Need Diecast Parts Faster?

Buyers of die castings are obtaining prototypes and short production-run "die castings" quickly thanks to investment casting and plaster mold casting.

Kevin O'Shaughnessy, *Associate Editor*

Imagine the following—you are in the bidding process on an engine design that includes diecast parts. You want to show your potential customers that your engine design is the most viable option, and the best way to do this is to show them a working prototype. With a deadline of less than a month, how can you have a working model with die castings? The answer: use prototyped or short run "die castings."

The combination of rapid prototyping with investment casting or rubber plaster mold (RPM) casting allow for the production of a sample cast component or short-run components that are close to or the exact same as the high-production diecast parts. More and more design engineers are turning to this option as an effective precursor to high-production diecasting, which requires a steel tool or die to be machined.

Typical leadtimes for high-production die castings can be 8-12 weeks because of the time it takes to make the tooling. Additionally, once the die is cast, changes to the component design can cost thousands of dollars in tooling modifications, or the tool is scrapped.

With these two other processes, casting engineers can obtain prototype parts and/or short runs that are similar to die castings (mechanically and physically) and assemble them to present a functional product to their customers. Such action can earn contracts and open the eyes of other customers in the future. Further, it can save a significant amount in tooling expenses (because design changes won't lead to excessive tooling costs) and allow for prototype part delivery in a timely manner.

Investment Cast Die Castings

The investment casting process has always been an ideal choice to produce rapid prototype parts because wax models (and other materials) can be created and turned into castings in as little as one day.

The process begins with the creation of ABS wax models from a digital design file (.STL). These models then are attached to an investment casting tree, coated with ceramic slurry and burned out, and poured molten metal takes the shape of the hollow ceramic shell to obtain a prototype cast component. After the parts are cast, they can be machined and shipped as normal. This process from design to delivery of prototypes can take from days to a few weeks depending on volume.

The engineers for Trico Products, Rochester Hills, Mich., have come to understand the benefits of prototyping.

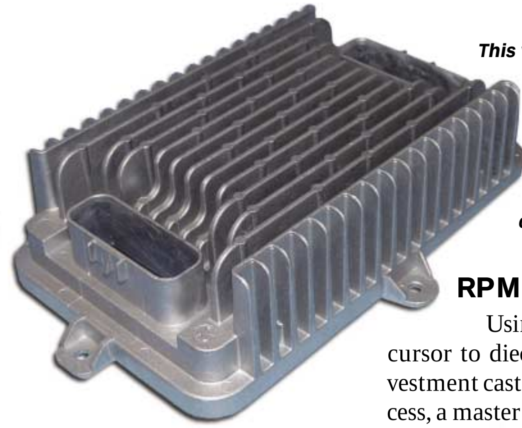
As a manufacturer of windshield wiper components for automotive companies, Trico endured a quandary with a diecasting supplier in 2003. Trico was in the advanced design phase for a new windshield wiper motor (which included six cast parts) for a major automotive manufacturer and had decided to outsource its prototype models to a foreign diecaster. However, after three months of conflicting discussions about the parts' designs, such as tolerances and draft angles, the diecaster still had not begun to cut a tool.

Trico was pressed by time constraints and needed to have something in hand soon to even consider showing the new concept motor to the automobile manufacturer.

At the suggestion of one of his businesses partners, Trico's Manager of Research and Development, Dave Peck, went to Aristo Cast Inc., Almont, Mich., to discuss the metalcasting firm's capabilities with rapid prototyping.

Peck presented Aristo Cast the same part design that the diecaster found incompatible and asked the firm to create a rapid prototyped casting. Within a week, Aristo Cast had a one-off part completed. "Aristo Cast was able to simulate in the investment casting process die cast parts," said Peck. "Basically (investment casting) gets into draft angles, tolerances, dimensions and wall thickness. So, it's a different

This multi-part magnesium component for a Trico Products windshield wiper motor was rapid prototyped and investment cast by Aristo Cast after Trico had no success to obtain prototypes for the same part from a diecaster.



This voltage regulator (r) designed by Sure Power Industries was rubber plaster mold cast (l) by A.L. Johnson prior to high-production diecasting. The plaster models allowed engineers to examine design efficiency and casting soundness.

methodology of what you pour into, but other than slightly rougher surface texture, the parts would be identical dimensionally. In the key areas where you have to machine the part, there's no difference."

After these first tests were completed, Trico and Aristo Cast examined several rapid prototype design iterations of one of the six motor parts to improve the rigidity of all parts. Each time, Aristo Cast made, machined and shipped five magnesium components from wax models in less than two weeks, and Trico assembled them to create a preliminary testable motor.

Once a design was finalized, Trico submitted a digital file to Aristo Cast for semi-production tooling. Aristo Cast then modified one of its investment casting tools to inject wax molds and several weeks later, cast in AZ91D magnesium alloy more than 50 components of each of the six parts and machined them. Trico then performed mechanical and system development tests and presented the parts to its own management and potential customers.

As a result, Trico is the only firm that has presented a viable 4 x 4-in. (10 x 10-cm) wiper motor to the automotive firm. This has led to the development contract, which currently is being finalized. Through investment casting, the component achieved the required wall thicknesses of as little as 0.04 in. (0.1 cm), and mechanical properties were similar to die castings for yield and ultimate tensile strengths. Trico saved more than 20% in prototype expenses than if it had kept the order with the foreign diecaster, and the whole process with Aristo Cast took less than three months.

"Typically, when we would have things rapid prototyped in the past, we would have to have parts made from aluminum tools to try them out in the diecasting process and then go to steel tools later on for production," Peck noted. "But that would take months before you could ever get one part. No one could present the customer a motor that worked and put it on the table. When we used rapid prototyping, that not only gave us a blueprint to put on the table, it gave us a functional part to test."

Aristo Cast Chief Engineer Larry Blum said that an investment casting facility's maximum cost of tooling can be the same price as the cheapest diecasting tooling block before it's cut. Thus, diecasting customers are looking for alternatives.

Aristo Cast currently is investigating more about the diecasting market and how to produce 100 pieces for semi-production. Through this, as Blum said, "all the bugs and design problems are worked out to a degree before engineers get to the final part when they start cutting diecast tooling."

A method commonly used to avoid tool cutting is creating stereolithography (.SLA) models, which are made from sintered photopolymer material. .SLA components may display the correct size and shape, but they also tend to be fragile and have the potential to break when not handled carefully, different from cast components. "(The investment castings) are actual metal parts; you can touch and feel them," Peck said.

He also noted that .SLA models do not provide for functionality, whereas with the investment castings, Trico's staff could assemble the motor, turn it on and watch the gears work.

"If you actually have a real part that resembles what the part will look like with the materials in it, and if you're getting it for a relatively inexpensive price quickly, it helps you sell advanced concepts to your own management and certain customers," Peck said.

Rubber Plaster Mold casting helps save in production time and tooling costs with reusable rubber molds.

RPM Die Casting

Using another process as a precursor to diecasting is not limited to investment casting. In the RPM casting process, a master cope and drag is made from epoxy cast against a reverse pattern machined from aluminum. An inverse-patterned rubber mold then is cast against the epoxy mold, and this rubber mold is used to cast plaster into a new mold. Once the plaster solidifies, the plaster mold is cut out and ready to cast with metal. Further, rubber molds also can be produced from rapid prototyped plaster molds, thus eliminating the need for hard tooling.

The RPM process allows the firm to mimic diecast tooling almost to the exact scale as production diecasting molds. Further, the rubber mold flexibility and heat insulation helps eliminate the need for draft and uniform wall thicknesses, and this minimizes the tooling process for the RPM cast parts. "(RPM castings) don't need the features diecastings need, so once we have the part in a diecast design, we can do it," said Terry Carlson, vice president—sales for A.L. Johnson Co., Camarillo, Calif., an RPM metalcasting firm. "It's a simple thing for us. Changes in design are easily and usually inexpensively done with tooling (at a fast pace)."

RPM casting utilizes low-cost tooling that can be completed in less than a month, and when tooling changes are needed, they can be corrected in only a couple days. Further, the rubber molds are reusable and can be duplicated as many times as needed. As Sure Power Industries, Tualatin, Ore., has discovered, these characteristics make the RPM process ideal for prototyping.

Sure Power, which manufactures electrical devices, such as battery equalizers and isolators for heavy trucks, busses and marine vehicles, began to examine producing parts through diecasting, which would provide for lighter weight components and be less time-consuming than the company's extrusion processes.

Matt Clark, a mechanical engineer for Sure Power, described how the firm was investigating its first diecast enclosure for a voltage alternator for an all-terrain vehicle. Sure Power was trying to determine how it would meet prototype requirements based on cus-

Discovering Plaster Molding

While, the rubber plaster molding (RPM) process is not as common throughout the metalcasting industry as green sand molding, its capabilities provide for a quick, flexible casting method when compared to many other casting processes.

With inverse rubber mold patterns, plaster molds can be made repeatedly for production. However, similar to the different kinds of sand molding, there are different types of plaster molding.

Morris Bean & Co., Yellow Springs, Ohio, currently utilizes its own plaster molding called the Antioch plaster process. This process uses a combination of sand- and gypsum-containing expansion control agents that are mixed under a vacuum with a liquid to form a slurry. The slurry is then poured into rigid (metal) or flexible molds, which are then processed in an autoclave, removed and allowed to reset to their positions. After the molds are dried to remove free and chemical water, they are cast with aluminum.

This impeller (above) achieved tight tolerances with good dimensional consistencies after it was cast from a plaster mold (r) through Morris Bean's Antioch process.

According to Morris Bean's Account Executive, Garry Robbins, the main differences between the Antioch process and other plaster casting processes is permeability and thermal conductivity. These characteristics allow a facility to cast heavy-section aluminum components while consistently maintaining high physical properties.

Further, this particular plaster's permeability is equivalent to that of sand molds, thus allowing gating and risering procedures to be similar to those of standard metalcasting practices.

With the Antioch process, Morris Bean casts aluminum components from 3-150 lbs. (1.36-68 kg) measuring up to 30 in. (76.2 cm) in diameter.

Common aluminum alloys used are C355 as well as A356, 201, B206, 514 and 6061.

In addition to the capability of maintaining tolerances to 0.005 in. (0.01 cm), the Antioch process allows for dimensional consistency, clean surface finish and minimum draft angles.

Casting engineers might consider the Antioch process for these reasons, particularly for high-speed rotating parts or those with ultra-high, pressure-tight requirements and smooth as-cast surface finish. *ECS*

tomer demands for time, so Clark contacted A.L. Johnson about its RPM capabilities to obtain the prototypes and deliver them to the customer.

Soon after that, Sure Power submitted a design to A.L. Johnson to produce more than 50 RPM cast parts. Although few augmentations were made to the original design, A.L. Johnson helped machine small mounting holes and other fragments into all the parts. After only five weeks, Sure Power sent 40 of the 7.5 x 4.5-in. (19.05-11.4-cm) prototype regulators to its customer where they were placed as part of a test assembly. Within nine weeks from when A.L. Johnson first received the design, Sure Power sent the order to a diecasting firm to begin high-volume production.

Similar to Peck and investment casting, Clark discussed how having an engineered cast component in hand through RPM casting can be more valuable than an .SLA model. Because Sure Power handles electronic parts, many of its pieces can dissipate a lot of heat, thus, a casting's thermal properties cannot be overlooked.

"With rubber plaster molding, we go through (mechanical testing processes) before releasing the design for hard tooling as well as thermal testing that you can't do with an .SLA model because it's plastic," Clark stated. "If we mount our electronics (in an .SLA part), it wouldn't represent what kind of heat dissipation we can expect because it would lack the same thermal characteristics as a diecast part."

Save More

In addition to "production-grade" castings, Trico and Sure Power noticed other advantages to rapid prototyping. These methods are less labor-intensive not only for avoiding cutting die tools prematurely, but also staying clear from fabrications.

Peck and Clark noted how fabricating a part from an aluminum billet does not provide for the internal composition that casting processes allow, which likely would lead to contrary evaluations on internal structural properties. Also, casting alloy properties differ from those of billet metals, and machining additional draft into a billet (something that can be achieved easily through a casting process) adds higher costs and additional labor. For example, during the semi-production phase of prototyping, machining 50 parts from an aluminum billet would be an arduous task to handle.

Although labor factors into the equation, both Peck and Clark agree that a critical factor saved with rapid prototyping is time.

"Time kills you," Peck said. "Rapid prototyping allowed me to get something in my hand so I could evaluate a problem right away."

Peck said Trico cut its prototyping timeline in half by working with Aristo Cast and made design refinements in one-tenth of the time that it would take for diecast prototypes. With investment casting and RPM, time also can be saved with short-run production castings, not just prototypes.

The time equation also is necessary for companies to keep pace in their markets. Once a firm catches up to one project, a second firm already is onto the next project, and it is a continuous line from there. "If you don't seize the opportunity, that one project goes away, and next year there could be a couple more coming up," Peck said. "But every time you lose one of those windows of opportunity, they don't always open up again. (With the wiper motor project), had I procrastinated, I would've lost this 500,000-product window."

Peck also pointed out how keeping pace with such contracts can give a firm a reputation to gain future contracts. "We have a customer interested in this new technology, and if he puts an order in, other people follow," he said. "But if I miss, not only do I miss the 500,000-part volume, I might miss the next customers.

"So, time is bigger than the cost." *ECS*

For More Information

"Investing With Rapid Prototyping," *K. O'Shaughnessy, Engineered Casting Solutions, Fall 2004, p. 37-41.*