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STUDY ON OPTIMIZATION OF GATING SYSTEM FOR REDUCING DEFECT IN DIE CASTING PROCESS

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Abstract

Die casting enables the production of thousands of consumer, commercial, and industrial products in high volumes, accommodating components of varying sizesfrom small to largemaking it a quintessential mass production method. Die casting is widely employed in the industry due to its high productivity and minimal need for post-machining. Because of its lightweight nature and excellent formability, aluminum die casting is crucial in manufacturing transportation and vehicle parts. Some die-cast products were found to be defective, indicating a need to enhance the process's performance. The goal of this study is to assess how injection pressureconsidering both process and dimensional factorsaffects the dimensional stability of die-cast components. To study the effect, a RSM model combined with GA was created for each response, considering process parameters like injection pressure. ANOVA for each response has also been performed to identify the influencing factors and their interactions.

Keywords: *Die Casting Process; Gating; Process Parameter, Response; Optimization.*

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1. Introduction

Die casting is a molding technique where molten metal is forced at high pressure and speed into a two-part mold. It is also known as pressure die casting. This type of casting employs a split mold that can be reused. Die casting is classified into two typeshot chamber and cold chamberas illustrated in Figure 1.1. Die casting is a manufacturing method that involves injecting molten metal under high pressure into a mold cavity to create metal parts. To ascertain consistent good quality of the end product in die casting, a proper monitoring of the raw materials and process parameters used in die casting is essential. From literature review, it has been found that most of the researchers over the years, have dealt with various process parameters.

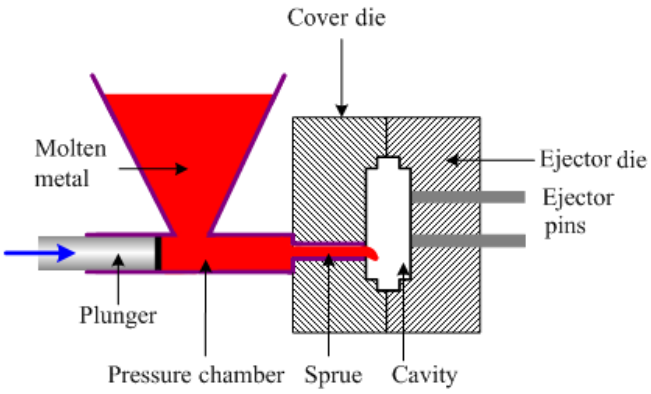

Figure 1. Basic circuit diagram of arc welding process

1.1 Gating System

It is the fundamental design required to ensure a seamless and accurate filling of the mold cavity during casting, free from discontinuities, voids, or solid inclusions. An effective gating system directs the molten metal, free of impurities, through a ladle into the mold cavity, ensuring a smooth and complete fill. This also depends on how the gating channels are arranged, including the direction and placement of the runner, sprue, and ingates.

2. Literature Review

Jayakumar Jayakumar et al. (2014), a simulation was conducted to determine the optimal placement for the gating systemincluding gate, sprue, runner, and riserso that the “hot spot” would be redirected to the riser, thereby producing defect-free components. This task is accomplished using software called WINCAST, which is exclusively designed for the casting process.

Ramnath et al. (2014), a Commutator End (CE) bracket was studied, and a cold chamber die-cast product was selected. At first, when the component was cast, it exhibited several defects, including cold shuts, misruns, shrinkage porosity, and gas porosity.

Mohanty and Jena (2014) studied how to optimize the process parameters in an aluminum die casting operation. During the manufacturing of a die-cast component, porosity was identified as the quality issue, and potential contributing factors were pinpointed using cause-and-effect analysis.

Adke (2014) applied the Taguchi method to fine-tune the die-casting process parameters, aiming to determine the optimal cycle time. There are four machining parameters, namely: melting temperature, injection pressure, plunger speed, cooling phase. Experiments vary depending on these parameters.

Amran et al. (2014), they presented the design and optimization of runner and gating systems for permanent mold casting. The quality of the casting is affected by fluid flow. The key design parameters for permanent mould casting were determined.

Panchal et al. (2015), they designed and conducted an analysis of the gating and risering system for casting ball valves. A CAD model of the ball valve has been created, and simulations have been performed using ProCAST. The Pro-CAST results are benchmarked against experimental data to ensure accuracy.

Kulkarni Singh et al. (In 2017, it was studied that simulation is now widely regarded as a scientific method for designing gating systems, ensuring internal quality, and achieving optimal casting yield. The simulated results allow prediction of defect quantities, enable design optimization, and guide corrective actions to reduce defects, ultimately enhancing casting quality.

Ravi and Kumar (2017) investigated castings from a foundry where internal shrinkage was a key defect; they found that the gating and feeding system had been inadequately designed. The designed gating system minimized defects and boosted yield.

Raveendran and Patil (2017) found that in die casting, dies frequently feature multiple cavities, each capable of producing either identical or distinct components. When multiple cavities are involved, branch runners must be used to connect to a central runner.

Apparao and Birru (2017) used the Taguchi method to determine optimal die casting parameters, aiming to enhance the quality and efficiency of Al-Si8Cu3Fe (EN AC-46500) aluminum alloy die casting by minimizing porosity. Using the Taguchi method, the influence of the chosen parameters on porosity formation and the subsequent optimization of those parameters have been successfully determined.

In 2018, Balikai conducted a study to optimize the die casting process parameters through the application of ANOVA and the Taguchi method, aiming to enhance the quality of high-pressure die casting (HPDC) productsa key challenge for both small and large-scale HPDC manufacturers.

Xavier et al. (In 2019, an experimental study was carried out using air-water and air-water-oil mixtures in a pipe with a 0.075-meter diameter. The superficial velocities of gas and liquid ranged from 0.03 to 0.13 m/s and 1.26 to 41.58 m/s, respectively. Slug flow was the predominant flow pattern observed. Moreover, the shift from churn to annular flow and the annular regime were also noted.

3. Conclusion

Pressure die casting is mainly influenced by process parameters including solidification time, molten metal temperature, filling time, and injection pressure along with plunger velocity. Thus, adopting the optimal casting method that minimizes defects is crucial to lowering the manufacturing cost of die-cast components in large-scale production.

Optimizing the process parameters is challenging due to defects, as it requires understanding how the parameters interact to properly configure the process for each component. In manufacturing, multiple parameterseach adjustable to varying degreescan impact the final properties of the product.

To fine-tune a manufacturing process, trial and error helps pinpoint the optimal parameters for producing a high-quality product. However, this approach requires a significant amount of experimental effort and leads to considerable waste of time and resources. Therefore, experimental design seems to be a crucial method for driving ongoing and swift quality enhancements. These experimental methods can be used to address manufacturing-related challenges, replace one process with another, create new products, and analyze how different factors affect the final quality of a given product.

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