Composite Molds: Choices and Considerations

By Rick Pauer and Andrew Pokelwaldt

Composite molds vary widely, depending on the industry and application. For instance, high-end, nickel-iron alloy tooling is commonly used in the aerospace industry, while boat and wind blade manufacturers typically use GFRP molds. This column will focus on traditional composite molds that utilize glass fiber as reinforcement and will provide guidance for manufacturers striving to invest in cost-effective molds that meet the required volume and quality standards, using the best-suited process for manufacturing.

Best practices for mold making vary based on many factors, including the following:

- Number of parts to be made with a mold
- Mold service life
- Cost
- Final product specifications, tolerances and surface finish
- Material selection
- Production rate and delivery deadlines
- Staff expertise

Because there are so many decisions to make concerning molds, we've divided the topic into two columns. In this issue, we will discuss the influence of the final product manufacturing process, mold design and plug production. In part two, which will be published in the January/February 2018 issue of *Composites Manufacturing* magazine, we will examine mold building, mold maintenance and up-and-coming mold innovations.

Composite Production Processes

Prior to starting the mold-making process, it's imperative to consider the expected production method for the final application. The method you use influences the mold you will build, and, conversely, the mold impacts the production method. Here's an example illustrating the symbiotic relationship between the two: If you only require a few parts, then you wouldn't build a mold for a heated resin transfer molding (RTM) process. The mold and process would simply be too costly. But if you plan on fabricating a dozen or so parts per day, then you would likely utilize heated RTM molds, which can turn out two to three parts per hour.

These are some of the factors to consider as you think about both your anticipated production process and the mold:

- Surface requirements – The gloss, profile and texture of the final part.

- Expected volume – Is the application a prototype (1-5), low volume (20-50), medium (several hundred) or high volume (several thousand)?
- Number of molds – Expected volumes determine the number of molds required.
- Accuracy – Parts are often joined together, so precision is key.
- Durability – This is often tied to required volumes, but simple design modifications (like higher draft angles) can reduce wear and damage of the mold surface.
- Speed to build – The time it takes to make one or multiple molds.
- Cost and budget

Design, plug making, mold construction, surface preparation, framing, maintenance and demolding can vary significantly depending on what type of composite manufacturing process the mold will ultimately be used for.

Mold Design

The mold-making process typically starts with a plug (a representation of the final part) and the initial mold (the mirror image that is "pulled off" the plug to make production parts). It's important to start projects off right with a solid design. By investing time, energy and money in the design stage, you can avoid or minimize production issues later. Your return on capital – realized only after production starts – depends on how quickly a high-quality mold can make high-quality parts that require minimal additional input to produce a finished, shippable part. If you build a poorly-designed mold, that return on capital may never happen.

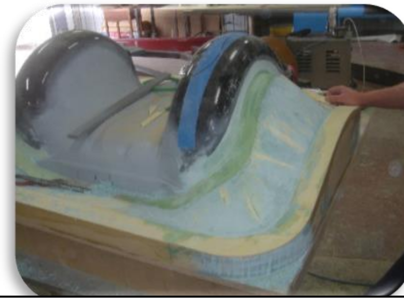
There are lots of factors that need to be considered during mold design, many of which have already been listed. One primary concern is shrinkage from plug to mold. With older mold-making materials, a rule of thumb was to expect 1/32-inch of shrinkage per inch of mold. Part shrinkage related to materials must also be considered in the design stage. With newer controlled-shrink mold-making materials, shrinkage can be minimized, but parts made with shrinking materials still need to be compensated for.

When designing plugs and molds, manufacturers also need to consider things like ease of gel coating, fiber placement, core placement, movement and storage at the plant and their impact on labor costs. Poorly planned designs will lead to build issues for manufacturing. Staff who oversee mold loading, mold care, mold prep, mold movement, demolding and production controls should be consulted during the design phase if production issues and mold durability/life expectancy are of any concern.

There are many software packages available to design plugs via computer aided design (CAD) files and then machine them, including SOLIDWORKS®, Autodesk™, NX for Design and ESAComp.

Plug Production

The plug can be designed using various materials, including plaster, foam, wood, tooling board, plastics and modified fiberglass parts. In addition to CAD design, machining and 3-D printing, plugs are often still made by hand, using wood products like medium density fiberboard (MDF) with fairing materials and coatings that are then sanded to the required surface finish. This is a common plug-making method for simple and smaller shapes.



Existing FRP parts are used to hand modify a new plug. Note the smooth transitions incorporated on this plug for ease of subsequent counter-mold making.

As stated earlier, the production manufacturing process of the final parts significantly influences plug and mold-making decisions. Traditional open molding molds usually provide the lowest cost entry because you only need to build a single mold – generally called the A-side – which gets you to part production faster. Closed molding processes can offer improved back side surfaces, especially when a rigid counter-mold (RTM or light RTM) is built off of the A-side mold.

After hand-working the plug surface, an easy-to-smooth coating is applied and sanded to size and surface.

RTM offers many benefits, including improved dimensional control (part thickness), better resin-to-fiber ratio, reduced void content, cleaner working conditions and reduced emissions during part production. However, there are significant additional costs in making two molds instead of one. Further, the required flange detail, vacuum seals and various ports for resin and vacuum also increase the costs and time associated with building RTM and light RTM counter-molds. Those costs generally are negated by process and production improvements.

This high-gloss coated, polished, buffed plug is ready for mold manufacturing.
Photo Credits: RTM North

Another closed molding option is vacuum infusion processing (VIP). VIP has the lowest entry point costs for closed molding, but it is likely the most expensive process in the long term because VIP is inherently tied to a plethora of disposable materials, such as film, peel ply, resin feed lines, vacuum feed lines and sealant tape. However, VIP only requires building one mold. In addition, the process is very forgiving in laminate and core modifications as the film allows for those modifications.

The guidance above certainly doesn't cover all the complexities of mold design and plug production. Every mold-building project is nuanced and presents different challenges. It's important that composite manufacturers keep up to date on new technologies

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and materials that can lower costs and increase capabilities. Check out our column in the next issue for information on some of the latest advancements in mold making.

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