A Buyer's Introduction to Plastic Injection Molding

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The first question that any potential buyer of injection molded parts will have is "How much will it cost?" This seems like a fair question, but it is not always easy to answer. New buyers may become frustrated and feel like they are getting the run-around. We hope that this pamphlet will help you determine whether custom molding makes sense for your application. If it does, you can take steps to make it easier and less costly to get what you want.

Do you need to have your own mold?

A custom mold can be a sizable investment. It makes sense to have your own mold if you have a very specialized product, or the expected volume is high. Otherwise, you would probably be better off finding an existing product and adapting it to your needs, or machining the parts in small quantities as needed.

The key question— How much does it cost?

We are frequently asked "How much does a mold cost?" or "How much will it cost to mold a part for me?" There is no single answer to these questions, but rather a series of answers, depending on the raw material selected, the design of the part, and design of the mold.

There are three primary cost elements of molding. The first is the **price of the mold**. The second is the **cost of the raw material,** usually expressed in dollars per pound. The third is the actual **cost of molding the part,** usually expressed as the machine hour rate, in dollars per hour. This is an all inclusive cost factor that includes the hourly cost of the molding machine, labor, packaging, overheads, profit, etc. These will be covered further on the following pages.

Where do I start?

The customer should start by doing his homework. Even if your knowledge of plastic or molding is limited, you do know your own requirements. Asking yourself the following questions will help define what a molder will need to know:

- What volume of production do you expect?
- Are you replacing an existing or similar product?
- Do part designs exist?
- Do you know what material (resin) you want to use?
- Do you have a cost target?
- What is the expected lifespan of the product?
- Is your company more sensitive to ongoing part costs or up front tooling costs? (You will see that there is a trade-off in these two parameters.)
- Are there any special requirements, such as FDA or UL approval?
- Are there physical, chemical, appearance, or thermal requirements?

Gathering all of the information that you can will speed the process along, and will ultimately save you money.

The Cost Elements of Injection Molding

Cost of the mold

This is often the most visible and shocking initial expense. The **size** and **complexity** of the part, and **number of cavities** are major influences on the price of the mold. Raw material selection can also influence mold cost if the resin is corrosive or abrasive.

There are several typical approaches to mold construction: Commercial mold bases made from pre-hardened steel offer excellent service and value, but can be difficult to change or repair, since the cavities are cut directly into the mold base. An alternative utilizes removable individual part cavities, made from hardened steel with surface treatment and then inserted into the mold base. This offers many advantages, but is typically the most expensive. Aluminum or mild steel mold bases can be used for prototype or short runs, but often disappoint the customer when he “forgets” that he bought a lower cost, short run mold when his demand suddenly increases and the quality of his part decreases.

Sometimes it is advantageous for a customer to buy only the mold cavity to be used in a removable insert-type mold base, and not a complete mold set. The advantage of this is cost. You are only buying the cavity to make your part, and not a complete mold. You rely on the molder to use his mold base to hold your (and other’s) insert. The disadvantage of this is that you may be tied to the particular molder that made the insert, and the molder may not want to dedicate his mold base to a single part if this becomes a high volume part. Insert molds may not be as rugged or as precise in alignment as a complete mold base. This approach is usually used with one or two cavity molds and small production requirements.

Design of the part has a very strong influence on the cost of the mold. When possible, communication with the mold designer in the early stages of product development can often simplify the part design and save money in mold construction.

Cost of the raw material

The cost of the raw material is a major ongoing cost component of the molded part. It is important to define this as early as possible. The mold designer will need to know the material to be used, because different resins have different shrinkage rates, corrosiveness, erosion characteristics, etc. It may not be practical to change resins after the mold is made. The type of resin may be dictated by physical properties, specifications, cost, or customer requirements. There are hundreds of resins to choose from, and this pamphlet cannot begin to discuss then all. We have included a sampling of common resins in the last section. It usually takes some time and discussion, and perhaps some experimental work to define the best resin for your application.

Cost of Molding the Part

A key factor that strongly affects part price and is totally controllable, is the relationship between the machine hour rate and the number of cavities built into the mold. This is easily shown in the following example. Assume the machine hour rate is $36.00 per hour. Also assume that the cycle time is 30 seconds. This would make the machine hour rate component of cost $0.30 per cycle. Let us also assume that the part weighs 45 grams (0.1 pound) and the resin costs $1.00 per pound. This would make the raw material cost component be $0.10 per part.

If there is one cavity in the mold, the part cost would be $0.30 for machine rate and $0.10 per raw material for a total of $0.40

per part. If there are two cavities in the mold, the machine rate is now $0.15 per part, but the raw material is still $0.10 per part, for a total cost of $0.25 per part. If there are eight cavities in the mold, the machine rate would be $0.04 each, and the raw material is still $0.10 each, for a total cost of $0.14 each. There are tremendous savings to be achieved by building molds with more cavities, but the cost of the mold is greater. Also, as the numbers of cavities in the mold increases, it may require a larger molding machine, which costs more per hour to operate. Each customer should consider how to prorate the cost of the mold in his cost model. Items such as original cost, mold maintenance cost, and the expected life cycle of the part are important considerations. Every situation has it's own optimum cost-volume relationship which must be evaluated.

Why Is Plastic Selection Important?

The choice of the plastic resin selected for your molded part can be the dominant long term factor in determining the cost of your part, and how well your part performs its intended function. The previous section showed how the number of cavities in the mold can influence the mold and part cost. The cost of the mold can be looked at as an "up front cost", but the cost of the plastic influences every part made. Please note that the costs mentioned for resins can vary greatly due to market conditions, quality, supply, etc.

There are literally hundreds of plastics to choose from that have prices that range from $0.30 per pound to $30.00 per pound! Which one do you need? The first rule that must be met is that the part must work. There is no reason to make the part at all if it won't meet its intended function. In high performance applications the choices of plastic may be surprisingly limited by electrical, thermal, physical, appearance, or cost requirements. There usually will be more choices in less demanding applications, but the "best" resin for the job may take some experimentation and testing.

This following list of common thermoplastic resins is by no means conclusive. Many alloys and blends offer attractive alternatives that are not shown here.

Commodity Resins

Commodity thermoplastic resins are usually lower cost, lower performance resins, that are widely available from many suppliers.

Polyolefins- Polyetheylene and Polypropylene. These are among the most widely used resins in the world. Prices range from $0.60/lb to $1.00/lb or more for specialty compounded resins. Typically used in high volume applications where cost is critical and property requirements are moderate.

Styrenics- A large family of resins that contain polystyrene. Prices start somewhat higher than polyolefins, and can range higher due to the many other polymers that can be added to the styrene to improve its performance (ABS, SAN, PC-blends etc.). Styrene by itself can be weak and brittle (typical of clear disposable drinking glasses, display cases, etc.), but improves considerably with additives.

PVC- Polyvinylchloride. A very versatile, tough, low cost resin. Easily dissolved by solvents (used for joining piping, etc.). The use of PVC requires special molds and machinery due to its tendency to release chlorine at high temperatures, which hydrolyzes into corrosive hydrochloric acid. Many molders will not use PVC due to this characteristic.

Engineering Resins

Thermoplastic engineering resins are another broad class of resins that have superior properties over commodity resins, and may even be tailored to specific needs. The costs of this group of resins can vary greatly, from ~$1 per pound for regrind nylon, to over $30 per pound for fiber filled high strength, high temperature resins. Physical properties, chemical resistance, electrical, and thermal properties can be so different that each application/resin should be "engineered" to get the desired results.

Nylon- Nylon is the grand daddy of the engineered resins, but by no means is its use in decline. It has great versatility, moderate cost, and good market acceptance. It is offered by many suppliers in a large variety of grades. It does have some chemical and high temperature limitations compared to some of the newer resins. Prices range from $1 to $4 per pound.

Polycarbonate- Polycarbonate also is available in a large variety of grades. It has a natural flame resistance and medium temperature capability, but is most noted for its superior toughness, glossy finish, impact resistance, as well as its clear glass-like appearance. Care must be taken to avoid contact with organic solvents. Prices range from $2 to $4 per pound.

Polyacetel- Another medium priced, $1.50 to $3 per pound resin with somewhat lower physical and thermal properties, but with excellent lubricity. Often used in bearings, conveyors, gears, etc.

Liquid Crystal Resins- A major jump in cost to $10 to $30 per pound. These resins are frequently used with filler materials. They have excellent flow characteristics to fill small channels, and are among the best in high temperature capabilities and dimensional stability. Their anisotropic nature can cause warpage of parts if not designed carefully. They are frequently used in the molding of electronic parts.

PEEK (Polyetheretherketone), PPS (Polyphenylene Sulfide), PAI (Polyamide-Imide) etc.- These are some of a long list of speciality high performance resins. They are usually characterized by high cost, and specialized chemical, thermal, or physical properties. Professional advice should be sought when the application requires these types of resins.

Alan D. Butcher has spent over 20 years in the materials industry. Assignments with Union Carbide and Amoco Chemicals range from Research and Development, Engineering, and Production Management, often associated with new products and their introduction. He is President of Intermold Corporation, a plastic injection molding company that can assist in material selection and product design, the design and construction of molds, as well as production of injection molded parts.