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Design optimization of gating and feeding system through simulation technique for sand casting of wear plate☆

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Summary Casting is a manufacturing process to make complex shapes of metal materials; during mass production, we may experience many defects, such as gas porosity, pin holes, blow holes, shrinkages and incomplete filling that may occur in sand casting. Porosity is one of the defects most frequently encountered in ductile iron casting. Porosity impacts cost by scrap loss and limits the use of cast parts in critical high strength applications. The amount of porosity is closely related to the parameter of sand casting process. The gating/riser system design plays a very important role for improving casting quality. Many researchers reported that 90% of the defects in casting are obtained only because of improper design of gating and feeding system. The main objectives were to study the existing design of gating and feeding system, to optimize the gating and feeding system using Auto-CAST X1 casting simulation software, to prepare the sand mold and cast the part, to compare the simulated result and experimental results, to reduce rejection rate and to enable the company to again start the production.

Introduction

Casting is a manufacturing process for making complex shapes of metal materials in mass production. There are two main consecutive stages: filling process and solidification process in casting production. The filling process gating system, composed of pouring cup, runner, sprue, sprue well and ingate, is designed to guide liquid metal filling. Riser system is used to compensate shrinkage caused by casting

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Figure 1 Existing gating and feeding system with simulated results.

solidification. Casting process design is important for production quality and efficiency. It is unavoidable that many different defects occur in casting process, such as porosity and incomplete filling. As such, improvement of the casting quality becomes important. Casting quality is increasingly dependent on the success of gating/riser system design, which is currently conducted mainly relying on the technician's experience. Bad design of the gating and feeding system can result in defects in the castings. One of the main variables that should be considered when designing a gating system is the flow of molten metal while filling the mold.

Literature review

The literature review is mainly focusing on design and optimization technique based on casting related defects and their research and outcomes. Ravi and Joshi (2007) worked on computer-aided casting design and simulation of feeder and gating design of castings using Auto-CAST software and they describe how it assists in designing, modeling, simulating, analyzing and improving cast products. Bhatt and Barot (2014) suggested that the design optimization of feeding system and simulation reduced the casting defects of cast iron in foundries, which arose during solidification and mold filling. In casting processes most important is to change riser and gates dimensions and simulate with the help of Auto-CAST software. The simulation got shrinkage and reduces hot spots and cracks in gear box of automobile components. Masoumi et al. (2005) suggested the effect of gating design on mold filling for light metal casting processes. The validation results showed that the design and shape of the gate and the ratio of the gating system have a great influence on the pattern of mold filling. Hassan et al. (2012) investigated the impeller shaped casting using MAGMASOFT Software. The effect of riser and gates on parameters, such as filling pattern, pressure and speed, cooling rate, solidification and related defects, was studied. Choudhari et al. (2013) suggested that by optimization method casting related defects can be improved. The proper location, size and design of gating and feeder system using simulation technology improved the shrinkage porosity and cracks in casting. Sun and Su (2008) suggested the numerical simulation technique, parameters of gating and riser for a magnesium alloy casting with multiple analysis characteristics in magnesium alloy base casting to analyse the effect of various gating system designs on cavity filling and casting quality using MAGMASOFT simulation software; satisfactory results were obtained with high yield and reduced shrinkage porosity. Sutaria (2010) worked on a new idea where optimization of casting feeding is done with the help of feed-paths. The computation of feed-paths is done by the method known as vector element method (VEM).

Research methodology

The entire study has been carried out in four stages, viz. design of feeder and gating system, numerical simulation by using Auto-CAST X1 software, validation with experimental results and testing by ultrasonic testing machine and finally comparing the results with old results.

As per the foundry requirement, casting material with grade SG-69-45-12 was used and mold material was taken as silica sand. The specifications of the parts of the wear plate were 342 mm length, 596 mm height, 38 mm thickness and weight around 49.50 kg. Wooden pattern was used for getting good quality of mold cavity and casting and it was easily available at a cheap rate.

Study of existing gating and feeding system

Before making a design of the gating and feeding system, mold, dies, pattern, etc., we studied the existing pattern, casted part and design of gating and feeding system of wear plate. The vertical gate and feeder were used for filling of molten metal into the cavity. Feeder was placed on the top of the plate and gate was placed at the bottom of the plate. According to the study, design was made of existing gating and feeding system using Auto-CAST X1 software and checked various results like solidification defects, hot spots, shrinkages, and mold filling, etc.; after this, sectional view was taken and we found hot spots at the center and bottom portion of the plate, which is shown in Fig. 1.

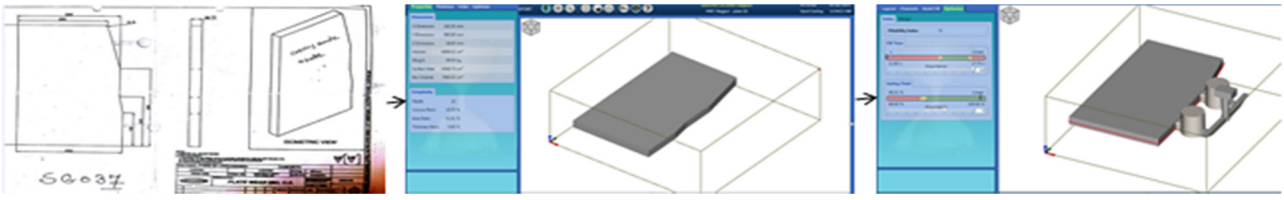

Figure 2 2D and 3D models with proposed (optimized) gating and feeding system.