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The effect of metal turbulence on hydrogen induced crack defects in steel castings

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Keywords
Hydrogen induced cracking
Steel casting
Gating system design
Molding design
Modelling and simulation

Abstract

In the study, various moulding and gating system designs have been designed for steel castings in the ÇİMSATAŞ foundry and the effects of the metal turbulence on hydrogen-induced crack defects have been investigated. The flow and solidification of the casting part were simulated by using Novacast flow and solidification program. The study clearly shows that metal turbulence has revealed that it plays a significant role in preventing hydrogen-induced crack defects in steel castings.

Introduction

Hydrogen cracking is characterized by its fine, hairline stepped appearance linking inclusions. Turbulence during the pouring of metals generates two main defects: (1) entrained air bubbles and (2) entrained oxide films from the surface of the liquid metal [1-9]. The oxides are always entrained with the dry top surface of the oxide folded over against itself. This unbonded double interface (a bifilm) acts as a crack in the liquid metal, leading to the initiation of cracks and hot tears in the casting [10-19].

Material and Method

The material of the casting part is determined according to the SEW 520 standard and material of the casting part has been selected as G 14NiCrMo10-6. The part with two different molding and gating systems have been molded in the flaskless resin molding system and casted in ÇİMSATAŞ foundry. The image of the casting part is shown in Figure 1.

Figure 1. Schematic representation of the casting part

In the first casting design study, gating system design of the casting part is based on total gross weight of the part and effective casting height. The gating system ratio of the casting part has been choosen as 1:3:1. The molding and gating system designs have been designed by using solid data and then, flow and solidification of the casting part has been simulated at 1600°C by choosing lip pouring ladle. The images of the simulation results of the casting part are shown in Figure 2.

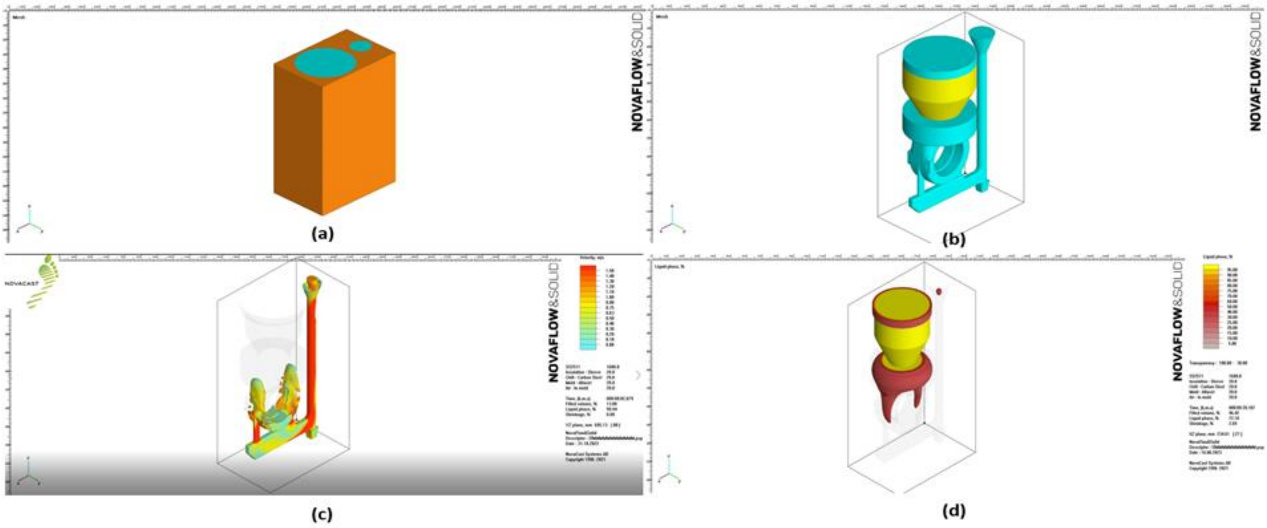

Figure 2. (a); The image of the molding design of the casting part, **(b);** The image of the casting part geometry, **(c);** The image of the metal flow and filling simulation of the casting part, **(d);** The image of the friction liquid mod of the casting part

After simulation results, one part was molded in the flaskless resin molding system in ÇİMSATAŞ foundry and the casting has been carried out with a lip pouring ladle at 1590 °C. After the casted part was heat treatment (normalizing and tempering), the flange of the casting part was machined according to technical drawing of the part and magnetic particle testing was performed on the part. The locations of the defects and morphologies in the flange of the casting part under UV light after machining are shown in Figure 3.

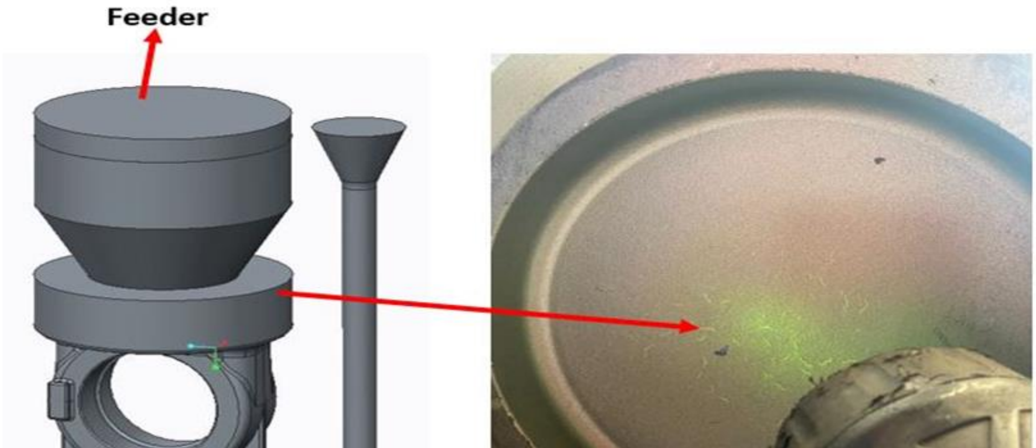

Figure 3. (a); The image of the molding design of the casting part, **(b);** The locations and morphologies of the defects on the flange of the casting part under UV light after machining.

After the first poured part was examined and then molding and gating system designs of the casting part were changed in the part solid data. In the casting part design, the gating system design of the casting part was calculated according to total gross weight and effective casting height of the part. After the molding and gating system designs of the casting part were chanced, flow and solidification of the part was simulated at 1600 °C by choosing lip pouring ladle. The images of the simulation results of the casting part are shown in Figure 4.

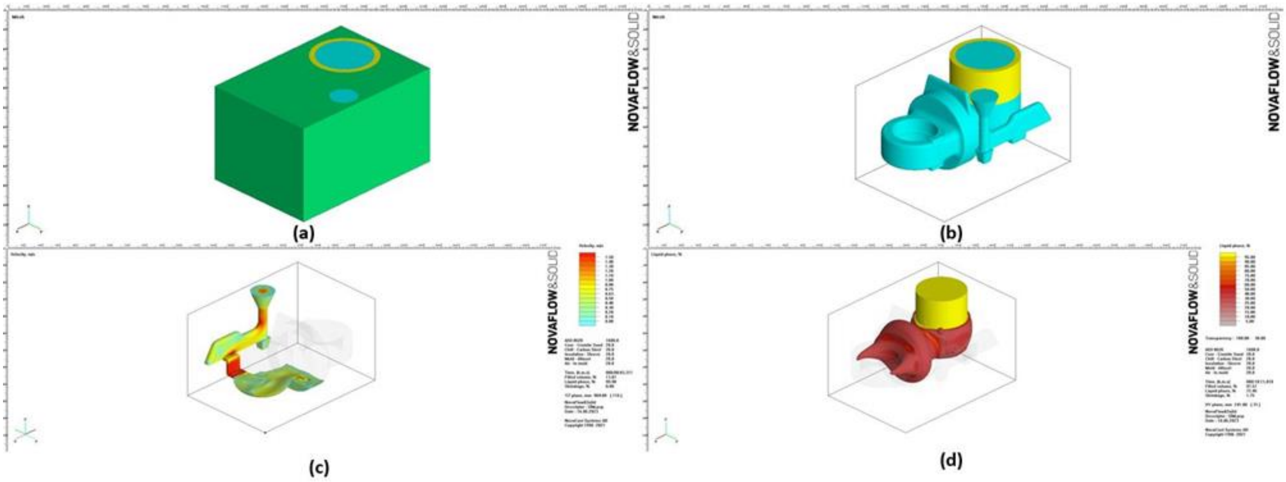

Figure 4. (a); The image of the molding design of the casting part, (b); The image of the casting part geometry, (c); The image of the metal flow and filling simulation of the casting part, (d); The image of the friction liquid mod of the casting part

After simulation results, one part was molded again in the flaskless resin molding system in ÇİMSATAŞ foundry and the casting has been carried out with a lip pouring ladle at 1590 °C. After the casted part with new designed was heat treatment (normalizing and tempering), the flange of the casting part was machined according to technical drawing of the part and magnetic particle testing was performed on the part. It was observed that there were no defects under UV light in the magnetic particle test applied to the flange of the cast part after machining. The locations of the defects and morphologies in the flange of the casting part under UV light after machining are shown in Figure 5.

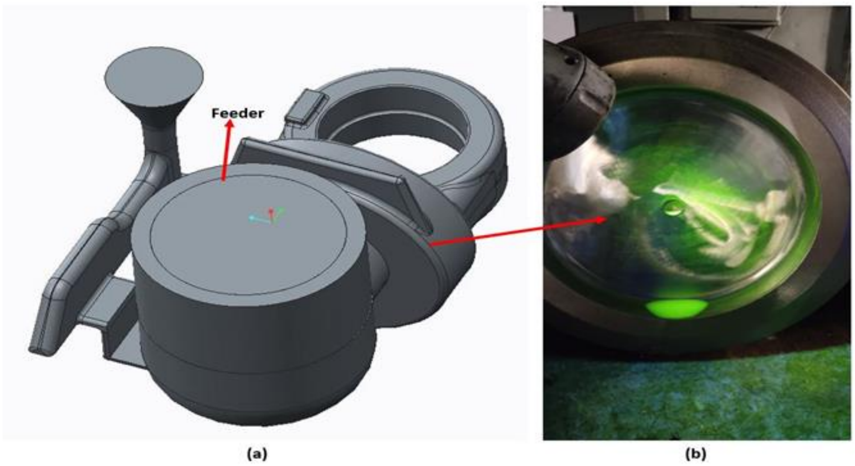

Figure 5. (a); Image of the mold design of the cast part, (b); Image of the flange of the casting part under UV light after machining

Results

- While it was observed that turbulence occurred in the liquid metal in the filling simulation of the first designed casting part, it was observed that there was no turbulence in the liquid metal in the filling simulation of the second casting part designed.
- It has been observed that the turbulence occurring in the liquid metal causes hydrogen-induced defects in the casting part.

Conclusion

In this study, the tried to relationship between hydrogen-induced defects in steel castings and molding and gating system designs were established and it was revealed that hydrogen-induced defects were related to metal turbulence. According to the results of the study, it has been revealed that NiCr, NiCrMo, NiCrMoV steel materials are sensitive to hydrogen-induced crack defects. Turbulence in the liquid metal causes the formation of re-oxidation products in the alloying elements in the liquid metal. In addition, the turbulence in the liquid metal increases the contact of the free moisture in the mold during the filling period of the molding and therefore causes the formation of hydrogen-induced defects in the steel casting parts.

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