KAYSUN

INJECTION MOLDING & ENGINEERING SOLUTIONS

Plastics Selection FOR INDUSTRIAL APPLICATIONS

Plastics are extremely versatile. More than 25,000 engineering-grade materials are available to manufacture wide-ranging industrial applications. High-performance blends and hybrids can be formulated to meet very specific structural and chemical requirements of complex plastic parts and products. With proper materials selection and design optimization, plastics can be as strong as metal but weigh far less.

Therefore, choosing the right material can take some time, depending on the project. Addressing plastics needs early in a project's design phase is ideal, as is partnering with an experienced injection molder. A molder's plastics-specific expertise will help you make informed decisions about the most efficient, cost-effective and performance-appropriate plastics and processes for your industrial applications.

This guide walks you through key considerations for assessing your application from a materials perspective, including project specs, plastic attributes and molding performance factors.

Project Specs

The first step in plastics selection has less to do with materials than it does knowing the ins-and-outs of your application.

Understanding exactly what the component will be exposed to and what it must withstand within the system parameters will largely define the properties you need in a plastic.

You'll be in a good position to answer the pointed questions your molding partner will ask at the project outset, like:

- WHAT IS THE EXPECTED PHYSICAL LOAD FOR THE PLASTIC PART? The impact expectations of the part must be determined to ensure it will stand up to the conditions of everyday fatigue, plus meet any safety requirements
- WHAT IS THE MECHANICAL FUNCTION? The plastic chosen must be right for the rigors of the application
- WHAT ARE THE THERMAL CONDITIONS? Fluctuating and extreme temperatures will limit plastics options
- WILL THERE BE ANY EXPOSURE TO CHEMICALS? Industrial environments and operation can introduce harsh substances that could erode plastic components, such as greases, oils and solvents, or certain chemicals found in cleaning solutions
- WILL DISSIMILAR MATERIALS BE USED IN ASSEMBLY? The solution may require multi-shot technology or overmolding to ensure plastic interplay and compatibility with other system components
- DOES THE PART REQUIRE HIGH-TEMPERATURE PLASTICS? Materials in this category are more difficult to work with due to their higher melting points, requiring careful deliberation of all application aspects, from safety to molding processes

Preparation at this level proved valuable for a cutting-edge technology manufacturer that partnered with Kaysun to design and produce a high-temperature industrial machine component. While the manufacturer chose polyether ether ketone (PEEK) for its ability to withstand the high temperatures, we identified molding complications that would arise because PEEK is not as fluid as other plastics. Design changes were made that accommodated both the particular plastic and moldability, resulting in a successful, durable solution.

Plastic vs. Metal: A Comparison

It's becoming more common to replace metal parts with custom injection-molded components. This brief comparison reveals why.

METAL PARTS:

- Require expensive, high-precision machining
- Must be individually machined
- Need secondary finishing to prevent corrosion
- Conduct heat in high-temperature applications

PLASTIC PARTS:

- Require one tool
- Can be produced quickly and easily in large volumes
- Are naturally corrosion resistant, eliminating most secondary/value-added operations
- Serve as insulators in high-heat applications because of slow heat conduction

Plastic Attributes

Evaluating your project needs narrows the breadth of appropriate materials, but a plastic's attributes will determine if it's the correct material for the job.

DURABILITY

Manufacturers of rugged electronic equipment count on their devices to perform in challenging real-life conditions and survive impact, shock and vibration. Therefore, impact resistance is a necessity that drives selection of polycarbonate (PC), acrylonitrile butadiene styrene (ABS), polyethylene terephthalate (PET) and nylon for molding robust housings.

Elastomeric polymers can also be added to the melt to increase impact resistance. These additives are elastic in nature. They deform upon impact without failing, and then recover their original shape even after stretching, compression or twisting — an ideal solution for products that face these risks, such as device housings or mounting structures.

Almost all elastomeric materials bend under impact at low hardness levels, but they tend to become more brittle when engineered for higher hardness. Polyurethane elastomers retain the most flexibility and are a good choice when design specifications require high hardness, in addition to ruggedness/impact resistance.

Similarly, thermoplastic elastomers can be overmolded on the product exterior to improve impact resistance, and on the product interior to further protect delicate components from shock and vibration.

Thermoset or Thermoplastic?

There are thousands of engineered materials, but only two main types of plastic:

Thermosets (e.g., liquid silicone rubber (LSR), epoxy, phenolic) join polymers on one application of heat and structure chemical bonds that harden permanently on cooling. The chemical reaction cannot be reversed, so thermoset parts cannot be re-shaped or re-melted. Thermosets have strength, chemical resistance, and temperature resistance that make them appropriate for medical implantables, electronic interfaces/touchpads, and wiring harnesses/housings.

Thermoplastics (e.g., polystyrene (PS), high-density polyethylene (HDPE), acrylonitrile butadiene styrene (ABS)) become plastic on heating and harden on cooling, without changing plastic chemistry. These plastics can be re-melted, reprocessed, and recycled.

DIMENSIONAL TOLERANCE

Different plastics can produce inconsistent tolerances for the same part, so sometimes a tradeoff must be made between tolerance expectations and the physical properties of the plastic.

Holding tight tolerances can be a challenge with many plastics because they have different shrink rates, high thermal expansion rates, will absorb moisture and — in semi-crystalline materials – may continue to crystalize after the molding process.

Even though plastic components can be held to tight tolerances in a climate-controlled environment, it doesn't mean they will maintain these dimensions as the temperature or humidity levels change. This idiosyncrasy must be considered when plastics are combined with fillers, must interact with other material types such as metals, or when the end use occurs in environments where temperature and humidity levels greatly fluctuate.

Amorphous or Semi-crystalline: What's the Difference?

Plastics are made up of polymers, long chains of repeated molecule units. The ways in which the chains intertwine determine the plastic's macroscopic properties.

Amorphous plastics have random polymer chain orientations, giving the plastic a formless structure with good impact strength and toughness. Acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), polycarbonate (PC) and polystyrene (PS) are good examples of amorphous plastics.

Semi-crystalline plastics have orderly, densely packed polymer chains. They have lower elongation and flexibility than amorphous plastics, but better chemical resistance. Acetal (POM), nylon (PA), ultra high molecular weight polyethylene (UHMW-PE), polyether ether ketone (PEEK), and polyphenylene sulfide (PPS) are good examples of semi-crystalline plastics.

HIGH TEMPERATURE

Highly engineered, heat-resistant thermoplastics offer an expanded range of physical characteristics that make advanced industrial applications possible, including:

- Strength
- Flexibility
- Temperature resistance
- Chemical resistance
- Wear and abrasion resistance
- Low fire, smoke and toxicity emissions
- Lighter weight
- Improved part integrity and durability

One of the biggest challenges in using high-temperature plastics is extremely high melt temperatures — exceeding 700°F in most applications. Conventional molding machines are not equipped to handle such high temperatures. Machines must be customized with special barrel heating and mold regulating equipment.

High-quality products are dependent on careful temperature control and the plastic chosen. Popular high-temperature plastics include:

- Polyphthalamide (PPA)
- Polyphenylene sulfide (PPS)
- Polysulfone (PSU)
- Polyetherimide (PEI)
- Polyether ether ketone (PEEK)
- Polyamide-imides (PAIs)
- Ethylene tetrafluoroethylene (ETFE)
- Polyethersulfone (PES)

Outdoor home equipment manufacturers often favor high-temperature plastics. For example, plastic components positioned near the engine block of a lawn tractor or snow blower need to be able to withstand extreme temperatures.

CONDUCTIVITY

Plastics manufacturers are developing some unique injection-molding plastics that have superior conductivity. These manufacturers use nanotechnology to produce tiny metal fibers and strands that are incorporated into the polymer matrix to influence the performance of the composite material. Polycarbonate (PC), polypropylene, ABS, polyamide 6/6 and PC/ABS can be infused with conductive stainless steel fiber or nickel-plated carbon fiber fillers and then injection-molded to produce lightweight plastic parts that are as hard, durable and conductive as the metallic parts they replace.

MULTI-MATERIAL MOLDING

In some cases, the desired characteristics aren't as clearly defined. For example, a manufacturer needing a complex garbage disposal component must consider both independent component performance and its interaction within the larger system. In this case, the rigid plastic housing would need to withstand the extreme demands of the machine in operation, while also being compatible with the internal seals and related plastic, metal and rubber components.

Overmolding can be used to ensure proper leak prevention, but this means that the selection of plastic for the rigid substrate must take into account the TPE overmold material, and vice versa. In this scenario, polypropylene with glass fibers could be an excellent choice. Polypropylene itself is relatively inexpensive, adding glass fibers makes it rigid enough to stand up to the structural requirements of the project, and it is compatible with the TPE overmolding material.

A Case for Adding Fillers to Polymers

Particulate fillers can reduce costs and improve properties such as modulus, conductivity, heat, and ultraviolet light resistance. Common particulate fillers include:

- Mineral
- Silica
- Ceramic
- Carbon powder/fiber
- Glass microspheres/fibers
- Powdered metal

Reinforcing fillers improve mechanical properties and include:

- Long glass fiber additives improve stiffness and strength, increase temperature performance (up to 150°), and create a moderate surface appearance
- Short glass fiber additives improve stiffness, increase temperature performance, and offer better aesthetics than long glass fibers. When the glass content is 30% or lower, short glass fibers allow parts to look comparable to unreinforced plastic parts
- Carbon, stainless steel, and Kevlar® fillers improve conductive and/or shielding properties

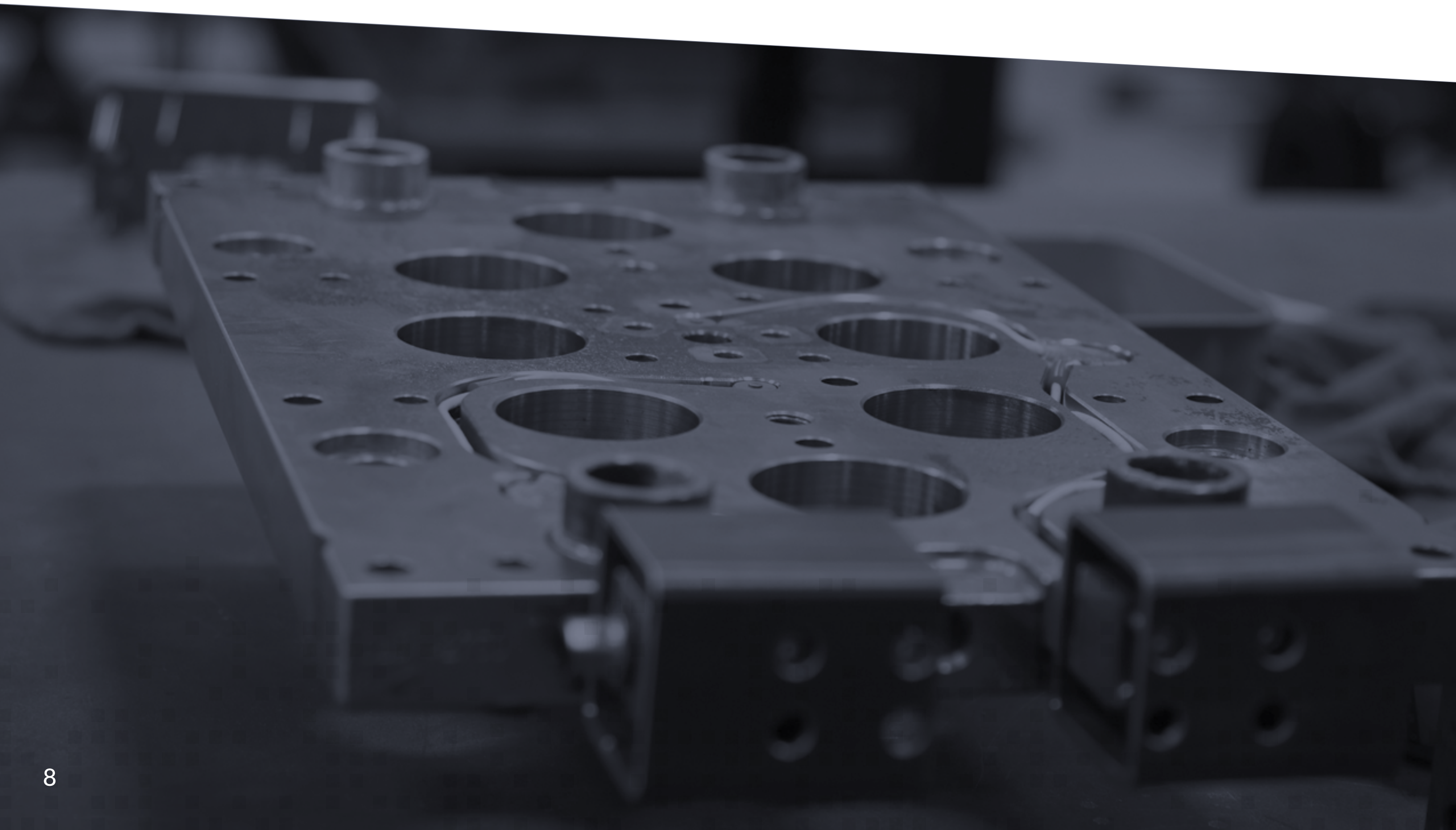
Molding Performance

Just like you're an expert on the intended performance of your applications, experienced custom injection molders have a deep understanding of how plastics behave during production.

Kaysun engineers are specially trained in scientific molding so they can control the molding processes and other factors that influence successful outcomes, such as:

DESIGN: Of utmost importance is to get a molder involved early in a project's design phase. Critical design changes may be required based on the material selected and how it will be injection-molded. For example, high-temperature plastics are very sensitive to uneven wall sections and knit lines. Depending on the material and temperature, differential shrink rates may result in unwanted voids and other flaws.

TOOL STEEL: For high-volume production, it is cost-effective to invest in quality tooling to avoid excessive tool wear. Draft, finish, undercuts and steel types should all be considered during product/part design. The type of steel selected for the tool largely depends on the amount of abrasive fillers in the engineered plastic.



MACHINE SIZE: Machines need to be properly sized so the correct residence time of the melt 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: Some plastics are hygroscopic and absorb moisture, which can alter material behavior during the injection molding process. Even small concentrations of moisture in the melt can affect material viscosity enough to cause dimensional and aesthetic problems. An increased concentration of volatiles, for example, can plug vents faster and cause plastic brittleness, burn marks, other surface imperfections and poor knit line strength — all of which reduce the quality and performance of the part.

COOLING: Cooling is perhaps the most important process step in molding, especially for applications using high-temperature plastics. Selecting the proper technique — conveyors, hot oil, pressurized water — prevents negative impacts ranging from variable shrinkage to imprecise dimensional stability. For example, nylon is extremely susceptible to warping, but an experienced injection molding engineer knows where to place cooling channels in the tool to control and prevent deformation.

Kaysun has developed an extensive, in-house database founded on 60 years of injection-molding work. We know, in detail, how plastics respond to various combinations of process variables – knowledge that goes far beyond the spec information provided by a plastics manufacturer. This depth of data allows us to help you select the correct plastic for your industrial part or component, and design the best possible tool.

Contact Kaysun today to discuss your next project.

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