MULTI MATERIAL INJECTION MOLDS

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MASTER PRECISION MOLD TECHNOLOGY

•Two material molds have been around at least as long as I've been in the business. Master Unit Die Products was developing their "two color" mold bases in the mid nineteen sixties. At that time most multi material applications were using two distinctly different colors. We built tooling for thousands of key buttons for computers, type writers, calculators and virtually any keyboard application imaginable. The term two color still endures although multi material is much more accurate. This paper will deal only with two shots but please realize that more are possible if you configure your molding machine with more injection units.

It didn't take long to realize that "two color" was too confining. More and more two material applications became apparent. The key button industry eventually moved away from the old "two color" technology but more industries have seen numerous advantages and the market continues to expand.

MATERIAL SELECTION AND HOW MATERIAL WILL EFFECT PART DESIGN AND MOLD CONSTRUCTION

When considering whether or not a project is a good prospect for two material molding the first question is, "What's to be gained?" If there are obvious answers, there are bound to be more obvious questions as to part design. Some of the obvious reasons to go to multi material molding are cost savings, consumer appeal and function.

The consumer appeal and function aspects are fairly self explanatory. Cost savings are incurred in many ways, including reduced labor by eliminating assembly operations, sorting and other labor intensive endeavors. As an example we've built two material molds to produce shut-off doors for the air conditioners in automobiles, eliminating the old method of gluing foam to a rigid part.

One of the first decisions to be made, after the basic concept has been determined, is what materials lend themselves to the project. Part design and material selections go hand in hand.

There are some basic material considerations to look at.

> Is a certain material critical in either of the shots for functionality?
>
> Do the two different shots need to chemically bond?
>
> Will a mechanical lock between the two parts be necessary?
>
> If one of the materials has a significantly higher melt temperature, can it be the first shot?
>
> Will the first shot be strong enough to maintain critical sizes and shape against second shot injection pressure?

Many materials bond very well. From our experience, ABS will bond to ABS or polycarbonate.

Polycarbonate will bond to polycarbonate, Nylon will bond to nylon. TPE's will bond to polypropylene or ABS. Acetal does not bond well to it's self or to anything else. This does not rule out Acetal or other materials that don't bond, from being used in multi material molding. Sometimes we don't want a good bond, such as if the two materials need to be separated at, or after assembly.

If we do need to keep the two shots permanently attached, and materials must be used that won't chemically bond, provisions for mechanically locking of the two shots will be necessary. This is an area that would greatly effect mold design.

In a situation where two materials of greatly varying melt temperature must be used, the material with the higher melt temperature must be able to be the first shot. If it can not be the first shot the chances of a cosmetically acceptable part is probably zero.

As I stated earlier, polypropylene or ABS and TPE's such as Sanoprene or Hytrel bond very well. Usually however part design needs to be such that the TPE is the last shot. We have seen through some highly unsuccessful prototyping that more rigid last shot polymers will deform or displace the TPE's.

When considering a multi material project, these are some of the basic material considerations. Utilize the knowledge of the tech reps from your resin suppliers.

•PART DESIGN AND HOW DESIGN EFFECTS CONSTRUCTION

At Master Precision Mold Technology, our cost estimators normally look at several potential multi material projects every week.

These range from detailed CAD files, or complete part prints, to sketches on bar napkins. Sometimes all we get is a sample or a mocked up part. As with even the simplest of single shot parts, the first step in quoting is whether or not the part is moldable. Are there die lock conditions or under cuts that would prevent molding? Is the physical part size and wall thickness such that they raise no concern.

After looking at these issues we look at the two material aspect.

Can this proposed part be two shot molded?

Do the material issues we've just looked at seem favorable?

Can it be molded automatically?

For now we'll assume that the production requirements dictate automatic, versus hand transfer or any secondary operations.

With any tooling quote, the need to be competitive is paramount. This is where the type of mold design needs to be determined. If a part is to be molded of two or more materials, there has to be open cavitation for each succeeding shot. Part design will determine how to make open cavitation available. In most situations we'd like to be able to keep the first shot part on the core in the ejector half of the mold. If this can be done we know the part location is as accurate as the location of it's core. Also, if the mold design requires rotation or indexing, the part is securely held in place during this process. To determine if this can be done we have to consider the two different portions of the part, their configurations and locations, and where the core side of the mold needs to be. Other major considerations at this time include how to get material to the individual shots and how to eject the parts and runners.

A simple and relatively inexpensive way to produce an automatic two material mold is to utilize a core pull and retract a portion of the core to make second shot cavity space available. This is generally less expensive because you only need one core and one cavity per part and can utilize a smaller base. This also in turn will generally allow for more cavities in less space. However, this can only be done if the bottom of the second shot area can have the same configuration or contour as the top of the retracted core.

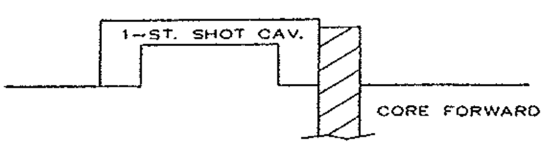

FIG. 1A

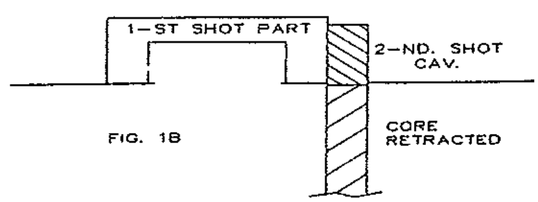

FIG. 1B

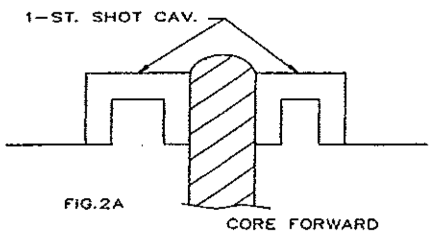

FIG.2A

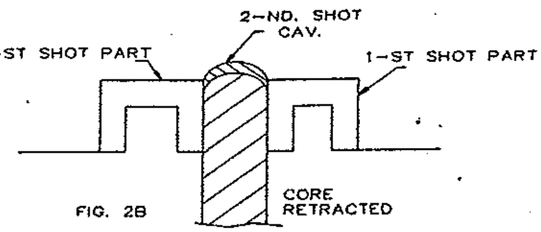

FIG. 2B

Figures 1A and 1B and Figures 2A and 2B show cross sections of such parts. The second shot cavity space is made available by the retraction of a core.

In figure 3, we see a part that can not be two shot molded, by means of a core pull, as designed.

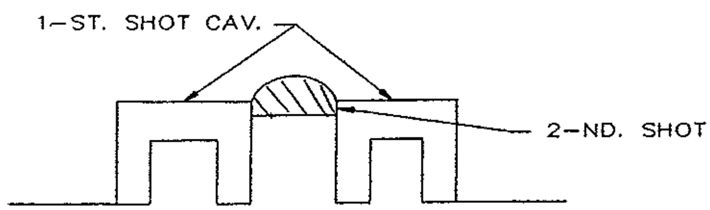

FIG. 3

A core pull will not work without a part change. This part could be molded in an automatic rotating or indexing mold of common core design. However, this type of construction is considerably more expensive whether you use an automatic indexing mold base or a conventional mold base on a rotating platen style molding machine. In either case you require a larger base and twice as many cores and cavities, per part.

This is a situation where a slight modification of the part design could reduce mold cost by allowing a core pull design to be utilized. See figures 4A and 4B.

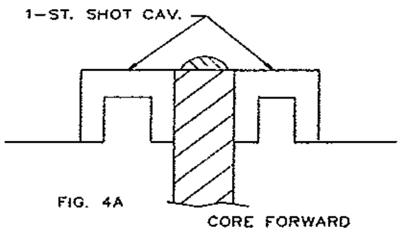

FIG. 4A

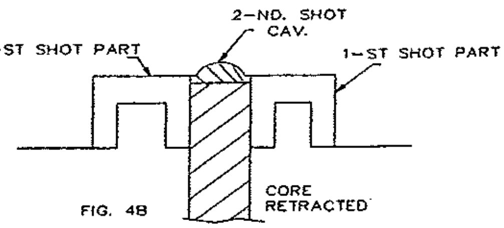

FIG. 4B

If the last shot contour could have a small flat of last shot material around it's periphery, without compromising the parts function, a core pull would work. The retractable core would seal against the flat and keep first shot material out of the last shot cavity.

If the part can not be changed, a common core design could be used. In this type of design, the first shot part would be molded on a core in the first shot cavity. Upon mold opening, this first shot part, on the core, would be indexed 180°to line up with a second shot cavity. There would be an identical core lined up with the now empty first shot cavity. When the mold is closed the second shot cavity accepts the first shot part and provides the open cavitation for the second shot material. (See figures 5A & 5B).

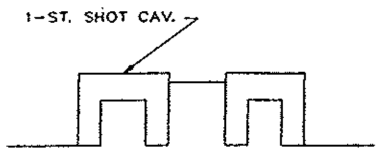

FIG. 5A
COMMON CORE IN
FIRST SHOT POSITION

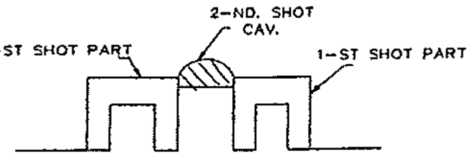

FIG. 5B
COMMON CORE IN
SECOND SHOT POSITION

In this type of mold construction, for a one out tool there would be two identical cores, one first shot cavity and one last shot cavity. Basically this type of design will work whenever the main core side features can all be of first shot material or can readily be shut off on the first shot by steel from the cavity side. Again, this is more expensive than a core pull but is a fairly common concept and works very well.

Figures 6A and 6B show a common core overmold application. Overmolding is a widely used common core application.

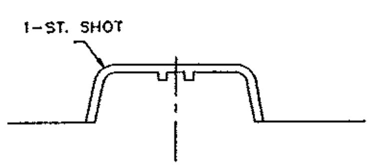

FIG. 6A

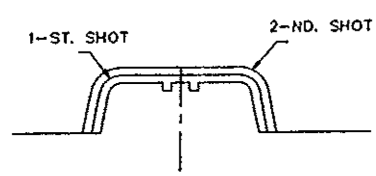

FIG. 6B

Figures 7A and 7B show another common core, two shot mold application where there are either wings or a flange of second shot material around, or adjacent to the first shot part. Again the cores are identical, or common and the cavities are different.

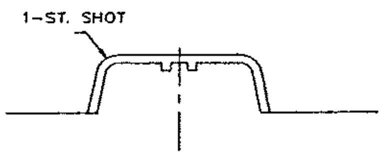

FIG. 7A

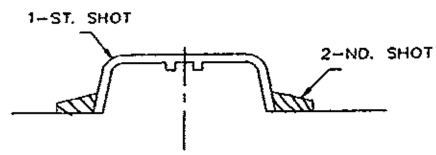

FIG. 7B

Remember that with some part changes, some parts may be produced in the less costly core pull style of design. For example, figures 8 and 9 are slight variations of figure 7B that could be done with a core pull.

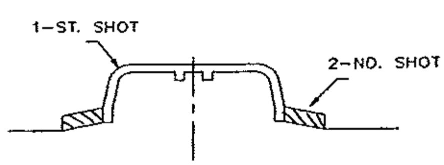

FIG. 8

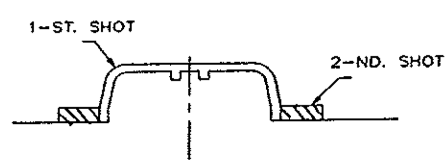

FIG. 9

Earlier I said that a common core design works well as long as the main core features can all be of first shot material or can readily be shut off on the first shot with steel from the cavity side. In figures 10A and 10B we see an over mold part that requires the inner core feature to be of second shot material.

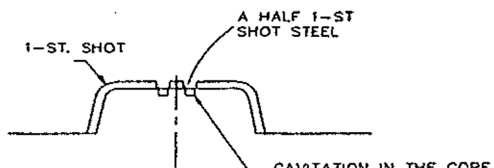

FIG. 10A

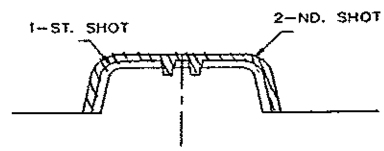

FIG. 10B

The steel from the A side must either be large enough to completely cover the last shot core features or it has to telescope into these features to seal them off. In figure 10B, sink could be a problem. Also if telescoping steel into cavities is utilized, tool life becomes a consideration. The term common core refers to the first and second shot cores being identical but may also refer to this type of two material mold being the most common. It is the most common, but as we've already discussed with the core pull, it is not the only type of two material mold.

Another type of automatic indexing, two material molding is to utilize different cores and cavities in both the first and second shot positions. To do this we need to index the parts, not the cores. If we do this we can have different features from the first shot to the second shot in both halves of the mold. There are two basic ways to do this. The first is robotic transfer, which we have done on numerous occasions. Basically this is just automating the hand transfer method.

The second method, which we more often use, again when there are core configurations that need to differ from the first shot to the second shot, is transferring the parts on a stripper plate. In this method the first shot part stays on the stripper plate after the mold opens and the stripper plate pushes these parts off the first shot cores. There has to be a feature on or in the stripper plate to securely hold these first shot parts while the plate indexes. When the mold recloses the second shot cores push the part out of the features in the stripper plate and into the last shot cavities. This can allow us to mold features inside of the part such as internal ribs or light blockers, utilizing last shot material. The holes through the first shot part need only to be large enough to fill the inside features, if the two materials chemically bond. If not they need to be large enough to provide adequate strength for the mechanical bond. Figures 11A and 11B show an overmold project done utilizing a stripper plate, automatic indexing design.

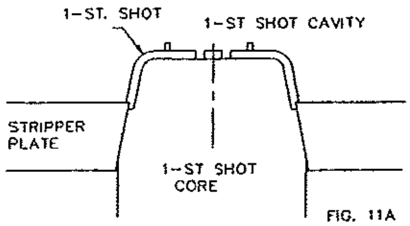

FIG. 11A

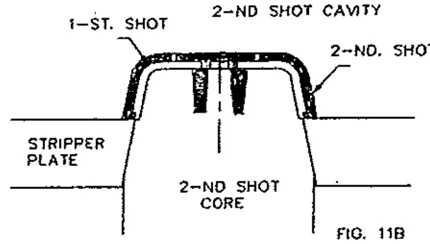

FIG. 11B

A stripper plate design is normally used only if there are first shot part features that can seal against the last shot cavity surface, such as graphics. This is needed to hold the first shot part in place, seated on the last shot core.

We have now looked at the basic mold construction concepts commonly utilized at Master Precision Mold Technology. There are other variations on these methods that may also work, or be necessary. It is possible that a common cavity design could be needed. This could mean putting the cavitation on the ejector side and utilizing stationary half ejection or could even mean indexing the A half of the mold. A core pull may be needed to be just a feature incorporated in one of the indexing style molds. A standard ejector system may need to be added to a stripper plate mold to ensure last shot part ejection after the stripper plate has served the purpose of first shot part transfer. Part design will of course be the driving force.

•STEEL SELECTION

The choice of steels to use in the construction of multi material molds is slightly more critical than the single material molds due to the usually higher initial mold cost. The same considerations will still prevail in your choice. We generally use S-7 and / or H-13 for all of our cores and cavities unless 420 Stainless is requested, or required for corrosion resistance. P-20 steel may be desirable for texturing but we would not recommend it's use in tooling as expensive as a multi material mold. Quality texture houses are very capable of producing most textures in the previously suggested, hardened tool steels.

•GATING OPTIONS

As stated earlier in this paper, how to get material to the individual shots is a major consideration. We have used every style of gate in multi material molds, at one time or another, that we've used in single shot molds.

In many cases, and virtually all overmold situations, we want to get rid of the first shot gate and runner prior to molding the last shot. Where possible a tunnel gate is ideal. Quite often pin point gates, either hot or conventional are used on first shots. This may be the only way to get to the first shot cavity area.

On an overmold situation, generally the first shot gate mark gets covered with last shot material. Pin Point gating may also be the only way to get material to a last shot cavity area, where the cavitation is surrounded by first shot part. Gate vestige or appearance may be a concern in this application, and needs to be considered.

A cashew gate may be necessary on either shot to get into the bottom of the cavity area or the side of an internal feature. If cashew gating is used on a stripper plate mold, an auxiliary ejector system will be required to eject the gate.

On last shot parts, especially in family molds, surface gates may be used to keep the parts in place on the runner for trimming, sometimes after assembly. If the parts do not need to be sorted and a gate mark is not a problem, tunnel gating is an obvious advantage because there are no trimming operations.

Other possibilities would include tunnel gating into an ejector pin under the part of either shot or coring a flow channel through a first shot part to get last shot material to an inner feature.

Once again part design, and to some extent material selection, will dictate what can be done.

•SHOT TRANSFER

In review we have looked at the shot transfer methods we use at Master Precision Mold Technology. When quoting a multi material project, as I've previously stated, we need to keep the cost as low as possible to be competitive. Part design and our customer's molding equipment will determine what we can do.

The least expensive, automatic multi material mold is generally the core back method, which requires no part transfer. Ejection units on the two material molding machine may be in line or at 90°.

Hand transfer from one core and cavity set to another, whether in one mold in a two shot molding machine or from mold to mold in two machines, is relatively inexpensive tooling wise. Cost savings on the tooling can quickly disappear in labor costs and operator error, which may severely damage tooling.

Robotic transfer, generally in a single mold in a two material press will eliminate the labor cost and is usually quite effective. This is probably an acceptable method when production requirements will allow the mold to remain in the press for extended periods of time. Either in line or 90° ejection units may be utilized in hand or robotic transfer. Indexing would not take place.

Common core indexing is done both in rotary mold bases and in standard mold bases on rotary platen machines. In this method the first shot part is transferred to the last shot cavity position on the core. A rotary base is more costly than a conventional mold base but the cost of a rotary platen on a two material press adds substantial cost to the molding machine. When looking at which way to go, when ordering a machine, it would be very nice to see into the future. If a machine is going to be dedicated to one particular project for an extended period of time, your decision is probably based on the best deal and personal preference

Machines with the injection units at 90° to each other function as single shot machines, with the conventional mold mounted in the center of the platen. Either parting line or sprue injection are possible.

The stripper plate, two material mold is another method of transferring the first shot part to a last shot position. In this method both the cores and cavities can be different from the first and second shots. Concerns are holding the first shot part securely during transfer and in place while clamping and molding the last shot.

We have built many automatic indexing, stripper plate bases for machines with 90° injection units. We have not as yet built one for a machine with in line heads, but this doesn't present any visible problems. If a new machine were going to be ordered for a particular, stripper plate, two material project, 90° heads would probably be the least costly. A rotating platen would not be required which would save on the press cost.

SUMMARY AND RECOMMENDATIONS

- Multi material molding is not new. What is new and exciting are your possibilities. If you have, or wonder if you have, a potential multi material project you need to contact an experienced, multi material injection mold maker. There are many available. Your press manufacturer may be able to steer you to someone they've worked with. Involve the mold maker and their engineering department in the part design as early as possible.