintains tight tolerances, and resists chemicals and solvents.

- **Polysulfone (PSU)**. PSU provides creep resistance and strong chemical resistance over a wide range of conditions, as well as transparency in its unreinforced state. It is also flame retardant and hydrolysis resistant, meaning it does not break down in the continuous presence of water/hot water/steam.

- **Polyetherimide (PEI)**. This amorphous plastic is favored for medical applications due to its ability to maintain structural integrity at high temperatures resist heat and chemicals, and provide high dielectric strength.

- **Polyether ether ketone (PEEK).** Part of the polyaryletherketone (PAEK) family, PEEK is a semi-crystalline thermoplastic with superior strength, electrical properties, and chemical and hydrolysis resistance. Its stability allows it to be used in extremely high-temperature settings (450 to 500 °F).

- **Polyamide-imides (PAIs).** This family of plastics combines the physical properties of both polyamides and polyimides for outstanding mechanical properties and heat and chemical resistance. PAI is, however, hygroscopic (moisture-absorbing) and must be thoroughly dried before injection molding can start.

- **Ethylene tetrafluoroethylene (ETFE).** ETFE is temperature-, chemical-, and electrical/radiation-resistant, making this thermoplastic ideal for pump parts that are used in corrosive environments. Its relatively high flow rates can also speed up injection molding and reduce operational costs.

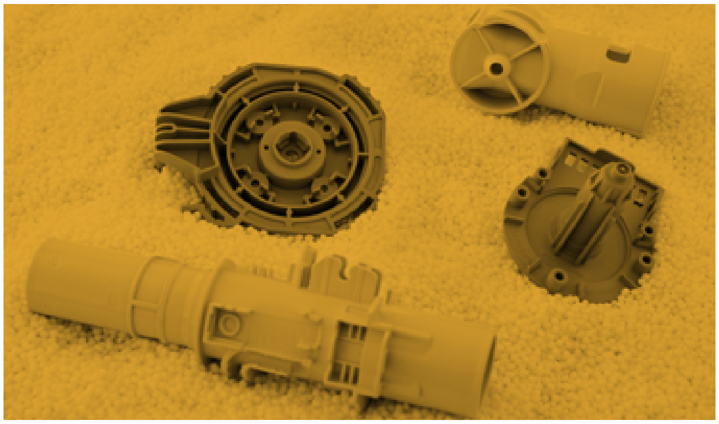
- **Polyethersulfone (PES).** This hydrophilic material plastic is extremely chemical resistant over a wide range of temperatures. Parts made from PES experience very low mold shrinkage, resulting in high dimensional stability and precise tolerances. PES can also be injection molded using standard machines.

Molding High-Temperature Plastics

Injection molding with high-temperature plastics results in high-performance parts and products that can outperform and outlast metal, even in harsh environments.

For all of its benefits, high-temperature plastics also present some challenges that require the focus, expertise, and specialized machinery of an experienced custom injection molder.

One of the biggest obstacles is extremely high melt temperatures (exceeding 700°F in most applications). Molten plastics behave differently at such high temperatures, which must be taken into account when developing the production process. For example, holding the melt above a certain threshold temperature may result in material degradation and inferior injection-molded parts that need to be scrapped.



The type and amount of additives present in the melt (if any) can also influence behavior since temperatures that are too high can alter the anticipated engineered physical characteristics.

Achieving maximum crystallinity is essential for high-quality injection-molded products and can only be fully achieved if the correct temperatures are reached and maintained for the appropriate length of time. A lack of maximum crystallinity may reduce chemical resistance and reduced dimensional stability, which compromise product performance at the service temperature.

Tools

THE TOOL USED FOR HIGH-TEMPERATURE PLASTICS MUST BE:

- Maintained at tightly controlled temperatures usually achieved using hot-oil and/or cartridge heaters. Heat loss should also be monitored for hot-oil tools.

- Constructed from high-hardness, wear-resistant steel (sometimes coatings are required) since many high-temperature plastics are glass-filled and abrasive.

- Outfitted with thermocouples for real-time steel temperature monitoring (on a case-by-case basis) to prevent flaws in the aesthetic appearance and functionality of the final parts.

- Properly lubricated, especially when tools have side actions or moving details. As most common tool lubricants cannot withstand high temperatures, special high-temperature greases, along with graphite-impregnated bushings and teflon-coated wear plates, are used.

- Insulated to keep heat from transferring to the machine platen and causing temperature inconsistencies in the tool. High-temperature pressure transducers may also be required to avoid sensor damage due to the heat.

- Heat-soaked prior to production in order to maintain higher temperatures throughout a production run. Due to heat-soak times, typical startups for high-temperature plastics can take 3-4 times longer than starting up using traditional plastics.

- Designed with accurate gate and knit-line locations to accommodate varying wall thicknesses (especially thin-walled components with intricate features), and any specific requirements regarding appearance and strength. Working with an experienced custom injection molder during the design phase will clarify and optimize gate requirements to make the highest-quality, strongest part possible.

- “Fit” at the production temperature. Tool steel expands with elevated temperature, so all shut-offs must be matched at the elevated temperature.

Machine Size

Machine selection is another critical variable for the successful molding of high-temperature plastics. Machines need to be properly sized so high injection speeds and pressure (up to 200 MPa [30,000 psi] for some plastics) are maintained, and the correct residence time of the melt — about 6 minutes or less for most high-temperature plastics — is not exceeded. Too much residence time degrades the properties of the melt and can result in inferior molded parts with visible surface flaws such as discoloration and burn marks.

Moisture Content

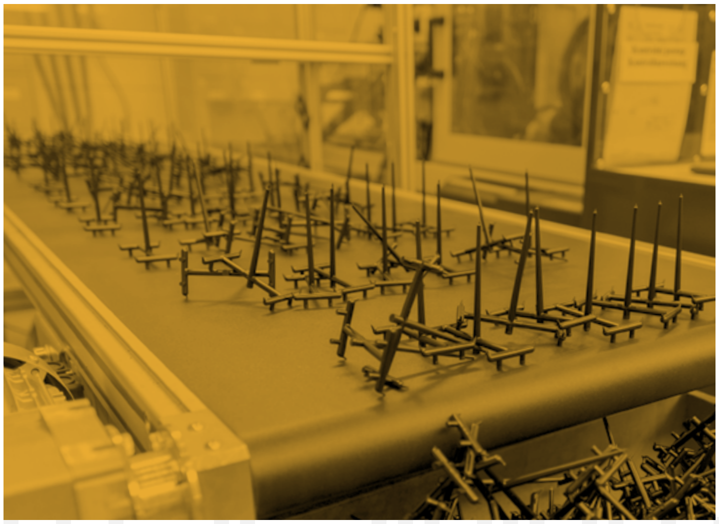
Most of today's high-temperature plastics are hygroscopic (moisture-absorbing), which can alter material behavior during injection molding. The degree of variance depends on the type of plastic, moisture content, and type of tooling.

One of the largest negative impacts of moisture is an increased concentration of volatiles, which can plug injection-molding-machine vents faster. This sometimes results in plastic brittleness, burn marks, and other surface imperfections, and poor knit-line strength—all of which reduce part quality and performance. Even small concentrations of moisture in the melt can affect material viscosity enough to cause dimensional and aesthetic problems. Therefore moisture content must be carefully controlled to establish stable, repeatable production runs.

Accurately measuring the moisture content of the raw plastic and thorough drying are essential for a successful run.

Part Cooling

Part cooling is perhaps the most important step in molding high-temperature plastics and must be carefully controlled at all times. Uneven tool temperatures can create variable shrinkage and negatively impact dimensional stability, especially when molding semi-crystalline plastics. Cooling conveyors can be used for additional uniform cooling of the parts.



General Cost of Plastics

High-temperature plastics are more expensive than commodity plastics. These plastics cost $2-4/ pound; high-performance and high-temperature plastics range in price from about $20 to $100/pound. (The final price also depends on the quantity of plastics purchased.)

Due to the price points of high-temperature plastics, it is imperative to minimize waste and scrapped parts. Therefore, plastics handling must be tightly controlled to maximize efficiency and quality. Extra part-quality checks may be required to minimize scrap.

To control costs, saving plastic must be top-of-mind during all stages of the project — part design, tool design, sampling, and production. This is accomplished through:

- Detailed part-design and tooling-design reviews
- Careful plastics handling to minimize pellet waste through purgings.
- Longer production runs to reduce waste.
- Automated part handling and the use of conveyors for controlled cooling to maximize quality and reduce scrap and rework.
- Applying scientific molding principles to help maintain quality from run to run and reduce scrap. This is where consultation with experienced injection molding engineers during the design phase is vital for designing scrap out of a part, optimizing manufacturability, and reducing cost. A properly designed part can save 10-20 percent on plastics costs.

Experience Required

The best way to achieve total success and satisfaction when molding complex, high-performance parts from high-temperature plastics is to get an experienced injection molder involved early in the design phase. Critical changes to the design may be required, depending on the plastic selected and how it will be injection molded.

Kaysun's extensive plastics knowledge, and expertise in engineering, materials science, scientific molding, and Design for Manufacturability (DfM) analysis guide us in selecting the best plastic for your project, designing the ideal tool, and developing the most efficient and cost-effective injection molding solution possible — all of which makes working with Kaysun a true value-added partnership.

Contact Kaysun to learn more about high-temperature plastics and how they can improve the production, performance, and cost-effectiveness of your next injection molding project.

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