"Permanent Mold Casting" Excellent Casting Method for Manufacture of Automotive Components

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Abstract: In this paper the study has been done why permanent mold casting method is excellent for manufacture of automotive components. In permanent mold casting process no external pressure is applied but hydrostatic pressure created by the risers is mainly responsible for casting of metal in the mold. As no external pressure is applied hence this process is also called Gravity die casting. In this process, solidification occurs much more rapidly than in sand casting, the main advantage is a permanent mold that can be used repeatedly for multiple metal castings. The mold also called a die is commonly made of steel or iron, but other metals or ceramics can be used. Permanent mold casting is typically used for high-volume production of small, simple metal parts with uniform wall thickness. Non-ferrous metals are typically used in this process, such as aluminum alloys, magnesium alloys, and copper alloys. However, irons and steels can also be cast using graphite molds. Common permanent mold parts include gears and gear housings, pipe fittings, and other automotive and aircraft components such as pistons, impellers, and wheels.

Keywords: *Mold, Mold material, Non ferrous metals, Risers*

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Introduction

[1]To manufacture automotive component using permanent mold manufacturing process the first step is to create the mold. The sections of the mold are most likely machined from two separate metal blocks. These parts are manufactured precisely. They are created so that they fit together and may be opened and closed easily and accurately. The gating system as well as the part geometry is machined into the casting mold. A significant amount of resources need to be utilized in the production of the mold, making setup more expensive for permanent mold manufacturing runs. However, once created, a permanent mold may be used tens of thousands of times before its mold life is up. Due to the continuous repetition of high forces and temperatures, all molds will eventually decay to the point where they can no longer effectively manufacture quality metal castings. The number of castings produced by that particular mold before it had to be replaced is termed mold life. Many factors affect mold life such as the molds operating temperature, mold material and casting metal. Before pouring the metal casting, the internal surfaces of the permanent mold are sprayed with refractory materials. This coating serves as a thermal gradient, helping to control the heat flow and acting as a lubricant for easier removal of the cast part. In addition, applying the refractory coat as a regular part of the manufacturing process will increase the mold life of the valuable mold. The two parts of the mold must be closed and held together with force, using some sort of mechanical means. Most likely, the mold will be heated prior to the pouring of the metal casting. A possible temperature that a permanent metal casting mold may be heated to before pouring could be around 350F (175C). The heating of the mold will facilitate the smoother flow of the liquid metal through the mold's gating system and casting cavity. Pouring in a heated mold will also reduce the thermal shock encountered by the mold due to the high temperature gradient between the molten metal and the mold. This will act to increase mold life. Once securely closed and heated, the permanent mold is ready for the pouring of the cast part. After pouring, the metal casting solidifies within the mold. In manufacturing practice, the metal cast part is usually removed before much cooling occurs, to prevent the solid metal casting from contracting too much in the mold. This is done to prevent cracking the casting, since the permanent mold does not collapse. The removal of the part is accomplished by way of ejector pins built into the mold.

Following are the important points regarding permanent mold casting:

- Generally this manufacturing process is only suited for materials with lower melting temperatures, such as zinc, copper, magnesium and aluminum alloys.
- Cast iron parts are also manufactured by this process but the high melting temperature of cast iron is hard on the mold.
- Steels may be cast in permanent molds made of graphite or some special refractory material.
- The mold may be cooled by water or heat fins to help with the dissipation of heat during the metal casting process.
- Due to the need to open and close the mold to remove the work piece, part geometry is limited.
- If the semi-permanent casting method is used, internal part geometry may be complex.
- Due to the nature of the mold, the metal casting will solidify rapidly. This will result in a smaller grain structure, producing a casting with superior mechanical properties.
- More uniform properties throughout the material of the cast part may also be observed with permanent mold casting.

- Closer dimensional accuracy as well as excellent surface finish of the part, is another advantage of permanent mold casting over most expendable metal casting processes.
- In industrial manufacture permanent mold casting results in a lower percentage of rejects than many expendable mold processes.
- The initial setup costs are high, making permanent mold casting unsuitable for small production runs.
- Permanent mold casting can be highly automated.
- This manufacturing process is useful in industry for high volume runs. When set up, it can be extremely economical with a high rate of production.

[2]When designing a mold, the following factors must be considered.

- Venting
- Gating and risering
- Chills

Mold materials for permanent castings are usually chosen on the basis of the number of castings to be produced and the cost of mold materials plus machining.

Materials for mold must have the following properties:

• The mold material must have adequate machinability. Machining the cavity is often the most significant cost factor. Tool wear, breakage, feed and feed rates all influence mold cost. Gray iron die blocks can usually be machined for less cost than tool steels.
• The mold must have good dimensional stability, high temperature strength, and thermal shock and fatigue resistance. The mold should not warp or change uncontrollably in size during the cycle. The mold must be able to withstand prolonged and repeated thermal cycling without softening, cracking or oxidizing.
• The mold material must bear resistant to reduce dimensional changes caused by sand blasting, hand cleaning, liquid metal erosion, abrasion from moving mold components and abrasion from casting removal.
• Molds must display good thermal conductivity properties. Thermal conductivity is the rate heat flows through a unit area of material under a given temperature gradient. Higher thermal conductivities reduce cycle time and produces finer cast aluminum structure by cooling the casting faster. [3]Non-ferrous Metals: Unlike mild steel, non-ferrous metals do not in general display the discontinuity of yield point in the stress-strain curve. An important method of increasing the strength and hardness of non-ferrous metals is by cold working in which the grains flow by a process involving the slip of blocks of atoms over each other, along definite crystallographic planes. Some of the non-ferrous alloys are aluminum, copper, zinc, and magnesium. [4] A riser, also known as a feeder, is a reservoir built into a metal casting mold to prevent cavities due to shrinkage. Most metals are less dense as a liquid than as a solid so castings shrink upon cooling, which can leave a void at the last point to solidify. Risers prevent this by providing molten metal to the casting as it solidifies, so that the cavity forms in the riser and not the casting. Risers are not effective on materials that have a large freezing range, because directional solidification is not possible. They are also not needed for casting processes that utilized pressure to fill the mold cavity. Risers are only effective if three conditions are met: the riser cools after the casting, the riser has enough material to compensate for the casting shrinkage, and the casting directionally solidifies towards the riser.
Conclusion:

The castings produce by Permanent mold method are generally sounder than sand castings and are generally stronger than sand or die-castings, and less porous.
Castings produced in the permanent mold process have finer dendritic arm spacing (DAS) and grain structure. The finer structure displays better strength properties than those cast in similar alloys in sand castings. Permanent mold castings have fewer inclusion defects than sand castings. The casting designer can use thinner sections and lighter weight for designs. The castings produced by this method have a higher degree of reliability with regard to pressure applications of fluids and gases. The material for automotive components should be lightweight for inertia force reduction, increased speed, and cost effective method of manufacturing. The connecting rod must be able to withstand tremendous loads and transmit a great deal of power. Reducing the weight of the rods reduces the mass of the rotating and reciprocating parts and allows the engine to revolve faster and revolve higher.

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