Tool design for pressure dies casting of Housing Component.

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Abstract—Die casting is a manufacturing process in which non ferrous metal in its molten state is forced into the dies under pressure to form the desired shape and size. A die is a steel box with consists of core and cavity which when butt together to form the impression. This impression forms the shape of the required component. The paper details the design of the die for housing component. In addition to the design of core and cavity a brief discussion about the die material is also presented. Die design is done using a parasolid platform software. HOT DIE STEEL H13 (HDS H13) grade is the die material. Reasons for selection of the die material and its justification are detailed. Casting material is Aluminium A380 alloy. Die designing is an important part in die casting. It is this die design which decided the actual shape and appearance of the component. Process flow chart explains step by step procedure for die designing. A brief explanation about the heat treatment carried and the reasons for carrying out the heat treatment are mentioned in the paper. Amount of heat treatment carried out with numerical values are stated and the reason for which heat treatment is carried up to those levels are also justified in this paper. Detailed gate design, core and cavity insert design are explained with suitable figures. Overflows are explained in connection with the insert.

Index terms- aluminium A380, die casting, die design, HDS H13.

I. INTRODUCTION

Die design is one of the important processes in die casting. Before designing the tool a designer must have the knowledge of the machine for which he is designing the tool. Platen size, day light and shut height, location of holes in the platen and tonnage of the machine has to be known. Designing of core and cavity includes designing of length and thickness of the core and cavity inserts. Die movement mechanism. Ejectors and ejection system mechanism. Selection of die material also plays an important role in die casting. Here hot die steel (HDS) H13 grade is used as die material for parts which come in contact with molten metal. Parts which are under the influence of friction are made of EN 353. Design of die casting die is done using solid works 2013. Process flow chart explains step by step procedure followed in designing of the die. Molten metal is forced inside the dies with high pressure and temperature (660°C) so the inserts must withstand such tremendous pressure and temperature, design must be made such that these pressure and temperature are resisted by the die material and design. Solid works 2013 software is used for die tool designing.

II. DESIGN FLOW CHART

Flow chart shown below explains in detail about the design procedure carried out in designing the dies. Component feasibility is carried to know whether the part can be manufactured using die casting process. Component feasibility is carried to know whether the part can be manufactured using die casting process. Make of machine is important as it gives the detail about the offset of plunger inlet from the center axis of the machine. Feed system is roughly imagined before core cavity extraction. Later a thorough study is made to decide the actual feed system. Chart 2.1 [1]

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2D/3D drawing from customer

- Component feasibility

Design considerations
2. Machine availability
3. Make of machine

- Draft angle
- Feed system (rough)
- Parting line
- Shrinkage

Core cavity extraction

Design of
- Feed system
- Gate
- Runner
- Overflows
- Air vents/ chill vents.

Mould base design
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III. COMPONENT AND MATERIAL STUDY.

Figure 3.1 shows the component 3D model. The component consists of intricate shapes. The die requires 3 side cores for manufacturing of the component. Component material is aluminium A380. The shrinkage factor of A380 is 0.6% with density if 2.71 gm/cm$^3$. The liquidous temperature and solidious temperature is 500 and 595°C respectively. Fill temperature for A380 must be maintained to 660°C, above this temperature the molten metal gets oxidized and below 650°C proper filling does not take place. Die is made up of Hot die steel (HDS) H13 grade. HDS material is preferred as it offers good heat checking resistance, toughness at high temperatures, and wear resistance at high temperature. \[2\]. Nitrating to around 1.5mm is done to improve the tool life. Nitrating creates a lamination on the inserts which protect the inserts and increases its life.

IV. TOOL DESIGN

Tool is the assembly of core and cavity inserts along with ejector assembly, spreader, sprue, and mould base. All the parts which come in contact with the molten metal is made up of tool steel, Hot die steel with hardness of 46-48HRC. And parts which experience friction are made up of EN343 case hardened to nearly 2mm. The mould base is made of mild steel. Thickness of the mould base plates (bolster plates, core and cavity back plate) depends on the thickness of the inserts and pressure applied by the machine on the tool. The tool has to be designed such that the overall height of the tool when opened during the ejection stroke does not exceed the maximum day light of the machine and also should not be within the minimum shut height.

Another important issue in die casting is proving of draft angle. Draft angle is the angle provided from the parting line for easy ejection of the component. Draft angle of $5^\circ$ is provided in this design.

4.1 Core and Cavity design.

Core is the male part of the die and forms internal shape of the component. Cavity is the female part of the die and forms the external shape of the component. Core and cavity are the parts of the die which provide internal and external shape of the component respectively thus forming one of the most important part in tool assembly. Core and cavity are designed after adding material shrinkage value to the component geometry. Shrinkage value for aluminium A380 is 0.6%. Usually the casted component sticks towards the core side hence the core must be designed such that it also facilitates easy ejection of the component. Both core and cavity must not obstruct the ejection of component. Maximum wear is obtained at an angle of 72°[3]When the component has complex geometry and shape and when castings cannot be produced just by using a single core and cavity side cores (split cores) are incorporated. In this paper the casting is made up of 3 side cores. The side core actuation is provided by finger cam. Core, cavity and side cores are manufactured using Hot die steel (HDS) H13 grade.
Fig 4.1.1 cavity insert.

Fig 4.1.2 core insert.

Fig 4.1.3 top side core

4.2 Runner and gate design.

Runner is the path provided for molten metal to flow into the die from the sprue and spreader. Usually runner area must be big enough to provide required amount of molten metal and at the same time maintain pressure during the material filling process. In this design a modified trapezoidal runner is used which widens and narrows near the gate fig 4.2.1 shows the detail.

The arrows in fig 4.2.1 show the direction of flow.

Gate is the passage provided for molten metal to pass from runner to impression. Gate area must be optimum it must break automatically or by application of small amount of force hence separating the component from runner and sprue. On the other hand gate must also be designed such that it allows molten metal inside the impression and get sealed off before the component starts freezing. Gate must also withstand the back pressure generated by the molten metal inside the impression during solidification. Fig 4.2.2 shows gate design. Gate thickness must be less than the wall thickness of the component [4].

4.3 Design of overflow and air vents.

Overflow’s also know as cold wells are used to pull the front end of the molten metal which sometimes will have low temperature due to the path traveled. Overflows are also used to reduce the weld line defects by placing these overflows at the point where two flow fronts meet. Air vent is the ration of the air volume to the air velocity and filling time [5]. Air vents are paths provided for air present inside the die to escape. Venting capability is directly proportional to the width and inversely proportional to the length of vent [5]. Usually air vents are made by removing very small amount of material on core and cavity (0.01 to 0.07mm) where ever necessary thus reducing the chances of porosity and eliminating blow holes and weak portions of the casting. The air inside the die cavity is compressed and high pressure can be created if there is not a sufficient venting area or of the die vents are sealed off before the die cavity is completely filled up. Porosity level of the casting decreases with increase in vent area for atmospheric pressure [5].
Fig 4.3.1 shows overflow designed for the die. The gate size for the overflow must be smaller than the wall thickness of the component.

4.4 Ejector assembly

Once the component is solidified it has to be ejected from the die. In this design, ejector pins are used for ejection purpose. Mechanism used for ejection of component from the die is known as ejector mechanism. There are many mechanisms with which component is ejected from the die, some of the mechanisms are rack and pinion, hydraulic mechanism, toggle mechanism, manual removal etc. For ejection of housing component is done by using toggle mechanism. Ejector assembly consists of ejector pins made up of HDS heat treated up to 48 HRC (depending on the design), ejector back plate to support the ejector pins, ejector plate to locate and lock the ejector pins. Support pillars which provide support for the core against pressure generated during metal injection. Ejector rod which connects the ejector assembly to the machine. Ejector pillars which align the ejector pins in position and ejector bush which supports the ejector pillars. Length of the ejector pins depends on the thickness of the core, thickness of ejector plate, counter bore length of the ejector back plate and the component height an additional 5% is added for safety. Ejector pins must be designed such that it does not damage the core and it must suit perfectly to the surface of the core. To be more specific the ejector pins must not project or suppress from the core surface on which it suits.

V. CONCLUSIONS

- Shrinkage value of the casting material must be added before designing the die tool.
- Draft angle must be provided for easy ejection.
- Placement of overflows and air vents plays an important role. Overflows must be provided at places where two or more melt fronts meet.
- Air vents must be placed in suitable places depending on how the molten metal moves inside the die. Thickness of air vents must be minimum.
- Gate thickness must be less than wall thickness of the component.
- Thickness of the insert must be such that it withstands the pressure applied on it.

REFERENCES

[4] Solution of gate system in dies design at pressure cast by Marcel Fedak, Email Ragan, Joroslav Pavel ASM international.