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Shell Mold Casting Manufacture of Complex Parts with Thin Sections

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Abstract

Shell mold casting or shell molding is a metal casting process in manufacturing industry in which the mold is a thin hardened shell of sand and thermosetting resin binder backed up by some other material. The internal surface of the shell mold is very smooth and rigid. This allows for an easy flow of the liquid metal through the mold cavity during the pouring of the casting, giving castings a very good surface finish. Shell mold casting enables the manufacture of complex parts with thin sections and smaller projections than green sand mold casting. Manufacturing with the shell mold process also imparts high dimensional accuracy. Tolerances of .010 inches (.25mm) are possible. Further machining is usually unnecessary when casting by this process. Shell mold casting is particularly suitable for steel castings under 20 lbs; however almost any metal that can be cast in sand can be cast with shell molding process. Also much larger parts have been manufactured with shell molding. Typical parts manufactured in industry using the shell mold casting process include cylinder heads, gears, bushings, connecting rods, camshafts and valve bodies.

Keywords: shell mold.

Experimental details

Raw Materials, Equipment's

- ❖ Resin coated sand.
- ❖ Chromel Alumel Thermocouple, digital panel meter.
- ❖ Muffle Furnace.
- ❖ 2 Kg Aluminium Silicon Alloy (LM6) scrap.
- ❖ Clay Graphite crucible.
- ❖ Fireclay.
- ❖ Asbestos Gloves, Tongs, safety goggles.

The process

The process was optimized to get a better shell by varying the temperature of the metal pattern, holding time of sand – resin mixture and final curing time of shell and pattern.

The first step in the shell mold casting process is to manufacture the shell mold. The sand we use for the shell molding process is of a much smaller grain size than the typical greensand mold. This fine grained sand is mixed with a thermosetting resin binder. A special metal pattern is coated with a parting agent, (typically silicone), which will latter facilitate in the removal of the shell. The metal pattern is then heated to a temperature of 350F-700F degrees, (175C-370C).

The sand mixture is then poured or blown over the hot casting pattern. Due to the reaction of the thermosetting resin with the hot metal pattern a thin shell forms on the surface of the pattern. The desired

thickness of the shell is dependent upon the strength requirements of the mold for the particular metal casting application. A typical industrial manufacturing mold for a shell molding casting process could be .3in (7.5mm) thick. The thickness of the mold can be controlled by the length of time the sand mixture is in contact with the metal casting pattern.

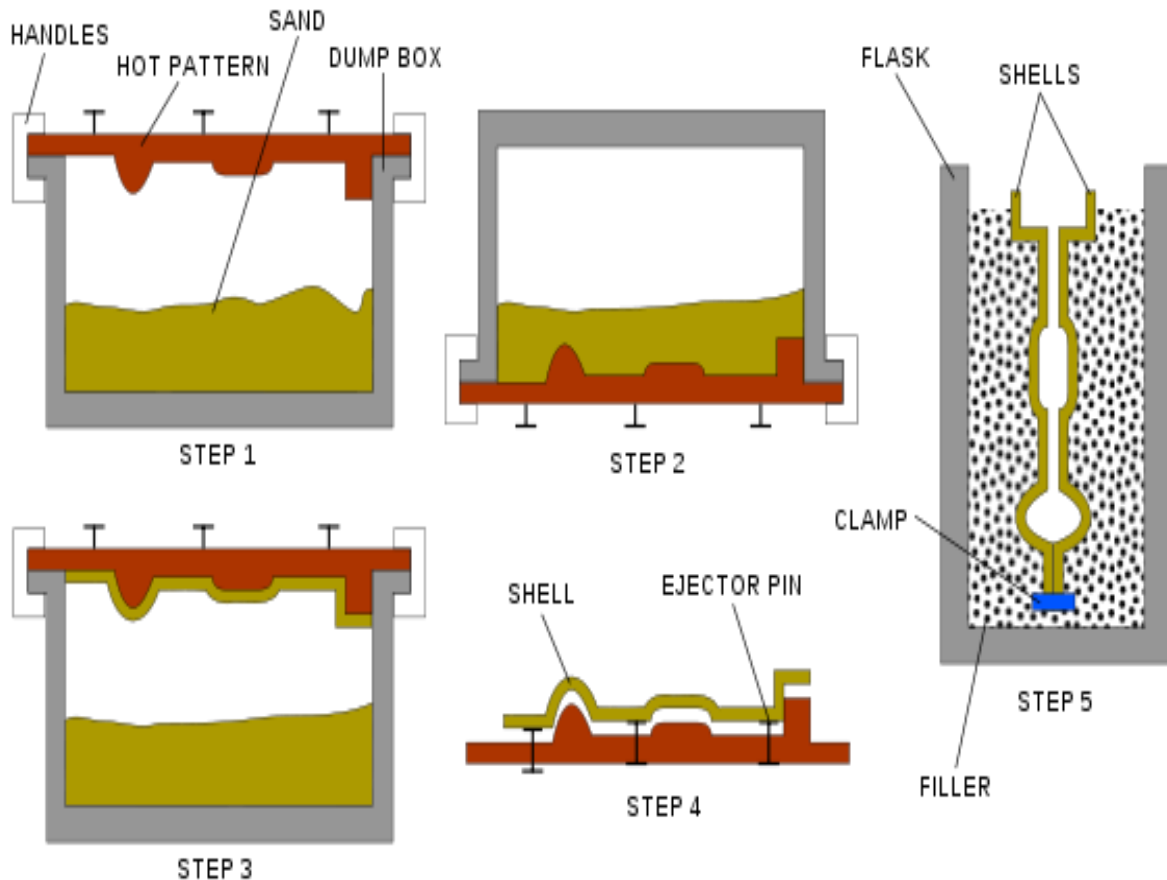
The excess "loose" sand is then removed leaving the shell and pattern. The shell and pattern are then placed in an oven for a short period of time, (minutes), which causes the shell to harden onto the casting pattern.

Once the baking phase of the manufacturing process is complete the hardened shell is separated from the casting pattern by way of ejector pins built into the pattern. It is of note that this manufacturing technique used to create the mold in the shell molding process can also be employed to produced highly accurate fine grained mold cores for other metal casting processes

Two of these hardened shells, each representing half the mold for the casting are assembled together either by gluing or clamping. The manufacture of the shell mold is now complete and ready for the pouring of the metal casting. In many shell molding processes the shell mold is supported by sand or metal shot during the casting process. . Fireclay is applied along the edges of the mold to avoid leakage of the molten metal

A 2 kg scrap of Aluminum Silicon alloy (LM6) was charged in a muffle furnace in a clay graphite crucible. The dross floating on the molten alloy was removed by a thin graphite plate. The molten aluminum silicon alloy was poured in the cavity of the shell mold.

Later on the shell mold was broken to remove the casting. The use of safety goggles, gloves, shoes is a must to avoid any accident.



Diagrammatic representation of shell molding process

The process of creating a shell mold consists of six steps:

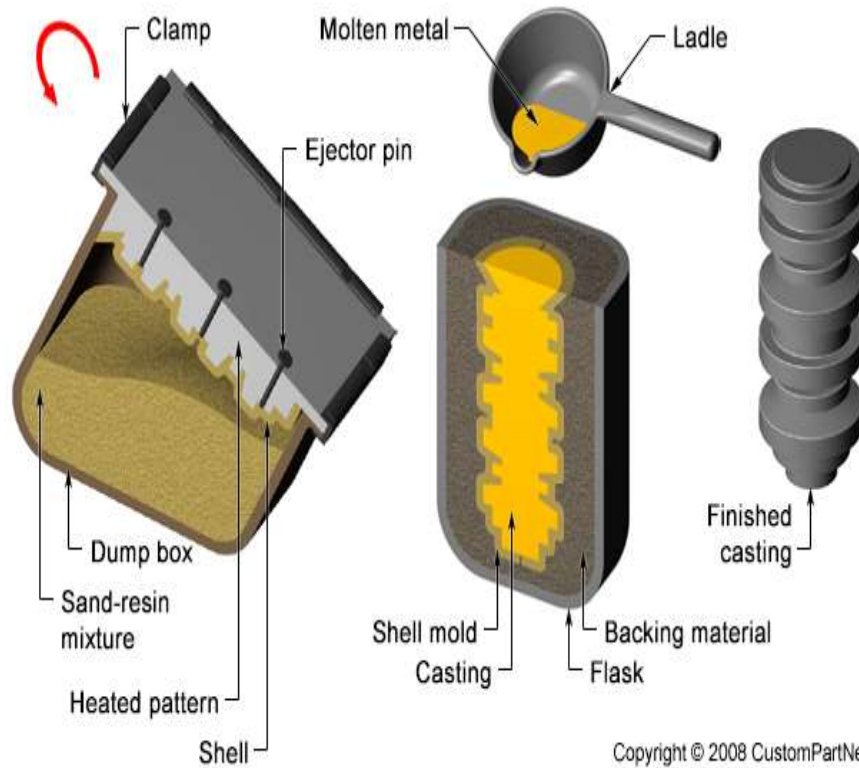
1. Fine silica sand that is covered in a thin (3–6%) thermosetting phenolic resin and liquid catalyst is dumped, blown, or shot onto a hot pattern. The pattern is usually made from cast iron and is heated to 230 to 315 °C (450 to 600 °F). The sand is allowed to sit on the pattern for a few minutes to allow the sand to partially cure.
2. The pattern and sand are then inverted so the excess sand drops free of the pattern, leaving just the "shell". Depending on the time and temperature of the pattern the thickness of the shell is 10 to 20 mm (0.4 to 0.8 in).

3. The pattern and shell together are placed in an oven to finish curing the sand. The shell now has a tensile strength of 350 to 450 psi (2.4 to 3.1 MPa).
4. The hardened shell is then stripped from the pattern.
5. Two or more shells are then combined, via clamping or gluing using a thermoset adhesive, to form a mold. This finished mold can then be used immediately or stored almost indefinitely.
6. For casting the shell mold is placed inside a flask and surrounded with shot, sand, or gravel to reinforce the shell.

The machine that is used for this process is called a shell molding machine. It heats the pattern, applies the sand mixture, and bakes the shell.



Shell molding machine



Shell No.	Temperature of the heated pattern measured by Chromel Alumel thermocouple	Temp. of pattern (°C)	Holding time	Final Curing time	Thickness of the shell. (cm)
A	12.5 mv	325	40 sec	60 sec	1.1
B	10.5 mv	260	60 sec	60 sec	1.65
C	10.7 mv	264	90 sec	90 sec	1.85
D	11 mv	270	120 sec	120 sec	2.0

Properties and Considerations of Manufacturing by Shell Mold Casting

- ❖ The internal surface of the shell mold is very smooth and rigid. This allows for an easy flow of the liquid metal through the mold cavity during the pouring of the casting, giving castings very good surface finish. Shell Mold Casting enables the manufacture of complex parts with thin sections and smaller projections than green sand molds.
- ❖ Manufacturing with the shell mold casting process also imparts high dimensional accuracy. Tolerances of .010 inches (.25mm) are possible. Further machining is usually unnecessary when casting by this process.
- ❖ Shell sand molds are less permeable than green sand molds and binder may produce a large volume of gas as it contacts the molten metal being poured for the casting. For these reasons shell molds should be well ventilated.
- ❖ The expense of shell mold casting is increased by the cost of the thermosetting resin binder, but decreased by the fact that only a small percentage of sand is used compared to other sand casting processes.
- ❖ Shell mold casting processes are easily automated
- ❖ The special metal patterns needed for shell mold casting are expensive, making it a less desirable process for short runs. However manufacturing by shell casting may be economical for large batch production.

Advantages:-

- ❖ Better surface finish
- ❖ Casting as thin as 1.5 mm and of high definition can be cast satisfactory.

- ❖ Better dimensional tolerances.
- ❖ Reduced Machining.
- ❖ Less foundry space required.
- ❖ Semi-skilled operators can handle the process.
- ❖ The process can be mechanized.

Disadvantages

- ❖ The raw materials are relatively expensive.
- ❖ Uneconomical on small scale production
- ❖ The process generates noxious fumes which must be removed.
- ❖ The size and weight range of castings is limited.

Applications

- ❖ Crank shaft fabrication.
- ❖ Steel casting parts, fittings.
- ❖ Molded tubing fabrication.
- ❖ Hydraulic control housing fabrication.
- ❖ Automotive castings (cylinder head and ribbed cylinder fabrication).

These are some of the castings made by using shell molding process. We can observe good surface finish of the castings.





Conclusion

- ❖ Shell molding replaces conventional sand molds by shell molds made up of relatively thin, rigid shells of approximately uniform wall thickness.
- ❖ We have to control the thickness of shell by adjusting the temperature of pattern, holding time and curing time.
- ❖ This gives near net shape no machining or very little machining is required.
- ❖ Tolerances of .010 inches (.25mm) are possible.

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