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Optimization of Process Parameters in Cold Chamber Die Casting Process Using Taguchi Method

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Abstract: High Pressure die casting process is a process ideally suited to manufacture mass produced metallic parts of complex shapes requiring precise dimensions. In this process, molten metal is forced in to empty cavity of desired shape and is allowed to solidify under high holding pressure. Die casting is a complex process which is controlled by many parameters such as die related parameters, machine related parameters, which has direct impact on casting quality. Improper settings of these parameters end up in producing quality related issues in the casting. One such issue is blow holes and porosity which is caused by improper setting of process parameters. In this paper an industrial component having blow hole problem has been taken. This study proposes application of Taguchi methodology in identifying the optimum process parameters in order to improve the casting quality. Process parameters such as holding furnace temperature, slow shot, Fast shot, Die holding time, Intensification pressure has been selected for optimization. The response factor (quality characteristic) chosen is density of the casting. Density of the casting is chosen as a quality characteristic since it has direct relationship with casting defects. Generally denser the casting lesser the internal defects such as porosity, blow holes etc. Besides all this, final results were validated by both experimental and casting simulation.

1. Introduction

In manufacturing processes, there are various parameters with different adjustment levels, which may influence the final characteristics of the product. To optimize a manufacturing process, the trial and error method is used to identify the best parameters to manufacture a quality product. However, this method demands extensive experimental work and results in a great waste of time and money. Thus, optimization methods appear to be an important tool for continuous and rapid improvements. These experimental methods may be employed to solve problems related

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to a manufacturing process, and understand the influence of various factors on the final quality of a given product. The die casting process is controlled by several parameters. When properly determined and adjusted, they result in an improvement in quality of the die casting parts. Usually, the main controlled variables are metal temperature, slow shot, and fast shot, intensification pressure, die holding time, chemical composition of metal. G.O. Verran et al. (2008) has analysed the effects of slow shot, Fast shot, and Intensification pressure on casting density. The results indicate that the injection parameters affect the casting density to a greater extent. Similarly V.D. Tsoukalas (2008) has analysed effects of die casting process parameters on porosity formation using genetic algorithm. The results reveal that under optimized conditions porosity formation is very less. P. Vijian et al. (2006) has applied Taguchi method for optimizing the parameters in squeeze casting in order to minimize surface roughness. In this study optimization of die casting parameters using Taguchi methodology was carried out to solve the blow hole problem in an aluminium component named 'Front Wheel Hub I'. The material is AlSi9MnMg alloy. The component has high rejection rate due to the occurrence of blow hole problem. Especially the critical area of the casting shown in Fig.1 has more number of blow hole occurrence compared to the other areas of the casting. {4].

2. Taguchi parameter design

Taguchi parameter design provides a means of both reducing cost and improving quality by making effective use of experimental design methods. This involves the determination of parameter values that are least sensitive to noise .When the goal is to design a process or product with high stability and reliability, parameter design is the most important step in which the functional non linearity is used to best advantage. Initially parameters that are to be optimized are chosen carefully. A cause and effect diagram can be used for identifying the parameters that affects the response. In this study, casting density has been chosen as a response, since if the casting density is higher, lower the internal defects such as blow holes and porosity. After analyzing the cause and effect diagram, and checking the various parameters, die casting machine parameters such as Metal temperature (A), Slowshot(B), Fast shot(C),Intensification pressure(D), Die holding time(E), have been selected for the analysis of the blow hole problem in casting. Interactions were also considered between parameters Metal temperature, slow shot, Fast Shot. The ranges for the chosen factors were selected based upon preliminary trials conducted during process.

3. Experimental Procedure

The experimental setup consists of die casting cell comprising of 250T die casting machine, an electric holding furnace, shot monitoring system. The die casting machine is semi-automated, having an auto ladler for pouring the molten metal from the melting cum holding furnace. The various settings required for this experiment can be set manually and it is monitored through the shot monitoring system. The shot

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monitoring system helps us in monitoring the parameters set so that we can check its status during each shot. Aman Agarwal et al. (2008). Aman AgarwalBefore starting the experiment, the dies were preheated to a temperature of 190°C using a gas burner. The die temperature was measured by using infrared gun. The molten metal was cleaned by removing the slag to avoid impurities and degassing was done to remove the hydrogen content. The material composition was checked by using spectro analysis before starting of the experiment. Initially 50 shots were carried so that machine gets stabilized to conduct the experiment. A total of 27 different combinations shown in Table 3 were tried and 3 parts were cast for each combination, which totals to 81 castings. Each casting was given separate identification mark to avoid mixing of the castings. Finally after completing the experiment, the castings were trimmed, fettled and cleaned thoroughly. Der Ho et.al (2004).

4. Experimental results

The density of the casting was measured by Archimedes principle and the results are shown below. Minitab 14 software has been used to carry out Taguchi optimization .The response value is taken as average density of the three sample castings that were cast under each trail condition. Then S/N ratio were computed based upon the formula S/N ratio for larger the better characteristics = -10 log (1/r Σ (1/yi 2)) where r -number of observations, yi -Response value for each trail.

5. Confirmation test

Finally confirmation test were carried out at optimized conditions. The average casting density (2.593g/cm3) of three confirmation test samples lies well within the confidence limit. Philip J. Ross(11). The Radiography test was carried out on the confirmation test samples and the test results revealed no significant defects were found. The Radiography images of defective sample and confirmation test. The optimization procedure has been made to study the effect of die casting process parameters on casting density. Generally when the casting density is higher, internal defects such as blow holes and porosity is eliminated. So, the basic idea is to provide a decision tool for setting optimum parameters so that the defects occurring in the casting is reduced. Taguchi method was applied for optimizing the die casting process parameters, and the results obtained using this method was useful in eliminating the blow holes problem in Front Wheel Hub I casting. At optimized parameters the casting quality was better than the previous casting that was cast under the non optimized conditions. The radiography test results also revealed that samples cast under the optimized parameters has no significant defects. Similarly the results obtained using simulation software Z-cast V2.6 (Trial version) at optimized condition shows no presence of defects in casting. Considering the contribution of the parameters, intensification pressure was the factor showing more influence on the casting density compared to the other parameters. The outcome of this project work was very useful for finding solution for casting defects that occurs due to the incorrect process parameters in die casting.

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Also these results will help in improving the productivity of Front Wheel Hub I castings at Roots Cast Private Limited in future. Thus combination of optimization techniques along with casting simulation serves as a tool for improving the productivity of the castings to a greater extent, in die casting industries.

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