APPLICATION BRIEF

Investment Casting with FDM Tooling

Overview

Investment casting, also called lost wax casting, is a process in which a pattern, also known as a master or master pattern, traditionally made of wax, is covered with a ceramic slurry. The wax pattern is normally produced with injection molding. The wax is melted out of the ceramic shell, which is pre-heated before molten metal is poured into it. After the metal cools, the ceramic is vibrated and blasted from the metal casting. Investment casting generally provides higher accuracy (+/- 0.005 in (0.127 mm) tolerance is normal) and surface finish (typically 125 micron RMS (3.125 micron Ra) than other casting processes. It is generally used in applications that have relatively low production quantities and changing product designs.

Application Outline

The wax patterns used in investment casting are typically produced using an injection molding process. Tooling cost ranges from $5,000 to $25,000 and lead time to produce tooling is approximately two months. A big problem for many investment casting foundries is that they are not able to produce prototype castings until the injection mold is completed. At this time, problems are often discovered, such as interference with other components in an assembly. Additional time and money must be invested to fix the injection mold. In a worst-case scenario, it may be necessary to scrap the original tool and start over from scratch. Another problem with wax patterns is that their complexity is limited by what is feasible from an injection mold in the allotted time.

Fused Deposition Modeling (FDM) provides an alternative method for producing investment casting patterns that can provide dramatic time and cost savings. FDM technology is an additive manufacturing process that builds plastic parts layer by layer, using data from CAD files. FDM makes it possible for the foundry to produce a pattern that can also serve as a prototype for form and fit evaluation. In one day, the foundry can provide the customer with a prototype that provides a perfect match to the casting that would be produced if it becomes the pattern. The strength of the materials used in the FDM process makes it possible to put the FDM component into an assembly and perform testing. If any problems are discovered, the foundry can usually make the changes requested by the customer and build a new pattern in about 24 hours.

Typical example of aluminum injection mold and wax pattern.

Pouring metal into gear set casting shell.

BENEFITS OF FDM

- No tooling delay; 70% - 98% lead time reduction
- No tooling expense; 60% to 95% cost reduction
- Part consolidation; assemblies become one piece
- No restrictions on design changes
- Niche market products become practical
- Full, functional testing before any tooling investment

FDM IS A BEST FIT

- Short project lead time (less than 2 months)
- Complex, intricate designs
- Low production quantities (1 to 1,000's) - Prototype and process refinement
- Design iterations anticipated
- Fine, but not delicate, features
- Blast furnace available for high temperature burnout

INVESTMENT CASTING WITH FDM TOOLING

As soon as the customer approves the prototype, the foundry can move into production by using the FDM parts as patterns for investment casting. Since FDM is an additive process, the pattern can be as complex as needed without any impact on cost. (With injection molding increasing pattern complexity often requires a more complex and more expensive tool).

Other advantages of FDM patterns are that they have greater strength, toughness and accuracy than wax or other additive manufacturing technologies. This durability is important because it prevents damage that often occurs in the transportation and handling of patterns made of wax or other materials.

Process Overview

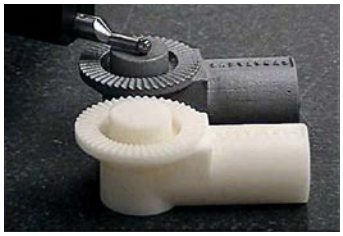
FDM patterns are direct replacements for traditional patterns that are injection molded with foundry wax. One significant difference is that FDM material does not melt like wax. It burns, which leaves a small amount of ash, typically 0.021 percent, in the shell cavity. The ash is later removed in a shell washing operation. Venting should be added to the ceramic shells to speed the burnout of the FDM pattern. Investment casting patterns need to be produced to close tolerances and with an excellent surface finish because any defects are reproduced in the finished part. The Stratasys Finishing Touch Smoothing Station uses a semi-automated process to improve the surface finish of FDM parts to near injection molded quality without the labor or cost associated with traditional finishing. Advancements in finishing technology have improved FDM parts to the point that hand finishing is no longer needed, making FDM a much stronger competitor in the investment casting market.

Customer Story

RLM Industries is a leading supplier of investment castings to the military, construction, food processing and handling, and automotive industries. Recently a major manufacturer of components and assemblies for the military found itself in serious danger of missing critical delivery deadlines when the foundry they had been using couldn't produce investment castings that met drawing specifications. The original foundry used injection molding to make wax patterns. RLM's customer needed a faster and less expensive solution to the problem and asked RLM if it could help.

RLM began the project by modifying the CAD model provided by the customer. These revisions were completed in one day, and at the end of the day, engineers set up their Stratasys machine to produce an FDM prototype. The prototype was provided to the customer for assembly review. The customer found an interference in the assembly. RLM made some modifications to the CAD model and printed another prototype, which was provided to the customer. The customer approved the design.

RLM then moved immediately into production of the first prototype castings, using the FDM prototypes as patterns to produce investment castings. The prototype castings matched the patterns perfectly, and the customer approved them. The production of the first prototypes was also used to refine the casting process, primarily for evaluating the gate location.



Male FDM pattern (foreground) and finished casting being inspected with coordinate measuring machine touch probe.

For RLM Industries, investment castings were produced to specifications in only seven days using FDM method.

RLM used FDM patterns to meet a critical deadline for the US Army's MIM-104 Patriot, a surface-to-air missile system.

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INVESTMENT CASTING WITH FDM TOOLING

"Using Stratasys equipment and technology, we were able to build patterns in less than a day," said Rick Meachum, vice president of sales for RLM. "The patterns were then expedited through our process, and in seven days we produced perfectly matching gear set castings that met drawing requirements and specifications and were functional as part of the assembly. The castings were used for a test launch, and we now have time to build hard tooling with all parties confident in the knowledge that the part design and dimensional attributes are correct for a large quantity production order."

How Did Stratasys Compare to Traditional Tooling Methods for RLM?

METHOD	COST	PRODUCTION TIME
Injection Molding	$5,000 to $20,000	2 months
FDM	$1,250	1 week
Savings	$3,750 to $18,750 (75% to 94%)	7 weeks (88%)

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