MACHINING VS CAST MOLDING:
CHOOSING THE BEST MANUFACTURING METHOD TO PROCESS POLYURETHANE FOAM

A technical paper by General Plastics Manufacturing Company
The Surprising Impact of Material Processing
When it comes to creating new products, most manufacturers agree that solidifying a bulletproof design and selecting the right materials are critical to the project’s success. However, did you know that selecting the right processing method for your materials can impact time-to-market, expenses, and overall product quality?

At General Plastics, our rigid and flexible polyurethane foams are commonly used to make production parts in nearly every industry – including aerospace, automotive, recreation, consumer, and medical markets. However, a common misconception is that using foam automatically means machining. Many new customers ask us, “Can I get a CNC quote?” without realizing that there are other processing options to consider, such as molding.

A misconception is that molding is more expensive than machining. After decades of working with clients on a wide variety of complex applications, we have recommended cast molding for our foams, especially for high volume runs. Our goal is to present more processing options for you to consider. In this whitepaper, we will explain the different nuances between and results from machining versus molding.

Overview of Machining Versus Cast Molding
CNC machining uses computer software to control machine tools that cut complex 2D and 3D shapes out of blocks of material. Usually a CAD drawing or other digital representation of the desired part is created, and then the drawing is translated into instructions (e.g., speeds, locations, and coordination) for the CNC machine. The machining process may require multiple routers, lathes, and other tools to remove different layers and accomplish the final shape. In general, CNC machining is very fast, accurate, and repeatable, capable of achieving precise tolerances.

Cast molding – also known as casting, hand-poured molding, and clamshell molding – involves creating a tool in the desired shape and then pouring the liquid thermoset resin into the mold. The polyurethane expands to fill the cavity during the reaction and becomes polyurethane foam. After the foam cures and hardens, it is removed from the mold and the tool is prepared to make the next, identical part.

View our Molded Parts: Armrest Pad video to find out how casting is used to create armrest pads for passenger aircraft.
Casting is similar but has notable differences from injection molding. Injection molding involves injecting materials into the mold at high pressures, which means the injection molds require stronger materials, more time, and more cost to make. Casting relies on low pressure or gravity only to pour the blended reactants into the mold, therefore casting tools are generally faster and less costly to make. Also, setup and teardown for injection molding takes longer than casting, and may require the assistance of heavy lifting equipment.

The Differences Between Machining Versus Cast Molding

Now that we’ve briefly described the machining and casting processes, let’s take a more detailed look at how they differ on cost, lead times, quality, and other considerations.

Cost

Cost is usually the foremost consideration on people’s minds when comparing the two methods, and it’s affected by several factors: production volume, price of the tool, material savings, and size of the part. Production volume is one of the easiest parameters to determine. Generally, if the production run for the life of the part is less than 100 parts, machining makes sense, whereas if the lifetime volume is greater, then casting is the better option.

The cost of the tool is surprisingly low for cast molding. Depending on the volume, the casting tool can be made out of aluminum, filled epoxy, silicon, or even high-density foam. In comparison, metallic tools are the most expensive choice for tooling but are more likely to last the entire lifetime of the program, whereas composite tools are approximately one-third the cost of metal but may require some repair over time.

Material savings plays a role in the cost of the processing method. Subtractive manufacturing, such as machining, involves creating a product by removing, cutting, and drilling away excess material to produce the desired shape. Naturally, this method produces excess waste, which is all raw material that you paid for and now have to discard. On the other hand, formative manufacturing uses techniques like casting, injection molding, and stamping to form or cast materials into the shape of the final product. This method generates very little excess waste, and therefore the material savings may be quite significant, depending on the size and complexity of your part.
Finally, the size of the component influences where that crossover point is for choosing machining versus casting. For very large components, in which the casting tool would be even larger, it may be more cost-efficient to machine instead of mold the part. However, sometimes it depends on circumstances. General Plastics recently worked with a company in the oil and gas industry who needed help producing large flotation modules for subsea pipe supports. The assumption was that we would machine the flotation modules out of huge blocks of foam, since a large tool for casting or molding it would likely be cost prohibitive to create. After some calculations, we discovered that the cost and time associated with machining didn’t work out and a large molded part would suit the client’s purposes better. This was a unique case since we had never heard of anyone else doing a custom casting of polyurethane foam of that size. The project achieved significant cost and material savings just by switching from machining to casting. Bottom line: every application is different, so it pays to consult a materials specialist like General Plastics early on.

**Lead Times**
From first customer engagement to first part in hand, CNC-supplied components have shorter lead times than molded parts. However, if the tool is already made and you’re scheduling another delivery of parts, then the molded components will be much faster. To give you an idea of tool creation timelines, the fastest, simplest tools made out of rigid foam may take about 40 to 120 hours to create (from design to first pour). However, more complicated tools will take at least 200 hours to produce, and additional time should be expected as the level of design complexity increases.
Product Quality
The finished parts produced by machining and molding have a few differences to take note of. On one hand, a component fresh off the machine has a smooth, uniform surface, since detailed textures are fairly difficult to accomplish with machining. The machined part also has a cellular foam surface, so further sealing and painting may be required.

On the other hand, a molded part has a better finish, since it comes off the tool with a smooth or textured skin that is already sealed. Paint can even be pre-applied in the mold. For post-processing, you simply wipe off the mold release and remove the parting line, and the product is ready to go. If product durability and waterproofing are important to your application, casting may be the better option.

As for tolerances, both types of processes have their benefits and limitations. In general, machining can achieve higher tolerances compared to molding. However, there will be greater variability from part to part and from lot to lot with machining compared to molding. With machining, many times a program is set up on a machine and then taken off so the machine can be used for another project. When you need to load your program again, the positioning may not be exactly the same, resulting in slight part consistency issues from lot to lot (all within tolerances though). Whereas with casting, a tool is built to have minimal wear, so molded parts from batch to batch are nearly identical.

Selection of Materials
There are so many different types of polyurethane foams depending on what properties you’re looking for: open versus closed cell, density and strength, impact- and thermal-insulation, self-skinning, buoyancy, etc. Depending on the mix of parameters, certain processing methods may be more suitable than others. In general, rigid foams can be processed with both machining and casting, since it has the hardness to withstand the cutting and grinding used in machining. However, some flexible foams may be too soft to withstand machining, so cast molding would be the only choice available for this category of materials. Flexible foam applications with simpler design specifications, such as dunnage and packing material, can potentially be machined.

Which Method is Right for You?
We’ve introduced a lot of different concepts and considerations for machining versus molding polyurethane foam, but this chart (see next page) helps tie together all the information, and will help you better understand how to choose the best method for your application requirements (e.g., speed, quantity, complexity, design certifications, and surface finish).

Ideal Applications for Machining and Molding
To summarize, machining is ideally used for prototyping, small quantity runs, precision tolerances, and components with large, complex volumes. Cast molding is great for large quantity runs, exactness from lot to lot, and parts where a skin or detailed texture is important. For example, casting is used in marine applications to make fuel floats where buoyancy is necessary and the skin helps by preventing water absorption. For automotive use cases, the skin on the foam provides a nice surface that is protected against abrasion during cleaning and regular use.
The two methods can also be blended, such as when a single part is composed of multiple types of foam in order to support specific material properties. Sometimes this means the foam A is machined and then foam B is molded over it, and other times foam A is molded and then foam B is poured over it and machined. Examples of these are aerospace padded parts and automotive dashboards, which incorporate both rigid and flexible foams to provide structural strength and impact absorption. Another reason for mixed mode processing is complex designs. In this case, a part may first be molded with a textured surface and then recesses or sharp negative drafts are removed more easily using machining.

<table>
<thead>
<tr>
<th>Machining</th>
<th>Molding</th>
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<tbody>
<tr>
<td>&lt; 100 parts</td>
<td>&gt; 100 parts</td>
</tr>
<tr>
<td>Volume</td>
<td>Allot time for mold/tool design and construction. Once mold is validated, high volume of parts can be produced in a short amount of time.</td>
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<tr>
<td>Speed</td>
<td>Longer lead time. Allot time to construct mold/tool and ensure parts are in tolerance.</td>
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<tr>
<td>Time to First Part</td>
<td></td>
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<tr>
<td>Price Per Part</td>
<td>At a high volume, even with upfront cost, price per part becomes more economical.</td>
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<tr>
<td>Repeat-ability</td>
<td>Repeatability from lot to lot. Parts from one batch to the next is almost identical.</td>
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<tr>
<td>Material Savings</td>
<td>Part is molded to net shape. No material is wasted.</td>
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<tr>
<td>Surface Finish</td>
<td>May achieve detailed textured finish or smooth rind/skin. Less post-processing needed.</td>
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<tr>
<td>Shape Complexity</td>
<td>Some design limitations. Additional finishing work may be needed depending on design.</td>
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<tr>
<td>Available in a shorter amount of time as it only requires machine programming (no tooling needed).</td>
<td>More cost-effective for smaller quantities or very large parts with tight tolerances.</td>
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<tr>
<td>Once design is programmed, machining can start.</td>
<td>Some variability from part to part each time material is placed on machine.</td>
</tr>
<tr>
<td>Final part is achieved by cutting, removing and drilling away excess material.</td>
<td>No skin. Smooth machined surface. Sealing and painting may be needed due to cellular foam surface.</td>
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<td>Allows for greater flexibility in design. Many features can be machined that may be cost-prohibitive with molding.</td>
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Reduce Your Engineering Shadow

When it comes to making manufacturing decisions, there’s more to consider than just cost. We want to reduce the “engineering shadow,” in which assumptions and misconceptions made early on in the design process end up having a negative, hard-to-reverse impact on decisions later down the road. The key is to involve materials experts like General Plastics early on in the planning phase to potentially save a lot of time and waste.

General Plastics supplies a wide selection of innovative rigid and flexible polyurethane foam solutions, and we also offer complete in-house production services for converting foam and other nonmetallic substrates into production parts for OEMs and Tier 1 and Tier 2 vendors. Our production facilities have large-capacity CNC machining and cast molding services that can accommodate projects of all sizes, as well as quality assurance and testing services to validate your products. Regardless of which method you use, let our team of scientists and engineers help you deliver machined or molded components efficiently, conveniently, and cost-effectively.

Contact us today to determine which foam and which processing method is best for your application.