Think diecasting tooling will ruin your lead times? Think again.

North American Die Casting Association, Wheeling, Illinois

Manufacturers seeking a competitive edge in today’s global economy are increasingly turning to rapid prototyping to bring products faster to market. As part of the rapid prototyping process, diecasters are using a variety of rapid tooling methods to produce pre-production models, limited runs of production parts and even production quality tools capable of running up to 100,000 parts.

Development of rapid prototyping began in the 1980s, using computer aided design or animation modeling software to transform virtual designs into cross sections representing the physical dimensions of the model. The process is similar to the construction of a topographical model, where the layers correspond to elevation changes. The virtual model is then translated into a physical design using either additive or subtractive prototyping.

In additive prototyping, the model is built by creating cross sections using successive micrometer or millimeter-thick layers of liquid plastic, powdered plastic or some other engineering material. The standard interface between the CAD software and rapid prototyping machines is the stereolithography format, which is similar to printing. The layers deposited by the prototyping machine, which correspond to the virtual cross section from the CAD model, are glued together or fused (often using a laser) to create the final
shape. The primary advantage of additive construction is its ability to create almost any geometry, except trapped negative space.

Subtractive prototyping is the traditional method used to construct a die tool. In this method, pre-hardened steels are machined into the desired shape, which shortens lead times when compared to machining the steel in the annealed condition. Modern cutting tools allow machining of steels up to 40-42 HRC. Die life can extend from a few thousand shots to tens of thousands, depending on the configuration of the part. The subtractive process produces accurate tools with excellent surface finish.

Rapid tooling has become an integral part of the rapid prototyping process. The various methods available to manufacture die inserts decrease lead times, reduce costs and often provide new ways to meet designers’ and purchasers’ needs for die cast parts.

Rapid Tooling Processes

Current technology offers six primary techniques for rapid tooling. While each process has certain characteristics that must be weighed when choosing between them, they all share the primary advantage of moving quickly from a prototype to production.

Direct Metal Deposition (DMD)—Typical lead times for DMD methods are near one week. The process produces an insert by injecting powder metal into the beam of a computer controlled carbon dioxide laser. The laser melts the powder and deposits it in the exact location where it is required. It is a similar process to the fused deposition rapid prototyping method. Using DMD, inserts can be made out of almost any metal. The estimated tool life is normally between 1,000 and 10,000 shots. However, current studies indicate that the life may be substantially longer. The insert size feasible with this method is relatively large (41 x 78 x 24 in.), with a tolerance of 0.003 in./39 in. The cost of insert prices can be as low as $2,500 if a base substrate is used, or they can be up to $60,000 if the entire insert is made with DMD.

Selective Laser Sintering (SLS)—In certain cases, SLS can be the fastest rapid tooling method, with lead times as low as two to three days. As with DMD, this method fuses metal powder together with a carbon dioxide laser. However, instead of injecting the powder into the laser beam, the powder is spread in layers. The laser then traces out the features, producing several rapid prototyping methods are now available that can produce tooling capable of up to 100,000 shots. Even when the rapid tooling method used does not produce a die with a long life, there may be production advantages because the geometry and computer settings needed to develop the initial tool can be transferred to the production tool.

Rapid Tooling Advantages

Producing tooling is the most time consuming step in creating a die cast product. Traditional methods of designing and manufacturing die inserts take between five and 20 weeks, but rapid tooling methods can cut this to one to five weeks. In addition, rapid tooling techniques may be less expensive than traditional tool production.

Rapid tooling also allows the development of more complex designs. Because rapid tooling methods are fundamentally a printing technology, they permit the creation of dies that would not be possible with other methods. For example, cooling lines can be placed exactly where they are needed to conform to the die design. Directly creating these lines in thin sections of the die can lead to better thermal management and a better running die.

Traditionally, these advantages were offset to some degree by the shorter life of dies produced using rapid tooling methods. However, online resource

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Visit www.diecasting.org/research/rapidtool for an interactive tool to help you select the best rapid tooling method for your part.
the die layer by layer. The metal particles are typically 0.02 in. in diameter. This method can use almost any metal. Dies made using SLS can produce up to an estimated 1,000 shots. The maximum die size is limited to 8 x 10 x 5 in. Tolerances as fine as 0.002 in. can be achieved using SLS. Normal die insert costs using SLS fall between $6,000 and $8,000.

**Direct Metal Laser Sintering (DMLS)**—With DMLS, lead times normally fall between one and three weeks. The method uses a 3-D CAD-driven automated machine to create the die insert. The machine starts a cycle by spreading a layer of powdered metal. Then, a laser sinters the desired cross section. Those two steps are repeated until the entire insert is created. DMLS can create parts out of steel and bronze. Tool steel dies using this method last an estimated 1,000 to 10,000 shots, with a maximum size of 9.75 x 9.75 x 7.75 in. This technology can attain 0.001-0.002 in./in. tolerances. Depending on the complexity and size of the insert, prices can range from $2,000 to $25,000.

**Rapid Solidification Process Tooling (RSP)**—RSP starts with a rapid prototype of the desired part, or a machined prototype. This is used to create a ceramic negative of the desired die shape. The ceramic negative is then sprayed with molten H13 or a similar tool steel. Once sufficient material is built up, the die is cut to fit and polished for use. This process takes up to two weeks. Once built, the dies last an estimated 1,000 to 10,000 shots and sometimes beyond. Currently, the maximum die size is 7 x 7 x 4 in. Tolerances can be held to 0.003 in. The process is relatively inexpensive, with a typical insert price around $1,500.

**Laser Engineered Net Shaping (LENS)**—LENS uses a laser to create a molten pool on a metal substrate. Metal powder is then added to the pool as the work piece is moved through a programmed x-y planar path. After one cross section is complete, the laser and metal feeder are moved in the positive z direction, and the process is restarted. The result of many layers is a die insert. In order to save time and money, a die “blank” can be used. This blank is normally a preformed substrate that has a large cavity. In this way, the LENS material is used only to shape the complex fea-
The Six Rapid Tooling Methods

Currently, six processes comprise the primary methods used in most rapid tooling applications. Following is an overview of each.

<table>
<thead>
<tr>
<th>Process</th>
<th>Lead Time</th>
<th>Tool Life (shots)</th>
<th>Insert Size (in.)</th>
<th>Tolerances</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Metal Deposition</td>
<td>1 week</td>
<td>1,000-10,000</td>
<td>41 x 78 x 24</td>
<td>0.003 in./39 in.</td>
<td>$2,500-60,000</td>
</tr>
<tr>
<td>Selective Laser Sintering</td>
<td>2-3 days</td>
<td>1-1,000</td>
<td>8 x 10 x 5</td>
<td>0.002 in.</td>
<td>$6,000-$8,000</td>
</tr>
<tr>
<td>Direct Metal Laser Sintering</td>
<td>1-3 weeks</td>
<td>1,000 to 10,000</td>
<td>9.75 x 9.75 x 7.75</td>
<td>0.001-0.002 in./in.</td>
<td>$2,000-$25,000</td>
</tr>
<tr>
<td>Rapid Solidification Process Tooling</td>
<td>2 weeks</td>
<td>1,000 to 10,000</td>
<td>7 x 7 x 4</td>
<td>0.003 in.</td>
<td>$1,500</td>
</tr>
<tr>
<td>Laser Engineered Net Shaping</td>
<td>2-4 weeks</td>
<td>10,000 and 100,000</td>
<td>36 x 36 x 60</td>
<td>+/-0.005 in.</td>
<td>$250 per cubic inch</td>
</tr>
<tr>
<td>Electron Beam Melting (EBM)</td>
<td>3-4 weeks</td>
<td>10,000 to 100,000</td>
<td>8 x 8 x 7</td>
<td>0.013 in.</td>
<td>$2,500 to $4,500</td>
</tr>
</tbody>
</table>

Business Considerations

Interest in rapid tooling has increased as OEMs seek ways to more quickly test market reaction to new products or react to changes made by their competition. Creating actual parts using a die casting can allow manufacturers to test their products under actual working conditions while accumulating data on the benefits of product improvements to assist with marketing.

Collaborating with a diecaster and building a bond by working together to achieve a business solution often can have long-term benefits. However, the stakes rise along with the expectations, particularly when working on critical projects with short time frames. The die casting supplier must maintain an appropriate commitment of resources and support to ensure that the rapid tooling is delivered as planned.

The die casting source and purchaser must consider a number of factors when choosing a specific rapid tooling process. These considerations include:

**Lead Time**—While all rapid tooling methods reduce lead time compared to traditional methods, the time can vary from one to five weeks. Also, certain processes may be more suitable to multiple cavity dies. For instance, the rapid solidification process method may take 10 days to produce the first cavity, but each additional cavity can be produced in only a half day.

**Quantity**—Rapid tooling offers the flexibility to produce dies for low volume product runs. As such, it can provide opportunities to use diecast parts in applications that...
Laser engineered net shaping uses a laser to create a molten pool on a metal substrate. Metal powder is then added to the pool. The direct metal deposition method can be used for larger dies.

may not be cost effective with traditional tooling. Several methods can produce tooling capable of up to 100,000 shots; however, rapid tooling may not be a good choice for high volume production runs, since many of the methods do not provide the longevity of premium or superior grade H13 in the fully heat-treated condition.

Size—The majority of rapid tooling methods are limited to die sizes of less than 10 in., although the DMD method can be used for dies of up to 41 x 78 x 24 in.

Complexity—The layering of material in rapid tooling methods makes it more difficult to add certain features, such as cooling fins or other standing metal elements in the finished product. However, small surface details can be easily reproduced because the methods utilize printing technology.

Cost—Although typically less expensive than traditional tooling, a wide range of costs for rapid tooling methods exists. Factors affecting the cost include the size of the tool and whether or not a substrate is used. For example, a tool could be made with high performance materials at the surface of the cavity and high thermal conductivity materials under the surface for better cooling. This would reduce the cost of the insert by using expensive materials only where they are needed.

This article was adapted from a transaction paper published by the North American Die Casting Association (NADCA). The papers are available free online for NADCA members.

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