Advanced Engineering Days

aed.mersin.edu.tr

Direct pouring system design and optimization in steel castings

Mustafa Murat Zor *[1], **Serdar Kesim**[1], **Buğra Erbakan**[1], **Ferhat Tülüce**[1], **Alper Yoloğlu**[1], **Kazım Çakır**[1]

[1]ÇİMSATAŞ Çukurova Construction Machinery IND. TRADE. A.S. Mersin, Turkey, foundry@cimsatas.com

Cite this study: Zor, M. M., Kesim, S., Erbakan, B., Tülüce, F., Yoloğlu, A., & Çakır, K. (2022). Direct pouring system design and optimization in steel castings. 4th Advanced Engineering Days, 111-115

Keywords
Steel casting
Direct pouring system
Modeling and simulation
Casting defects
Filtration

Abstract

In this study, a computer-aided design solid modeling program was used in the design of the Kalpur direct pouring sytem, non-filter bottom direct pouring system, and filtered direct pouring system for steel castings. The flow and solidification simulation of the different direct pouring systems of the casting parts were made in magma flow and solidification program. The study clearly shows that the kalpur direct pouring 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, it has been revealed in the study that the non-filter bottom direct pouring system prevents non-metallic casting defects in steel castings such as the kalpur direct pouring system. Kalpur direct pouring system is recommended to be used in ferrous based castings by FOSECO, was used for the first time in the ÇİMSATAŞ foundry in the steel castings and the appropriate result was obtained.

Introduction

Non-metalic inclusions are important defect in steel casting process. Inclusion defects of steel castings are defects such as slag of oxide and other substances generated in the pouring ladle by the reaction, and sand of molds and cores that flake away and are included in the molten metal, flowing into casting parts and appearing on the surfaces of parts as non-metalic inclusions. In order to reach desirable quality casting part, well design pouring system is the first step. Dimensions of the pouring system need to be calculated according to casting part geometry beceause of each casting part has different shape and an incorrect design is the root cause of the casting defects onto casting parts, mostly. High casting quality depends on a reasonable pouring system design [1-6].

Filtration technology is evolving as the demand for clean, quality castings with high yield, low scrap rates, and low process costs increases. The benefit of filters, especially reticulated foam filters, besides their turbulence-reducing effect, is to prevent non-metallic inclusions such as sand and slag from entering the casting part during pouring the liquid metal into the sand mold [7-15].

Material and Method

The direct pouring system designs of the bearing casting part are based on the modulus and geometry of the casting part. In the study, the material of the part was determined according to the EN 10293 standard and material of the casting part was selected G20Mn6N. The part with three different direct filling systems was molded in the flaskless resin moulding system and cast in the ÇİMSATAŞ foundry. The nominal chemical composition of the casting part was selected as shown in table 1 and the image of the bearing casting part is shown in Figure 1.

Table 1. Chemical composition of the bearing casting part

Content	**% C**	**% Mn**	**% Si**	**% P**	**% S**	**% Cr**	**% Ni**	**% Mo**	**% V**
	0,199	1,593	0,432	0,014	0,007	0,191	0,065	0,035	0,013
Content	**% Cu**	**% B**	**% Ti**	**% Sn**	**% Al**	**% Zr**	**% Nb**	**% Pb**	**% Sb**
	0,071	0,00018	0,001	0,003	0,048	0,002	0,008	0,001	0,000
Content	**% Fe**	**% CEQ**	**% Zn**	**% Ce**	**% Bi**	**% W**	**% As**	**% Co**	**% N**
	97,264	0,528	0,002	0,001	0,000	0,000	0,007	0,008	0,008

Figure 1. Schematic representation of the bearing casting part

In the first direct pouring system study, filtered direct pouring system was designed by placing a dimension of Stelex Pro Ø150x30 mm 10 PPI graphite-based filter was placed inside the BGK6 exothermic feeder in the cope side of the part solid data. Then, the flow and solidification simulation of the part was made at 1600 °C by choosing lip pouring ladle. According to simulation results, filtered direct pouring system was assembled to the casting part model.

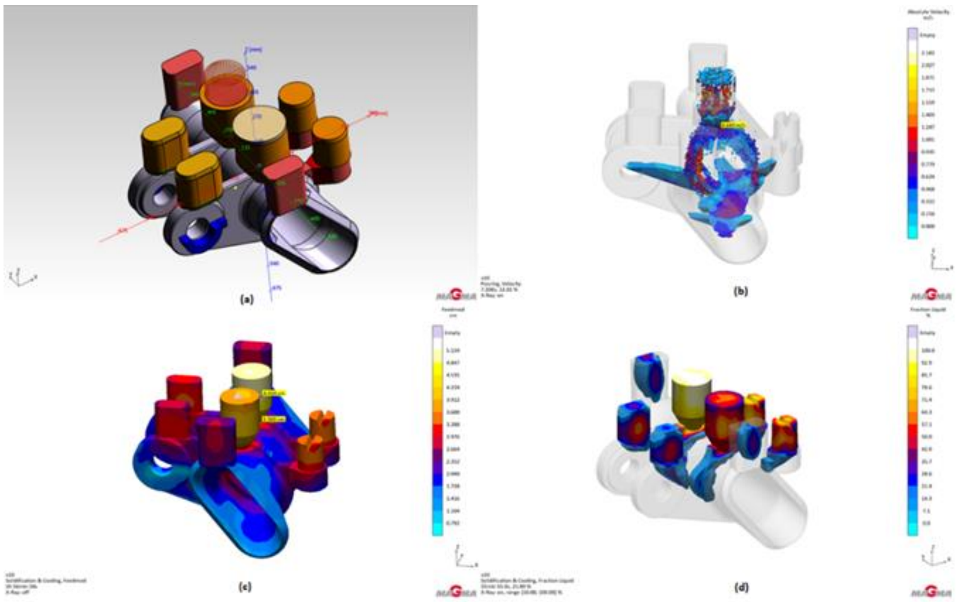

Figure 2. a); The image of the casting part geometry, **(b);** The image of the metal flow and filling simulation of the casting part, **(c);** The image of the feeding mod of the casting part, **(d);** The image of the friction liquid mod of the casting part

After simulation results, one part was molded in the flaskless resin moulding system in the ÇİMSATAŞ foundry and the casting was carried out with a lip pouring ladle at 1600 °C and 38 second. Total weight of the casting part is 590 kg.

Figure 3. The image of poured casting part with the filtered direct pouring system

The part that was poured with the filtered direct pouring system was examined and then a design change was made in the part. In the casting part design, Stelex Pro Ø150x30 mm 10 PPI graphite-based filter was placed inside the Kalminex ZTAE PPE 18/20 exothermic feeder and the filling point of the casting part was revised as kalpur direct pouring system. Kalpur direct pouring system was placed at the lowest point of the cope side in the casting part solid data and flow and solidification simulation was made at 1600 °C by choosing bottom pouring ladle. According to simulation results, kalpur direct pouring system was assembled to the casting part model.

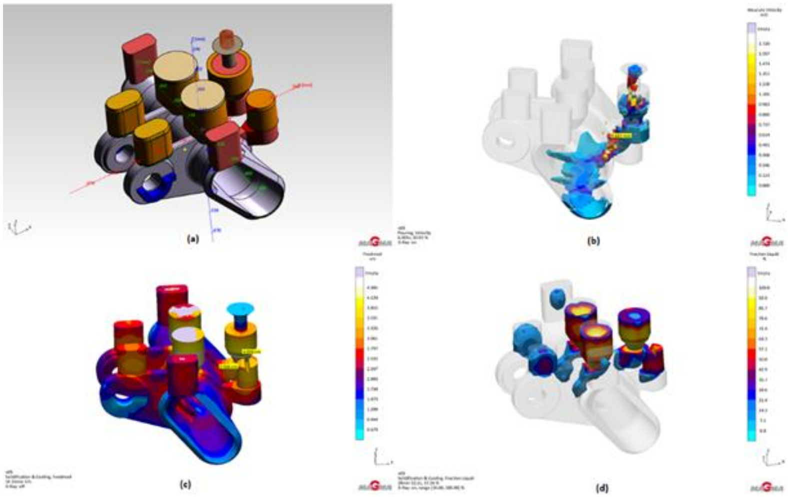

Figure 4. (a); The image of the casting part geometry**, (b);** The image of the metal flow and filling simulation of the casting part, **(c);** The image of the feeding mod of the casting part, **(d);** The image of the friction liquid mod of the casting part

After simulation results, one part was molded in the flaskless resin moulding system in the ÇİMSATAŞ foundry and the casting was carried out with bottom pouring ladle at 1609 °C and 32 second. Total weight of the casting part is 613 kg.

Figure 5. The image of poured casting part with the kalpur direct pouring system

After examining the poured part with the Kalpur direct casting system, the part design was revised as non-filter bottom direct pouring system. In the casting part design, Stelex Pro Ø150x30 mm 10 PPI graphite-based filter was not placed inside Kalminex ZTAE PPE 18/20 exothermic feeder as the casting practice of the ÇİMSATAŞ foundry. The filling point of the casting part was chosen as the same region as the kalpur direct pouring system. Flow and solidification simulation of the casting part was made at 1600 °C by choosing bottom pouring ladle. According to simulation results, non-filter bottom direct pouring system was assembled to the casting part model.

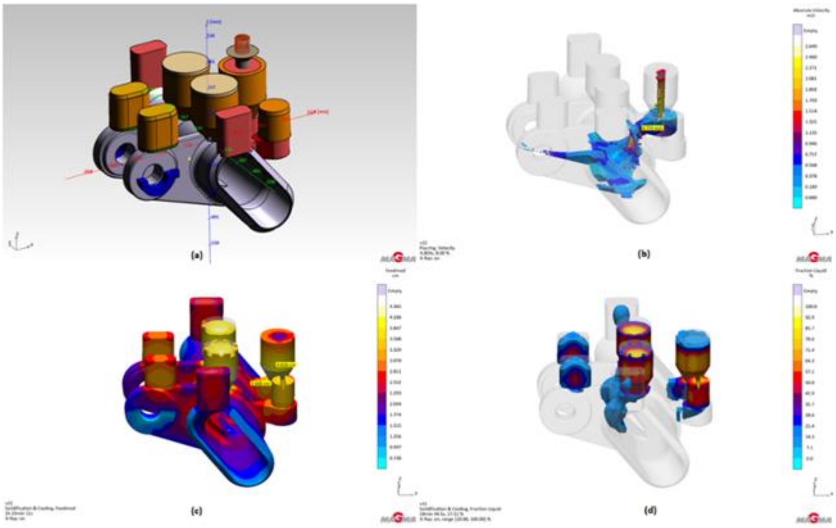

Figure 6. (a); The image of the casting part geometry**, (b);** The image of the metal flow and filling simulation of the casting part, **(c);** The image of the feeding mod of the casting part, **(d);** The image of the friction liquid mod of the casting part

After simulation results, one part was molded in the flaskless resin moulding system in the ÇİMSATAŞ foundry and the casting was carried out with bottom pouring ladle at 1582 °C and 20 second. Total weight of the casting part is 613 kg.

Figure 7. The image of poured casting part with the non-filter bottom direct pouring system

Results

In this article, casting parts were designed according to the simulation results with different direct pouring system versions in steel castings. The findings were obtained from the simulation and casting results of the parts.

- It is found that the simulation results highly represent the actual casting results.
- Cold shut defects were detected as well as non-metallic inclusions on the surface of the part poured with the filtered direct pouring system. And filling time of the casting part is 38 second.
- Poured with kalpur direct pouring system and non-filter bottom direct pouring system, the gross weight of the casting parts has increased from 590 kg to 613 kg. In total, gross weight of the casting parts have increased by 23 kg.
- It has been revealed that pouring design of the casting part and the selection of the pouring region is very important for the surface quality of the casting part.

- With the kalpur direct pouring system, a remarkable improvement has occurred on the surface quality of the casting part.
- With the non-filter bottom direct pouring system, the need for Stelex Pro Ø150x30 mm filter used in the moulding of the part has been eliminated. It has been observed that clean parts can be poured with this system by using bottom pouring ladle too.
- While the filling time of the poured part with the kalpur direct pouring system is 32 seconds, the filling time of the poured part with the non-filter bottom direct pouring system is 20 seconds.
- It has been observed that the surface qualities of the poured parts are close to each other with the kalpur direct pouring system and the non-filter bottom direct pouring system.
- It has been observed that the surface qualities of the poured part are worst with filtered direct pouring system.

Conclusion

Although non-filter bottom direct pouring system for steel castings minimizes the escape of non-metallic inclusions from ladle into the casting part during sand mould filling, the use of ceramic foam filter inside the non-filter bottom direct pouring systems are very important for the scrap rate of the foundries. With the design of the different version of the direct pouring systems in the ÇİMSATAŞ foundry, the surface quality of the casting part has improved positively by design of the kalpur direct pouring system and non-filter bottom direct pouring system. Ceramic foam filters are cost-effective and efficient way to reduce casting defects. The results of the study show that the kalpur direct pouring system and non-filter bottom direct pouring system have best given positive and reliable results in the steel casting process.

Acknowledgements

We would like to thank ÇİMSATAŞ General Manager Mr. Fatih ERDOĞAN, ÇİMSATAŞ Production Group Manager Mr. Necmettin ACAR, ÇİMSATAŞ Foundry Finishing Engineer Mr. Mert DEMİRDÖĞEN, ÇİMSATAŞ Foundry Production Engineer Mr. Vedat UZ, ÇİMSATAŞ Foundry Production Foreman Mr. Sabahattin KAYA, ÇİMSATAŞ Foundry Finishing Foreman Mr. Erdal YALÇIN, ÇİMSATAŞ Foundry Finishing Foreman Mr. Halil Deniz ÇOBAN, ÇİMSATAŞ Foundry Model Shop Foreman Mr. Ahmet AVCI, FOSECO Simulation Engineer Mr. Volkan EVNİ, and FOSECO Sales Engineer Mr. Halis ARTUT

References

1. Campbell, J. (2015). *Complete casting handbook: metal casting processes, metallurgy, techniques and design*. Butterworth-Heinemann.
2. Campbell, J. (2004). *Casting Practice The 10 Rule of Castings. Butterworth-Heinemann*
3. Campell, J. (2012). Stop Pouring, Start Casting. International Journal of Metal Casting Research, 6(3), 7-18
4. Melendez, A. J., Carlson, K. D., Beckermann, C. (2010). Modelling of Deoxidation Formation in Steel Casting, International Journal of Casting Metal Research, 23(5), 278-288
5. Renukananda, K. H., & Ravi, B. (2016). Multi-gate systems in casting process: comparative study of liquid metal and water flow. *Materials and Manufacturing Processes*, *31*(8), 1091-1101.
6. Brown, J. (Ed.). (2000). *Foseco ferrous foundryman's handbook*. Butterworth-Heinemann.
7. Modaresi, A., Safikhani, A., Noohi, A. M. S., Hamidnezhad, N., & Maki, S. M. (2017). Gating system design and simulation of gray iron casting to eliminate oxide layers caused by turbulence. *International Journal of Metalcasting*, *11*(2), 328-339.
8. Janiszewski, K., & Kudliński, Z. (2006). The Influence of Non-Metallic Inclusions Physical State on Effectiveness of the Steel Filtration Process. *steel research international*, *77*(3), 169-176.
9. Foseco Foundry International, SEDEX, the Ceramic Foundry Filter with Foam Structure. Staffordshire, England, 1999.
10. Hsu, F. Y., Jolly, M. R., & Campbell, J. (2009). A multiple-gate runner system for gravity casting. Journal of Materials Processing Technology, 209(17), 5736-5750.
11. Janiszewski, K. (2013). The slenderness ratio of the filter used in the process of liquid steel filtration as the additional parameter of the filter form. *steel research international*, *84*(3), 288-296.
12. Ogawa, K., Kanou, S., & Kashihara, S. (2006). *Fewer Sand Inclusion Defects by CAE* (Vol. 52, No. 158, pp. 1-7). Komatsu Technical Report.
13. Hrabina, D. Effective Filtration of Steel Castings. 7th International Ankiros Foundry Congress, 11-13 September, Istanbul, Turkey
14. Jezierski, J. Dojka, R. & Jenerka, K. (2017). Optimizing Gating System for Steel Castings, 5th International Conference on Modern Manufacturing Technologies in Industrial Engineering, 14-17
15. Foseco Foundry (1999). International, SEDEX, the Ceramic Foundry Filter with Foam Structure. Staffordshire, England.