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Pressurized gating system design and optimization in steel castings

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Abstract

The aim of this study is to establish a correlation between the proven version of the pressurized gating system for steel castings and the cost-effective version of the pressurized gating system in industrial conditions. In the study, a computer-aided design solid modeling program was used in the design of the pressurized gating system for steel castings and the ratio of the pressurized gating system was selected as 1: 3: 1. Flow simulation of the gating-designed casting part was made in computer-aided design metal casting simulation. In the study, calculations used in the design of the pressurized gating system were made based on the weight of the part and effective casting height. The study clearly shows that the well-designed pressurized gating system has revealed that it plays a significant role in preventing non-metallic casting defects in steel castings, such as sand, gas, and slag. In addition, the '' Spin Trap '' that is recommended to be used in gating systems in ferrous based castings in the literature, was used for the first time in the ÇİMSATAŞ foundry in the steel castings at the end of the runner in the pressurized gating system and the appropriate result was obtained. Computer-aided flow and solidification simulation was used in the design of the gating system containing Spin Trap

Introduction

In steel castings, all the cavities created in the sand mold are called the gating system for the liquid metal to fill the mold cavity without any problems. As important as the effective use of feeders in a cast part is, the correct design of the gating system is just as important. The basic components of the gating system in the casting processes; casting chamber (casting countersink), vertical runner, horizontal runner, and ingate consists of four parts. Although the main task of the gating system is to direct the molten metal and fill the mold with molten metal, a well-designed gating system plays an important role in preventing various casting defects (non-metallic inclusions such as sand, gas, and slag) that may occur the casting part [1-3]. Likewise, a poorly designed gating system can cause defects in the last part that may require repair, or cause the part to be scrapped. Well-designed gating system; should be able to fill the mold at the appropriate time, direct the liquid metal to the desired and/or targeted location, allow air and gases to escape from the mold, prevent non-metallic inclusions from entering the mold, not cause the mold to deteriorate with erosion, not cause gas suction due to turbulence, and should be minimum weight [3-9].

Pressurized Gating System

The tightest cross-sectional area of the pressurized gating systems used in steel casting processes is the ingate. In the pressurized gating system, the total cross-sectional area decreases towards the mold cavity, and back pressure formation is prevented by the pressure of the liquid metal in the runner. In the pressurized gating system, the gas absorption is significantly reduced because the horizontal runner remains constantly filled throughout the casting period. In addition, the use of a pressurized gating system in steel castings ensures uniform filling in the ingates and minimum runner weight for high runner efficiency. Typical ratios used in pressurized gating system design are 1:3:2 and 1:3:1 [3-6].

Spin Trap System

There are many versions of various slag capture systems in the literature for steel castings. In recent years, the use of a Spin Trap chamber at the end of pressurized gating systems for steel castings has been recommended by many authors in the literature. The main purpose of the Spin Trap system is; to obtain a cleaner casting part by grabbing non-metallic inclusions such as sand, gas, and slag that the gating system cannot prevent from entering the part, and to optimize the gating system [6-15].

Material and Method

In this study, it is aimed to develop a pressurized gating system for steel castings by using a computer-aided solid modeling program. The pressurized gating system design of the fork part is based on the total weight of the part. The part was molded in the green sand molding system and cast in the ÇİMSATAŞ foundry. In the study, the material of the part was determined according to the TS EN 10293 standard (material of the casting part is G17CrMo9-10 + QT). Due to the high carbon equivalent of this material and the visuality of the part, it is aimed to minimize non-metallic inclusions such as sand, gas, and slag that may occur on the surface of the part during casting. The pressurized gating system design of the part was made in the computer-aided solid modeling program and the flow simulation of the part was made in the computer-aided metal casting and solidification program.

Table 1. Pressurized gating system ratio and dimensions

Gating system ratio	Vertical runner	Horizontal runner	Ingate
1:3:1	1	3	1

The filling and solidification simulation of the casting part was made with a lip pouring ladle at 1600 °C . The nominal chemical composition of the casting part was selected as shown in table 2 and the metal flow and filling simulation was performed.

Table 2. Nominal chemical composition of the casting part

Contents	% C	% Mn	% S	%P	% Si	% Ni	%Cr	% Mo
Min.	0.13	0.5	0	0	0.4	0	2,0	0.9
Max.	0.2	0.9	0.02	0.02	0.6	0.3	2,5	1,2

After simulating metal flow on the part, 12 parts were molded in the green sand molding system in the ÇİMSATAŞ foundry and the castings were carried out with a lip pouring ladle at 1586 °C as shown figure 1.

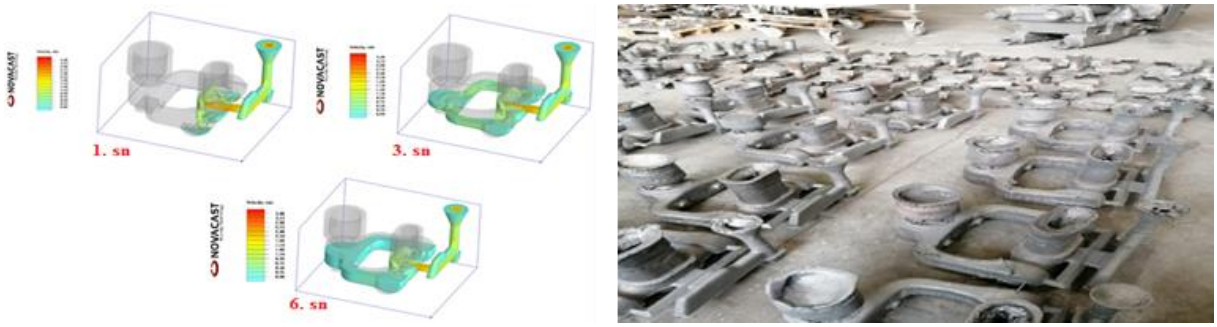

Figure 1. Image of the metal flow and filling simulation and the pouring parts

By using the metal flow and filling simulation data of the part for which the pressurized gating system was designed, the Spin Trap chamber was placed at the end of the gating system without changing the dimensions of the part gating system, and the part was simulated again under the same conditions . After simulating metal flow on the part, 12 parts were molded in the green sand molding system in the ÇİMSATAŞ foundry and the castings were carried out with a lip pouring ladle at 1586 °C as shown in figure 2.

Figure 2. Image of the metal flow and filling simulation and the pouring parts with Spin Trap chamber

Findings

- It is found that the simulation results highly represent the actual casting results.
- Although the pressurized gating system for steel castings minimizes the penetration of non-metallic inclusions into the part, it has been concluded that in some specific cases there may be situations where these inclusions cannot prevent their penetration into the part.
- Although the data that the part gating system could not catch slag was obtained, the presence of non-metallic inclusions that can be seen in the gating systems of the cast parts.
- It has been observed that the Spin Trap chamber significantly captures non-metallic inclusions in the part filling, and the results obtained revealed that the part simulation significantly confirmed the actual situation.
- Destructive inspection was performed on the Spin Trap chambers and the presence of non-metallic inclusions was detected in the cut pieces.

Figure 3. Images of inclusions captured in the Spin Trap chamber

Results

Although the pressurized gating system for steel castings minimizes the penetration of non-metallic inclusions into the part, it is concluded that it cannot prevent the non-metallic inclusions escaping from the ladle during casting to entering the part at the desired level.

With the design of the Spin Trap chamber pressure gating system in the ÇİMSATAŞ foundry, the surface quality of the cast steel parts has improved positively. The improvement in the casting part surfaces which get obtained by using a spin trap was reduced the rework needed (such as cosmetic welding, grinding, etc.).

The results of the study show that the Spin Trap chamber, which has been widely used in non-ferrous castings in recent years, has also given positive results in the steel casting process.

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References

1. J. Campell, *Complete Casting Handbook*, 2nd ed., Butterworth-Heinemann, Oxford, 2015
2. J. Campell, *Casting Practice The 10 Rule of Castings*, 1st ed., Butterworth-Heinemann, Oxford, 2004
3. S. I. Karsay, *Ductile Iron Production*, 1st ed., Quebec Iron and Titanium Corporation, Canada, 1976
4. R. Dojka, J. Jezierski, and J. Campell, Optimized Gating System for Steel Castings, *Journal of Materials Engineering and Performance*, 2018, **27**(10), p 5152-5163
5. J. Jezierski, R. Dojka, and K. Jenerka Optimizing Gating System for Steel Castings, *5th International Conference on Modern Manufacturing Technologies in Industrial Engineering,* 2017, p 14-17
6. J. Jezierski, R. Dojka, K. Kubiak, W. Zurek, and T. Ltd, Experimental Approach for Optimization of Gating System in Castings, *Metal 2016: 25th Anniversary International Conference on Metallurgy and Materials,* 2016, p 104-109
7. F. Hsu, M. Jolly, and J. Campell, Vortex-Gate Design for Gravity Casting, *International Journal of Casting Metal Research*, 2006, **19**(1), p 5736-5750
8. N. Ducic, R. Slavkovic, I. Milicevic, Z. Cojbasic, S. Manasijevic, and R. Radisa, Optimization of the Gating System for Sand Casting Using Genetic Algorithm, *International Journal of Metal casting Research*, 2017, **11**(2), p 225-265
9. K. Ogawa, S. Kanou, and S. Kashihara, Fewer Sand Inclusion Defects by CAE, *Komatsu Technical Report*, 2006, **52**(158), p 1-7
10. P. David, J. Massone, R. Boeri, and J. Sikora, Gating System Design to Cast Thin Wall Ductile Iron Plates, *International Journal of Metal Casting Research*, 2006, **19**(2), p 98-109

11. A. J. Melendez, K. D. Carlson, C. Beckermann, Modelling of Deoxidation Formation in Steel Casting, *International Journal of Casting Metal Research*, 2010, **23**(5), p 278-288
12. J. Campell, Stop Pouring, Start Casting, *International Journal of Metal Casting Research*, 2012, **6**(3), p 7-18
13. F. Hsu, M. Jolly, and J. Campell, A Multiple-Gate Runner System for Gravity Casting, *Journal of Material Processing Technology*, 2009, **209**(17), p 5736-5750
14. K. Renukananda and B. Ravi., Multi-Gate System in Casting Process: Comparative Study of Liquid Metal and Water Flow, *Materials and Manufacturing Process*, 2016, **31**(8), p 1091-1101
15. A. Moderasi, A. Safihani, A. Noohi, N. Hamiznezhad, and S. Maki, Gating System Design and Simulation of Gray Iron Casting to Eliminate Oxide Layers Caused by Turbulence, *International Journal of Metal Casting Research*, 2017, **11**(2), p 328-339