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Research paper

Reduction of Blowholesin Aluminium High Pressure Die Casting Machine

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Abstract

The main objective of this research is to reduce the blowholes by analyzing the factors which are affected during the casting process. The process parameters are optimized and change is made in the design part to reduce the blowhole and to increase the efficiency of the high pressure die casting machines. Product manufactured from every manufacturing process shows some defects. For supplying quality product to the customer these defects must be reduced. In this work, an attempt is made to reduce the rejection due to the blowhole defect is found out through why-why analysis technique. Process capability of current high pressure die casting manufacturing process is checked. Manufacturing process found capable to manufacture the components. Current problem of blowhole defect is solved making an improvement in design of die which we insert. In gate directions are changed so as to obtain modified improved flow pattern. Using magma flow simulationsoftware existing and modified design has then been compared. It is found that, modified design shows superior results and using this, the defect of blowholes is minimized up to satisfactory level.

Keywords: *Pressure die casting, Aluminum, Blowholes, Casting Defects*

1. Introduction:

Die casting involves the preparation of components by injecting molten metal at high pressure into a metallic die. Die casting is closely related to permanent mold casting, in that both the processes uses reusable metallic dies. In die casting, as the metal is forced in under pressure compared to permanent molding, it is also called pressure die casting. As the high pressure is involved in die casting, any narrow sections, complex shapes and fine surface details can comfortably be produced.

In die casting, the die consists of two parts. One is the **stationary half** or **cover die** which is fixed to the die-casting machine and the second part is the **moving half** or **ejectors die** which is moved out for the extraction of the casting. The casting cycle will start when the two parts of the die are apart. The lubricant is sprayed on the die cavity manually or by the auto lubrication system so that the casting will not stick to the die. After the two halves of die are closed and clamped, the required quantity of metal is injected into the die. After the casting is solidified under pressure, the die is opened and the casting is ejected. The die casting needs to have the provision of ejectors to push the casting after it gets solidified. It will also have cooling channels to extract the heat of the molten metal to maintain proper die temperature.

The die casting machines are of two types:

Hot-chamber die casting

Cold-chamber die casting

The main difference between the two types is that in the hot chamber, the die-casting machine is integral withthe holding furnace, whereas in the cold-chamber machine, a separate furnace is used to meltthe metal and the molten metal is poured into the die-casting machine with a ladle for each casting cycle which is also called shoot**.**

2. Usage of Electric Arc Furnace:

In the electric arc furnaces the resistance type heating is generally used for holding furnaces to maintain the liquid metal at a certain temperature for non-ferrous alloys such as for die casting. However, the electric furnaces in view of their high degree of temperature control and flexibility of operations have been widely used for melting small to medium sized castings in ferrous as well as non-ferrous alloys.

- For heavy steel castings, the open-hearth type of furnaces with electric arc or oilfired would be generally suitable in view of the large heat required for melting.
- Electric arc furnaces are more suitable for ferrous materials and are larger in capacity. This type of furnace draws an electric arc that rapidly heats and melts the charge material.
- The bowl shaped bottom of the furnace, called the heath is lined with refractory bricks and granular refractory material. Heat is directly transferred to the charge material from the electrode arc.

The furnace has a tilting mechanism allowing it to be tilted forward for metal tapping or backward for de lagging. Once the melt is ready to pour, the electrodes are raised through the roof and the furnace is tilted to pour the molten metal into a receiving ladle.

3. Nitrogen Degassing Process:

Molten aluminum contains a large amount of dissolved hydrogen, which should be expelled before it is poured in the molds, this process is called degassing. During the solidification of aluminum alloys, dissolved hydrogen generates porosity which is detrimental to the mechanical properties of this alloy casting. The inert gas when expelled through the metal accumulates the soluble hydrogen atoms, letting a hydrogen molecule to form inside the lower pressure of the collector gas bubble. Pure argon is frequently injected into the liquid alloy through a submerged lance or bubbler, so that dissolved hydrogen enters the argon bubble prior to discharge from the environment. As this bubble disrupts the surface, aluminum may be lost to oxidation by the entrapment in dross andfurnace gasses. Additionally, the use of chlorine creates environmental issues.

Another technique is a **rotor degassing process**, proved to be more effective by producing smaller bubbles and hence in degassing. One of the advantages in this technique is that, flux may be injected simultaneously with the degassing when gas is used as a carrier for different types of fluxes. The **Foseco Metal Degassing Unit (MDU)** has a graphite rotor, which will introduce inert gasses near the bottom of the vessel, which generates very small bubbles and blends them withmolten aluminum drawn into the rotor. As the bubbles float to the surface, they enlarge with a decrease in pressure that attracts the dissolved oxygen to thebubble surface and into the bubbles that escape from the metal.

The Foseco MDU rotor operates as a pump, pulling the metal into the rotor chamber. The inert gas is transported to the rotor through the center of the shaft which is then sheared into tiny gas bubbles that interact with the metal. The mixture is then ejected through quadrants around the perimeter of the rotor. The rotor, since it rotates continuously, assures fast and complete treatment. A refractory baffle board at the center eliminates.

4. High Pressure Die Casting Process:

High pressure die casting process is the most common technology for the production of components made for the alloys. Because the process characterized by molten metal is forged into cold empty cavity of the metal in the mold. When the die is opened, the casting is returned in the moving half from which it is ejected by pins activated either hydraulically or mechanically. These characteristics are good mechanical properties in the casting. However the quality defects that may occur most frequently in casting process at high pressure is blow holes defects that occur is mainly composed as follows.

- The operation in casting process.
- Machine used in the casting process.
- How to design appropriate

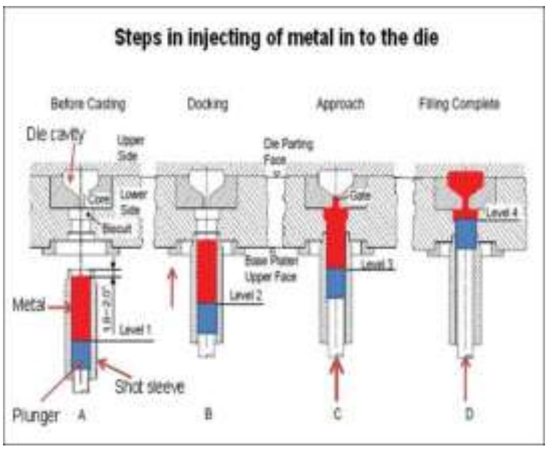

Figure 1: working of high pressure die casting machine

The three components are the priority that the operations should be created to the same standards for properly practice. Further, machinery selection for the product is important which must be considered in the next stage.

The condition of parameters is to determine the appropriate step molding process. Because of some parameters which affects the quality of the part for actual practice was difficult to control due to variations. The most common method, which is at the same time the most easily applicable in the foundries environment, is the trial and error method. Usually, the main controlled variables are mold temperature, dosage volume, slow and fast shots, communication spots, injection pressure, upset pressure as well as chemical composition and liquid metal temperature. Recently some papers have some shown the die casting injection speed and the low-speed starting position.

Pressure in compression during the coagulation that effect on the quality of the air inside the cavity. The time for cooling setting work piece in the mold which in fluency only to the external surface quality

Blow holes caused by gas in the water metal or may be a result of the remaining air in the material is mixed. Pore appearance of cavitation is often a small hole. The shape of blowholes is with a round and sharp holes. Usually, occurs as a group within the meat casting and found after the component is turning. The focus of this paper is on the blowholes of the die casting process by using the R14 aluminum alloy. The basic step as following:

Determine the blow holes ratings of the die casting process. The blow holes have been selected as the most quality problem.

The select of most significant factors effects on the blow holes rating when adjusted to different levels.

Analyze the summary data to determine the significant of each factor and considering for the best condition that the minimum effects on the blow holes rating. Determine the optimum setting of controlling factors is considered. Verification of a result by the optimum factors setting as new as levels in the predicted of the die casting process. In the first step the ladle was pouring the mold into the machine and in the second step the plunger injects the mold into the die, when the plunger injects the mold in the high pressure the mold transforms into the casting part by the intensification process.

To reduce the rejection rate in aluminum high pressure die casting machine one must have to analyze the casting defects and their causes. So, the problems which are faced while casting are analyzed and discussed below.

5. Problem Statement:

Porosity defect in the die casted product is major issue considered in this work fig 1 shows chart for Sep 2016. Contribution of porosity in injection is maximum from return chart for the months January 2016 to September 2016 that the rejection of the product due to porosity is increasing month by month see figure2. Objective is set to reduce the rejection of the product due to porosity defect below 5%

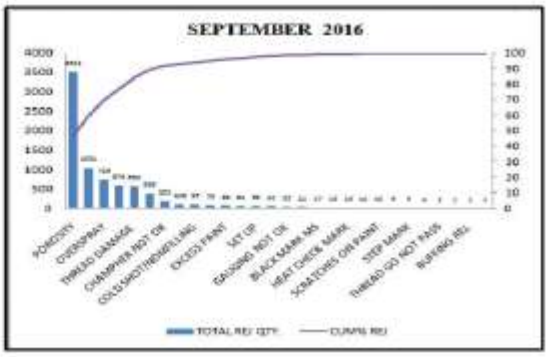

Figure 2: Pareto chart

6. Result and Discussion

6.1. Causes of Porosity:

Porosity is defined as void in casted part where there is absence of cast metal. Main case for gas porosity is high velocity of the metal injection. Before producing to solve any problem of porosity,identification of the type of porosity is very essential to obtain optimum solution for minimizing of defect. A blowhole typically shows series of smooth pores in casting as shown in the figure, there are series of pores near gate region in final product. Therefore mentioned porosity is gas porosity.
After the type of porosity is recognized, the root cause for the sameis found. North American die casting association has listed some causes for gas porosity, some of them are trapped air in plunger system, poor gate design, turbulent metal flows inside the cavity, etc... Some secondary causes are coolant leakages in die, excess lubricant and die coat spray on die, etc.. Figure shows the causes and effect diagram for porosity defect by performing brain storming on all obtained causes, we come to conclusion that maintained blowhole defect problem can be reduced by either modifying process parameter or by modifying gating design.

6.2. Parameter Optimization

To reduce the blowholes we had chosen to optimize the process parameters by changing the high speed change position. The following parameters are used before.

Table 1: Existing parameter for housing cover

PROCESS PARAMETERS	**UPPER SPECIFIC LIMIT (U.S.L)**	**LOWER SPECIFIC LIMIT (L.S.L)**
High-speed velocity	6	4
Intensification pressure	35	25
High-speed change position	250	210
Biscuit thickness	31	15
Metal temperature	685	655

Table 2: New parameter for housing cover

PROCESS PARAMETERS	**UPPER SPECIFIC LIMIT (U.S.L)**	**LOWER SPECIFIC LIMIT (L.S.L)**
High-speed velocity	6	4
Intensification pressure	35	25
High-speed change position	210	170
Biscuit thickness	31	15
Metal temperature	685	655

It hasbeen decided to change the **high speed change position from 230 to 190** so as to obtain the defect free parts. The other parameters like biscuit thickness, intensification pressure are remains unchanged.
The new process parameter reduces the pressure and the chance of forming blowholes is reduced. We also made a change in design near gate system to avoid chip off.

6.3. Design Modification:

After obtaining CAD design for current using design and shot details, flow simulation results using magma software is obtained. The figure shows the air entrapment results. It is observed that, there is an entrapment near gate design.

The blowhole defect is identified using why-why analysis technique.

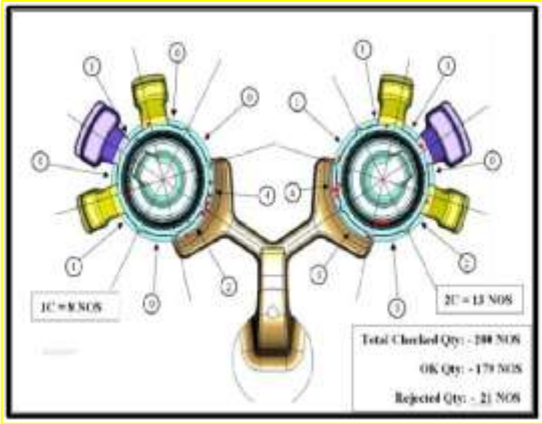

Figure 3: Existing housing cover design

Table 3: Why-Why analysis

SI.NO	**Why?**	**Answer**
1	Chip off in gate region.	Bad design near gate.
2	Blowholes near gate region are obtained.	Air entrapment in gate.
3	Gating directions are wrong.	Poor feeding system design.

This results into chip off and blowholes, Analysis called why-why analysis is performed to obtain the exact root cause for blowhole problem. From why-why analysis, it is concluded that the blowholes is occurring at gate section due to improper design near gate. Gating directions are designed with modifications so as to improve metal flow in die cavity. To reduce the affection of parental material during chip off the design has been changed near the gate region. By modifying the gate design the parental material remains unchanged during chip off hence the design is safe.

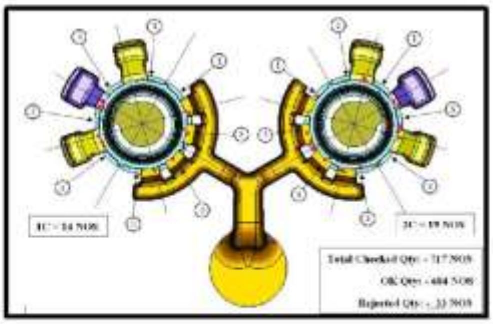

Figure4: Modified housing cover design

The new modified design **protects the parental material during chip off and reduces the air entrapment**.

7. Conclusion

By optimizing parameters and by modifying the design near gate region the defects of blowholes and affection of parental material during chip off is reduced. The defect concentration diagram for modified design is shown in figure 7. As a result of this project the rejection rate reduced from **20% to 8.9%.**

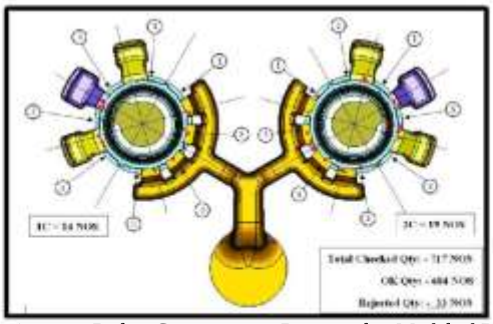

Figure 5: Defect Concentration Diagram for Modified Design.

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