EUROPEAN JOURNAL OF LIFE SAFETY AND STABILITY (EJLSS)
ISSN2660-9630
www.ejlss.indexedresearch.org Volume 56, 2025 ||

Analysis of the Fluidity of 35хгсл Steel Alloy

Saidmakhamadov Nosir Muysinalievich, Abdullaev Kamol Khakimovich,
Mamashaev Muzaffar Abdumalikovich, Babaev Narimon Otabaevich
Namangan state technical university

Usmanov Bobirjon Bakhodirjanovich
Andijan Mechanical Plant JSC

Annotation: *In this article, the effect of adding different amounts of aluminum to a low-alloy 35ХГСЛ steel was investigated to determine its influence on the alloy's fluidity. The experiments were conducted using an induction melting process. During the tests, aluminum was added to the molten metal in amounts of 0.2%, 0.4%, 0.6%, and 0.8%, and samples were cast using a U-shaped sand-clay mold. The results showed that the addition of aluminum significantly increases the fluidity of the metal; however, when its amount exceeds the optimal level, the fluidity decreases. The best result was observed with the addition of 0.6% aluminum. This amount reduces the surface tension of the molten metal, improves its flowability, and enhances the casting quality. Moreover, it was found to be the most economically feasible amount.*

Keywords: *35ХГСЛ, steel alloy, aluminum, fluidity, induction furnace, foundry, melting, resource efficiency.*

Date of Submission: 25-10-2025 ***Date of Acceptance: 27-11-2025***

INTRODUCTION

Nowadays, the demand for cast products in the foundry industry is steadily increasing. At the same time, many researchers are conducting scientific and practical studies aimed at improving the quality and service life of cast products. By enhancing the mechanical properties of castings [1], it is possible to increase their resistance to wear, bending, torsion, and compression under operating conditions, as well as to improve their overall performance characteristics. However, during the melting process of cast products, several foundry properties must be considered, such as the effect of harmful elements in the molten metal on casting quality, fluidity, methods for reducing iron oxides, separation of slag from the molten metal, slag composition, nonmetallic inclusions in the melt and ways to minimize them, uniform distribution of alloying elements within the casting volume (segregation process) [2], and the volumetric and linear shrinkage that occurs during solidification of the molten metal.

RESEARCH METHODS

Raising the temperature of molten metal above the specified level increases its fluidity due to the reduction in surface tension of the metal or alloy. However, excessive overheating causes the burning of alloying elements within the metal, which leads to a deterioration in the quality of the cast product. On the other hand, when the temperature of metals and alloys becomes too high [3, 4], the sand in sand-clay molds can burn and adhere to the surface of the casting. Such castings cause

excessive wear of cutting tools during machining and generate dust, which can be harmful to workers.

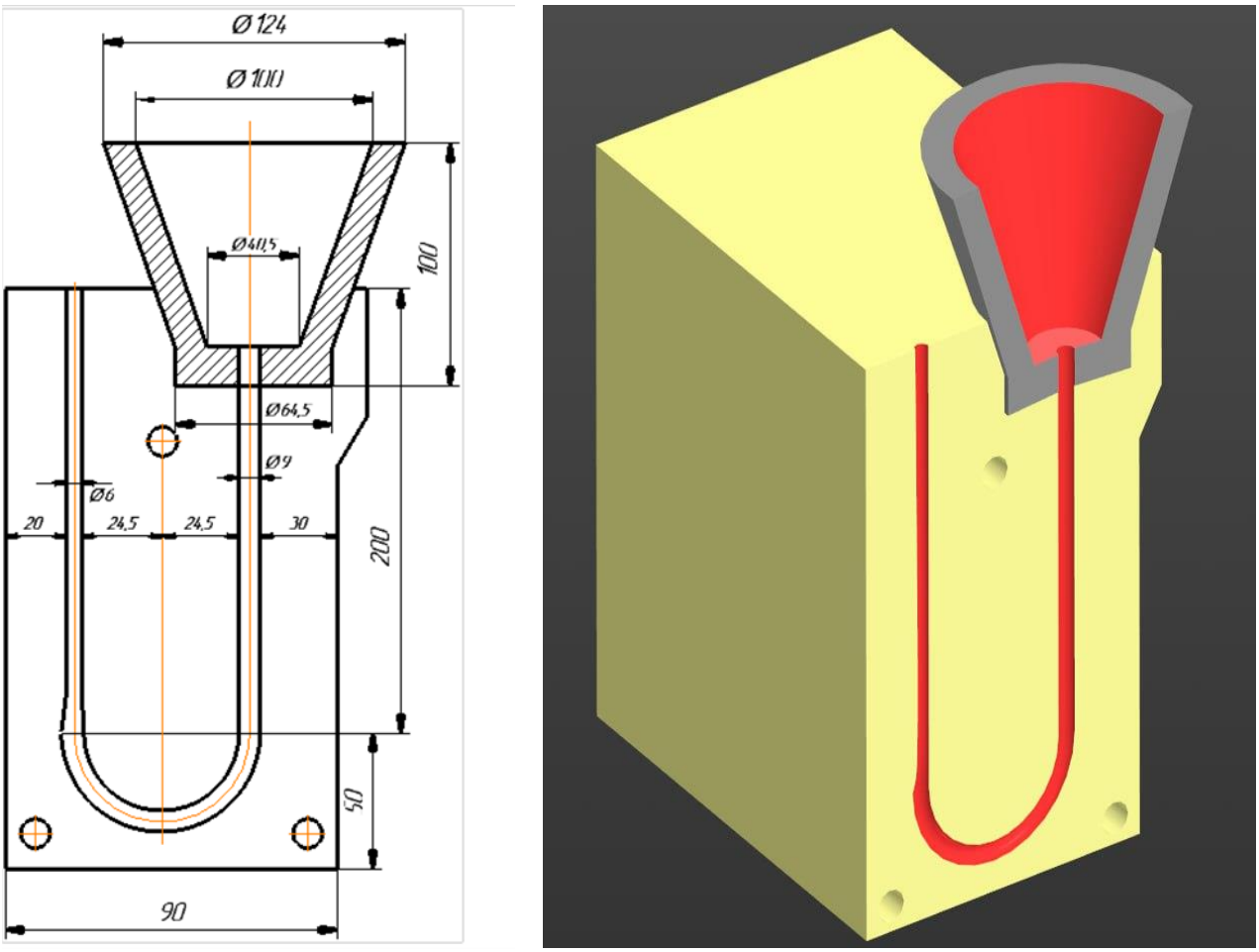


Figure 1. Drawing of the U-shaped sample created using the "Compass – 3D" software.

Taking these factors into account, during the melting process of cast products, it is possible to obtain high-quality castings by improving their fluidity based on the grade of the alloy, its chemical composition, as well as the shape and complexity of the casting. In this study [5], as an experiment, samples were prepared in U-shaped sand-clay molds by adding different amounts of aluminum and chromium elements to low-alloy 35ХГСЛ steel. The fluidity of the steel alloy was then tested and analyzed.

First, the U-shaped sample was fabricated from polypropylene material on a "CNC ROUTER 2130" machine, based on the drawing created in "COMPASS – 3D" according to the specified dimensions [6]. The technical drawing and 3D model of the sample produced in "COMPASS – 3D" can be seen in Figure 1.

The main purpose of preparing the U-shaped sample using the "CNC ROUTER 2130" machine was that, although the shape of the sample was simple, its small size made this equipment suitable for precise fabrication from polypropylene material. The fabricated U-shaped samples are shown in Figure 2.

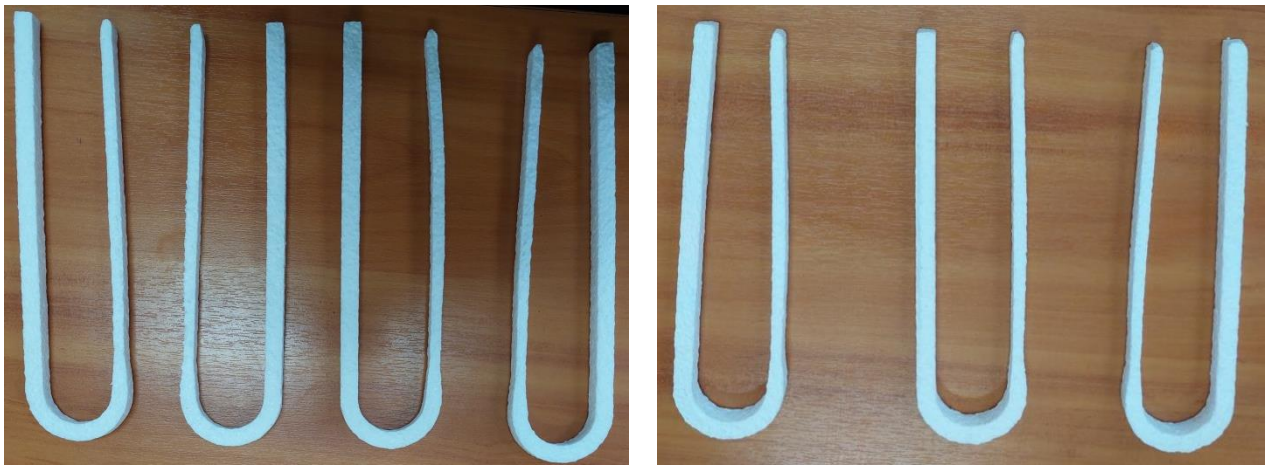


Figure 2. Appearance of the U-shaped samples.

RESULTS

To cast the samples made of polypropylene, a sand-clay molding mixture was prepared. The molding mixture consisted of 88% quartz sand, 4–5% water, and 6–7% bentonite clay, and it was mixed for 12–15 minutes. Then, the polypropylene samples were carefully placed into the flask (cope and drag), and the mold mixture was compacted around them [7, 8]. The process of placing the samples into the mold and compacting the sand mixture is shown in Figure 3.



Figure 3. Process of placing the polypropylene samples into the sand-clay mold

After placing the polypropylene samples into the sand-clay molds, the chemical composition of the low-alloy 35ХГСЛ steel was checked according to ГОСТ standards [9], and slag was removed from the molten metal in a 20 kg induction furnace. Proper slag removal from the molten metal is crucial. Even a small amount of slag remaining in the melt could mix with the metal and enter the U-shaped mold cavity, clogging the channels intended for testing fluidity, which would require repeating the experiment. Therefore, the slag was first removed in the furnace, and any remaining fine slag particles were eliminated in the ladle [10].

The main reason for selecting an induction furnace to determine the fluidity of steel alloys is that, during the melting process, the molten metal moves under the influence of a magnetic field. This

motion prevents the formation of sediment and its accumulation at the bottom of the furnace. In addition, the loss of alloying elements due to oxidation is lower compared to that in an electric arc furnace, which contributes to resource efficiency. However, the disadvantage of the induction furnace is that its lining is acidic [11], which limits the use of calcium carbonate as a flux. Therefore, SiO_2 and glass fragments were mainly used as fluxing agents. The charge was loaded into the furnace in the following order: large-sized charge materials and FeCr100 first, followed by smaller charge materials and ferroalloys such as foundry coke, FeSi45, and FeMn90. During melting in the induction furnace, due to thorough mixing of the molten metal, the rust and oxygen from the charge partially entered the metal, while the remaining portion oxidized other elements and transferred them into the slag [12]. The oxygen remaining in the molten metal continued to oxidize it through intense mixing. The first reaction occurred between oxygen and iron, as follows:

$[Fe] + 1/2O_2 \rightarrow [FeO] + Q$	(1)

Complete melting of the charge materials took 1 hour and 32 minutes, after which the metal became fully molten. Then, to reduce the iron oxide present in the slag and recover iron, a certain amount of ferrosilicon, ferromanganese, and aluminum was added to the melt [13]. As a result, the following reaction occurred:

$[2FeO] + [Si] \rightarrow (SiO_2) + [2Fe] + Q$	(2)
$[5FeO] + [2P] \rightarrow (P_2O_5) + [5Fe] + Q$	(3)
$[FeO] + [Mn] \rightarrow (MnO) + [Fe] + Q^*$	(4)
$[3FeO] + [2Al] \rightarrow (Al_2O_3) + [3Fe] + Q$	(5)

The resulting oxides combined with each other to form slag:

$(MnO) + (SiO_2) = (MnO \cdot SiO_2)$	(6)
$[FeO] + (SiO_2) = (FeO \cdot SiO_2)$	(7)
$(P_2O_5) + [3FeO] = (FeO)_3 \cdot P_2O_5$	(8)

After that, the molten metal was cleaned from slag and poured into a preheated ladle. During pouring, when about 20% of the molten metal had been transferred, 0.2% aluminum (calculated based on the total mass of the molten metal) was added to the ladle. The remaining 80% of aluminum was then added to the molten metal in the ladle. The aluminum element was introduced in proportions of 0.2%, 0.4%, 0.6%, and 0.8%, depending on the weight of the molten metal. The main reason for first pouring 20% of the molten metal into the preheated ladle before adding a portion of aluminum was to prevent the aluminum from burning and sticking to the ladle bottom [14]. Dividing the aluminum addition into two stages ensured that the first portion reacted with the oxygen (O_2) in the molten metal, forming Al_2O_3, which transferred into the slag. The second portion of aluminum improved the fluidity of the steel alloy. After aluminum treatment in the ladle, the molten metal was poured into the pre-prepared sand-clay molds. The process of adding aluminum to the molten metal in the ladle and pouring it into the sand-clay molds is shown in Figure 4.



Figure 4. (a) Process of adding aluminum to the molten metal in the ladle; (b) Process of pouring the molten metal into the sand-clay mold.

After the samples were cast into the sand-clay molds, they were allowed to cool inside the molds for one hour. Then, the castings were removed from the molds, and the sand adhering to their surfaces was cleaned off [15]. After surface cleaning, the U-shaped cast samples made of 35ХГСЛ steel were analyzed to determine how the addition of different percentages of aluminum affected the fluidity of the molten metal.

When 0.2% aluminum (by weight of the molten metal) was added to the low-alloy 35ХГСЛ steel, the length of the U-shaped cast sample was measured to be 310 mm (Figure 5a). When 0.4% aluminum was added, the sample length increased to 420 mm (Figure 5b). With 0.6% aluminum addition, the sample length reached 500 mm (Figure 5c). However, when 0.8% aluminum was added, the sample length decreased to 440 mm (Figure 5d).



Figure 5. Results obtained from U-shaped samples of low-alloy 35ХГСЛ steel after adding four different amounts of aluminum

CONCLUSION

The effect of aluminum addition on the fluidity of low-alloy 35ХГСЛ steel was analyzed. The results showed that the optimal aluminum content for improving the alloy's fluidity is 0.6%. Adding more than 0.6% aluminum not only increases production costs but also leads to a decrease in the fluidity of the molten metal.

REFERENCES

1. G‘aybullayev M. N., Saidmaxamadov N. M. Kam legirlangan po ‘latlarni induksion pechida suyuqlantirish jarayonida azot yutilishini nazorat qilish //Строительство и образование. – 2025. – Т. 4. – №. 4. – С. 232-239.
2. To‘xtaboyev I. T., Saidmaxamadov N. M. Suyuq metallga pechdan tashqari modifikatorlar bilan ishlov berish //Строительство и образование. – 2025. – Т. 4. – №. 4. – С. 220-225.
3. Nosir S. et al. Improvement of the Technology of Pouring Thin–Walled Gray Cast Iron into a Sand–Clay Mold. – 2023.
4. Tashbulatov S. Qora metall qotishmalarini suyuqlantirish jarayonida shlaklarni quymaning sifatiga taэsirini tadqiq qilish //Uz Conferences. – 2025. – Т. 1. – №. 6.
5. Saidmakhamadov N. et al. Improving the design of the lining of the ball mill used to improve the quality of grinding //E3S Web of Conferences. – EDP Sciences, 2024. – Т. 525. – С. 02017.
6. Nodir T. et al. Development of composition of wear-resistant white pig iron with a stable structure obtained by the casting method //ACADEMICIA: An International Multidisciplinary Research Journal. – 2020. – Т. 10. – С. 33-39.
7. Saidmakhamadov N. M. et al. Development of technology for liquefaction of steel alloys: development of technology for liquefaction of steel alloys. – 2023.
8. Saidmaxamadov N. M., To'xtaboyev I. T., G'aybullayev M. N. Induksion va elektr yoy pechlarida po'lat suyuqlantirib olishda energiya balansi //Uz Conferences. – 2025. – Т. 1. – №. 6.
9. Saidmaxamadov N. M. et al. Eritilgan po'latni shlakda past darajadagi oksid bilan qayta oksidlash //Uz Conferences. – 2025. – Т. 1. – №. 6.
10. Salimovich X. T. et al. Po‘lat qotishmasiga purkash orqali ishlov berishda qotishmaning mikrostrukturasi va g'ovakligiga ta'sirini o'rganish //Uz Conferences. – 2025. – Т. 1. – №. 10.
11. Tadjiyev N. X., Saidmaxamadov N. M. Xromomolibden po‘latiga bor elementini kiritish orqali qotishmaning mexanik xossalariga ta’sirini tahlil qilish //Строительство и образование. – 2025. – Т. 4. – №. 3. – С. 259-262.
12. Volida B. et al. Induksion pechida po‘lat qotishmasini suyuqlantirib olish tehnologiyasini takomillashtirish //Innovations in Technology and Science Education. – 2023. – Т. 2. – №. 8. – С. 212-218.
13. Saidmakhamadov N. M., Abdullah T. Development of a micro-structured photonic crystal fiber as a biological or chemical sensor based plasmonic application //Development of a micro-structured photonic crystal fiber as a biological or chemical sensor based plasmonic application. - 2023.
14. Saidmakhamadov N. et al. Mathematical modeling of the influence of the gating system on the quality of the cast product during alloy casting //AIP Conference Proceedings. – AIP Publishing LLC, 2025. – Т. 3268. – №. 1. – С. 030002.

15. Saidmakhamadov N. et al. Improving the design of the lining of the ball mill used to improve the quality of grinding //E3S Web of Conferences. – EDP Sciences, 2024. – T. 525. – C. 02017.