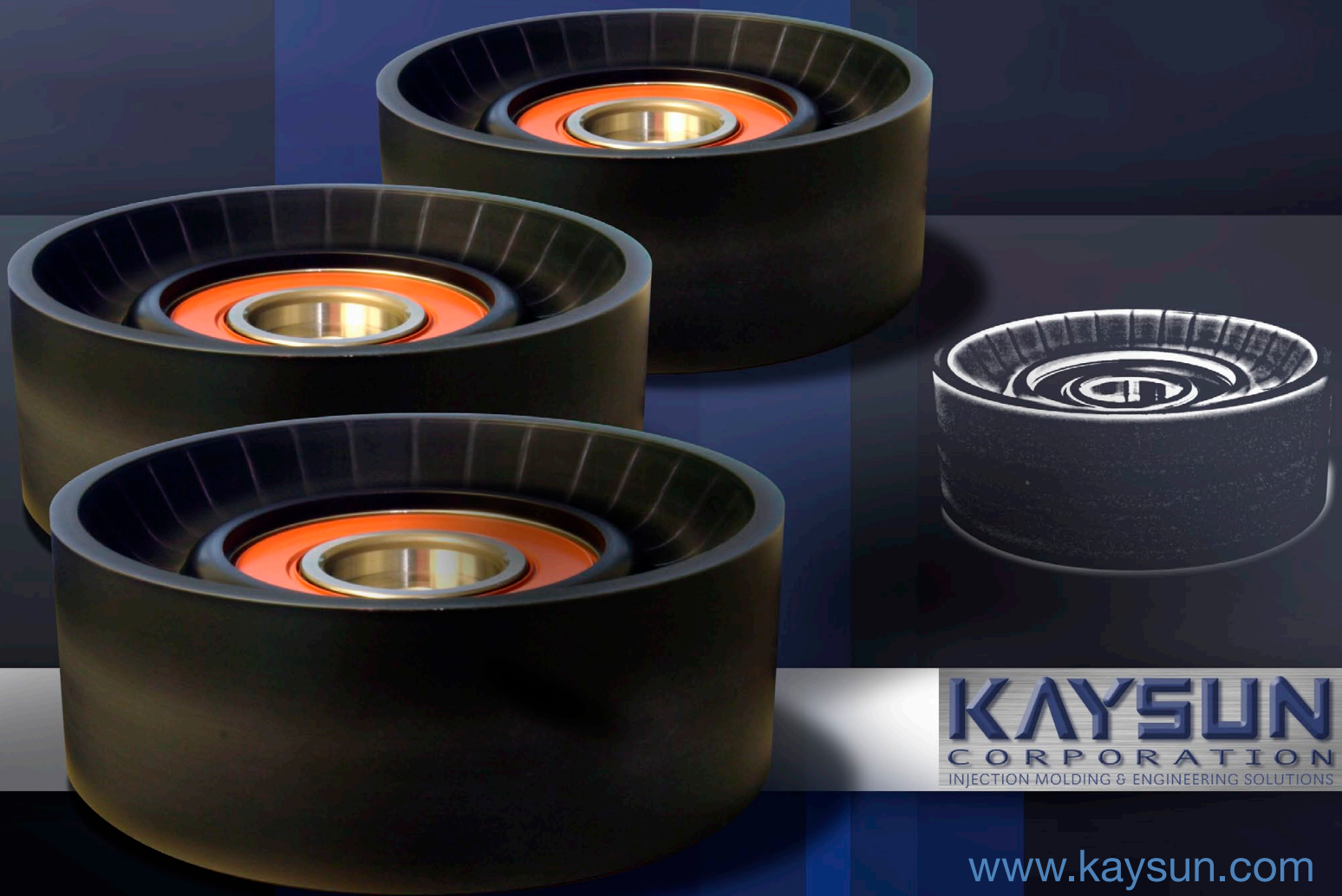


# WHITE PAPER

## Complex Injection Molding for Competitive Advantage

With Careful Planning, Complex Injection  
Molding Can Result in Reduced Costs,  
Optimized Function, and Improved Aesthetics



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By Dave Robinson

**C**omplex injection molding is the manufacturer's most direct route to competitive differentiation because it provides the design freedom and process efficiency required to create new features and incorporate new technologies as quickly and cost-effectively as possible.

Today's complex injection molding is defined by simultaneous complexity in four critical areas: part design, mold design, material selection, and process control. To make the best product, OEMs should choose a molding partner that can offer them expert guidance in these areas. This article explores the pertinent molding considerations and why it is important to address them at the beginning of the complex injection molding process.

## Why Use Complex Molding?

With complex injection molding, additional materials — from dissimilar polymers to metal components and other nonplastics — can be integrated during molding. These materials and features are combined in the molding process to facilitate assembly by adding metal inserts, threading for fasteners, and elements such as lenses. Such features can also optimize function by creating waterproof seals and increasing durability. Aesthetic reasons can also drive the decision to use complex molding. For example, some OEMs want to use a polymer with an appealing color or integrate decorative elements such as metal flake, gloss, or some other proprietary pattern. Such visual uniqueness can be vital to differentiate products within a manufacturing line or separate them from the competition.

In addition to streamlining production and reducing costs, incorporating the decoration or functional item with the injection process improves quality. Machine paced production always yields higher quality product by eliminating or greatly reducing

human involvement and inconsistency. It also reduces potential process variances introduced by secondary machining or joining operations. Just as important, complex molding yields more predictable quality because manufacturers are able to maintain consistency no matter how many units are produced, ensuring that tight tolerances are met.

## Part Design Considerations

Many of the crucial decisions involved in complex injection molding should be made as early as possible in the design phase, when adjustments can be made without a significant effect on the total costs and product timeline. For example, the placement of ejector pins and gating — the point where the plastic enters the mold — is critical aesthetically and stylistically. A visible knit line, where the flow fronts of the molten material meet, may be objectionable to the customer. If such marks cannot be strategically located to a place on the part that will not be visible, they can sometimes be disguised by texturing the mold. Either way, the part designer must plan them in.

If multiple materials are to be used, the polymers must be chosen carefully for compatibility to ensure a permanent chemical bond. Different plastics undergo thermal expansion at different temperatures, and any incompatibility will become a serious issue.

For example, polysulfone will not bond with polypropylene, which in turn bonds weakly with nylon, styrenic, and urethane-based elastomers.

Process complexity is added when a part requires metal inserts or pass-through coring. For example, the metal elements being added to a mold often require preheating to reduce thermal shock, improve retention properties and to prevent flash — thin, sharp, or unsightly areas that can form in the pass-

throughs due to stress (e.g. molten plastic meeting cold metal fasteners) during the molding process. The presence of flash can have an adverse effect on the performance of the product or require secondary operations to be removed.

A robust part doesn't just meet the original requirements its designer intended. It also stands up to the wear and tear — or even abuse — it can be subjected to in daily use. Aesthetically, a device must maintain its appearance. This means no fading, hazing, or yellowing of the plastic after exposure to sun, fluorescent lighting, chemicals, or other potentially harsh elements.

for small and finite production runs. They can range from soft steels used for simple, single-cavity prototype molds with smaller runs to hardened steels used for complex, multi-cavity molds to satisfy greater production volumes.

When production leans toward high volume and high complexity, these requirements increase the importance of selecting the proper steel for building the tool. The determining factors are based directly on the goals and expectations of the project, ranging from total quantity sought to the finish quality needed. Budgets for both time and cost can influence material choice as well (see Table I below for more information).

## Mold Design Considerations

The development of the mold or tool is the heart of the injection molding process, the stage from which everything else flows. The ultimate success of the part is determined at the point when the engineering team designs, creates, and maintains the mold — accounting for the materials to be used and the quantity of the item to be produced. Poor choices in any aspect of the mold development process will ultimately result in poor products, regardless of part design material choice or process control.

The type and durability expectations for a mold determine which material is used to make it. For example, aluminum is relatively inexpensive and easily machined but it offers limited longevity. Thus, it should be used only

Softer metals, such as P20 steel and aluminum, are easily machined and therefore less costly to mold. Stainless steel resists corrosion, pitting, and wear while supporting smooth finishes. In general, the harder the steel, the more effort and expenditure is required. Each additional step used to create the mold drives up time and cost. But these harder steel molds also last considerably longer and return higher-quality parts with greater consistency.

Other steels used for complex injection molding include high-carbon varieties, such as H13. These varieties contains a negligible amount of impurities — an important factor in heat-treating — and are economical to purchase in larger sizes. See Table II for a breakdown of the types of steel and their characteristics.

	< 10,000	10,000 – 200,000	200,000 – 1MM
Aluminum	X		
P-20	X	X	X
Tool Steel (various grades)		X	X

*Table I. Rules of thumb for material choice based on project volume requirements.*

Corrosion resistance in a mold is especially important with the use of materials that have a high degree of acidity. These include resins in the PVC family or with certain added agents, such as flame retardants.

***Different types of steel that can be used to make a mold.***

**S-7** General all-purpose, heat-treatable tough steel. Normal wear resistance.

**A-2** General all-purpose, heat-treatable hard steel. Higher wear resistance and less toughness.

**D-2** High-wear applications.

**420 SS** Medium wear-resistance. High polish. Corrosion resistant. Not as hard.

**H-13** Medium wear-resistance. Can be nitrided for surface lubricity with flex strength.

## Materials Considerations

Just as important as selecting the material for the mold is choosing the material for the part. Determining the proper material for a complex injection molding application should begin with a plastics engineer interviewing the OEM about its requirements. This decision requires information about five defining factors (outlined below), as well as any outstanding special needs.

### ***1. Physical load.***

The impact expectations of the part must be determined so that it will stand up to the conditions of everyday use without fatigue. Any degradation can lead to part failure.

### ***2. Mechanical function.***

The particular polymer must be right for its application.

### ***3. Thermal.***

What exposure will the device have to fluctuating and extreme temperatures? Polymers must be chosen to endure such conditions.

### ***4. Chemical.***

What exposure will the device have to chemicals?

The need to mold dissimilar plastics also plays a role in material selection. One of the most common complex injection molding techniques is multishot technology, which is required to add softer polymers for ergonomic and waterproofing features (such as keypads, grips, protective bumpers, and seals) over a hard-plastic substrate, as in an impact-resistant device body. Other times, overmolding of silicone tubing may be required.

By accomplishing steps like these simultaneously during molding, the manufacturer eliminates costly and inefficient secondary steps from the production process. It can also result in higher quality because the material itself can be monitored during production through cavity pressure feedback — a pressure reading of the resin as it is going into the mold. The feedback provides data on the consistency of the pressure and where correction is needed. Causes for inconsistent pressure include a change in the viscosity of the molten material.

Thus the mold and the process must be designed to suit the part and materials. No OEM would tolerate a soft-touch keypad separating from one of its handheld devices during use. Nor would they accept a waterproof seal failing because materials were improperly selected or the process to manufacture it was not expertly designed.

The last material concern of importance is whether or not a project requires high-heat resins. The high-heat resins required to



withstand autoclaving, such as polysulfone, have their own set of process considerations. These materials are more difficult — and therefore more costly — to work with, mainly due to their higher melting points, which complicates everything from safety concerns to the molding process.

As an example, polysulfone has a melting point of 700°F, versus 500–550°F for typical resins. Oil, rather than water, must be used to control mold cooling, requiring a longer molding process and different equipment—with different risks involved. Heating oil also takes longer and metal-braided hosing must be used as opposed to rubber. These higher demands mean higher risks for both safety and deviation. Since the mold itself can reach 325°F (whereas a water-heated mold typically reaches 180°F), it is subject to higher levels of thermal expansion, which adds complexity to the overall mold design process.

## Selecting a Manufacturing Partner

The importance of selecting the right manufacturing partner increases in direct proportion to the complexity of the task at hand. With all that is at stake, the OEM's evaluation process should be rigorous. It should cover every aspect of a partner's operations, equipment, personnel, track record, culture, and financial health. A site visit should also be part of this process because it provides the best method for assessing the quality of the plant's environment and personnel.

## Conclusion

Complex injection molding can provide a manufacturer with competitive differentiation, but it requires highly specialized equipment, skills, and engineering expertise. OEMs that take advantage of the complex injection molding process will enjoy the benefits of high quality parts and devices with optimum efficiency and lower total production costs.

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*This content first appeared in Medical Device and Diagnostic Industry Magazine, July 2010. Copyright Canon Communications LLC. Used by permission.*