Modern American Journal of Engineering, Technology, and Innovation
ISSN(E): 3067-7939
Volume 01, Issue 08, November, 2025
Website: usajournals.org

TESTING THE FLUIDITY OF 65Г STEEL ALLOY

1Saidmakhamadov Nosir Muysinalievich,
2 Abdullaev Kamol Khakimovich,
3 Mamashaev Muzaffar Abdumalikovich,
4 Babaev Narimon Otabaevich,
5 Usmanov Bobirjon Bakhodirjanovich,
1,2,3,4Namangan State Technical University
5Andijan Mechanical Plant JSC

Abstract

In this article, the effect of adding different amounts of aluminum to a low-carbon 65Г steel alloy on its fluidity was investigated. The research was carried out using the induction melting method. During the experiments, aluminum was added to the molten metal in amounts of 0.2%, 0.4%, 0.6%, and 0.8%. Based on U-shaped sand-clay mold samples, the degree of fluidity was determined by measuring the casting length obtained for each aluminum content. The results showed that the addition of aluminum increases the metal's fluidity; however, adding more than a certain amount leads to a decrease in fluidity. The best result was observed when 0.6% aluminum was added. At this concentration, the surface tension of the metal decreased, the fluidity improved, and the complex-shaped parts of the mold were completely filled.

Keywords: 65Г steel, fluidity, aluminum, induction furnace, foundry, alloy, sand-clay mold, melting, metal composition, resource efficiency.

INTRODUCTION

Nowadays, if even one foundry property of metals and alloys deteriorates, the resulting cast products are considered defective and are not approved for production use. As an example, let us analyze one of the key foundry properties – the fluidity of metals and alloys. If the fluidity of a metal or alloy does not meet the required standard, the molten metal cannot properly fill the mold cavity. As a result, the casting will have dimensional defects and must be remelted. Therefore, to improve the fluidity of metals and alloys [1, 2], depending on the shape, size, and complexity of the casting, additional alloying elements may be introduced, or the temperature of the molten metal may be increased to a specific level.

MATERIAL AND METHODS

Raising the temperature of the molten metal above the specified level increases its fluidity due to the reduction of surface tension in the metal or alloy. However, excessive overheating causes the alloying elements in the metal to burn off, which leads to a deterioration in the quality of the cast product. On the other hand, when the temperature of metals and alloys rises too high, the sand in sand-clay molds can burn and adhere to the casting surface. Such castings cause excessive wear of cutting tools during machining and generate dust [3, 4], which can be harmful to workers.

During the melting process of cast products, the brand, chemical composition, shape, and complexity of the casting are taken into account to enhance fluidity and thereby achieve high-quality cast products. In the experiment, low-carbon 65Г grade steel alloy was used, and various amounts of aluminum and chromium were added to its composition [5]. Samples were cast in U-shaped sand-clay molds, and the fluidity of the steel alloy was tested accordingly.

The U-shaped sample was designed using the “Compass–3D” software and manufactured on a “CNC ROUTER 2130” machine. The primary goal of producing the sample on the “CNC ROUTER 2130” is to ensure that the physical model precisely matches the designed dimensions. This is crucial because any deviation between the drawing dimensions and the actual sample can lead to errors when determining the alloy’s fluidity [6, 7]. The manufacturing process of the U-shaped sample on the “CNC ROUTER 2130” machine is shown in Figure 1.

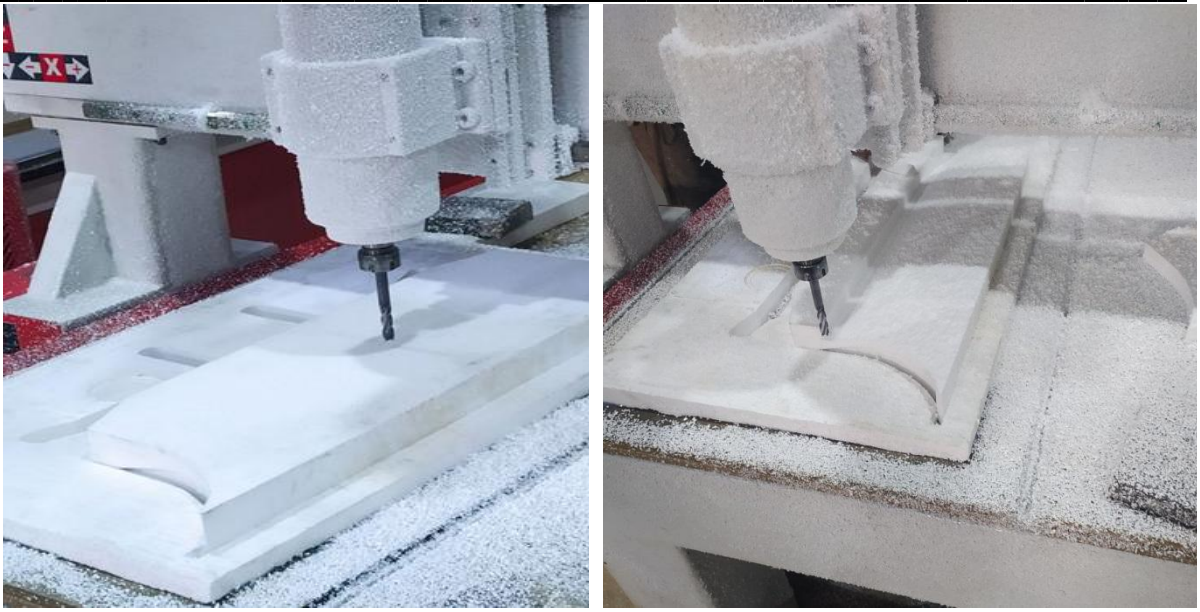


Figure 1. Machining process of the U-shaped sample on the "CNC ROUTER 2130" machine

The main purpose of preparing the U-shaped sample using the "CNC ROUTER 2130" machine was that the sample, made of polypropylene material, has a simple shape but small dimensions; therefore [8], it was manufactured using the "CNC ROUTER 2130" equipment. The prepared U-shaped samples are shown in Figure 2.

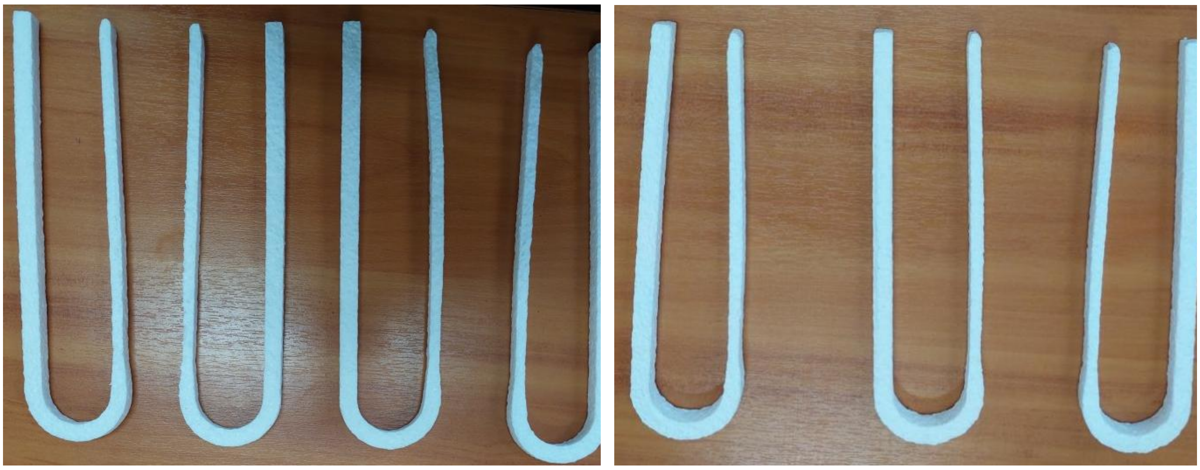


Figure 2. Appearance of the U-shaped samples

RESULTS

After placing the polypropylene samples into the sand-clay molds, the chemical composition of the 65Г grade low-carbon steel alloy was checked according to ГОСТ standards in a 20 kg induction furnace, and slag was removed from the molten metal. It is essential to thoroughly remove slag from the molten metal. Even a small amount of slag mixed with the molten metal can enter the mold cavity of the U-shaped sample, block the channels designed for flowability testing, and require the experiment to be repeated [9 ,10]. Therefore, slag was first removed in the furnace, and the remaining fine residues were eliminated in the ladle. The process of melting the steel alloy and removing slag from the molten metal is shown in Figure 3.

Figure 3. a) Melting process of the steel alloy in the induction furnace; b) Slag removal process from the molten metal

The main purpose of selecting the induction furnace for determining the fluidity of steel alloys is that, during the melting process, the molten metal is set into motion by the electromagnetic field, which prevents the formation and accumulation of sediment at the bottom of the furnace. In addition, the burn-off of alloying elements in the steel is significantly lower compared to that in an electric arc furnace, which ensures resource efficiency [11]. However, the disadvantage of the induction furnace is that its lining is acidic, which limits the use of calcium carbonate as a fluxing agent. Therefore, mainly SiO_2 and glass fragments were used as flux materials. The charging sequence in the furnace began with large charge materials and FeCr100, followed by smaller charge components such as ferroalloys (foundry coke, FeSi45, FeMn90). Due to the effective mixing of molten metal in the induction furnace, iron oxide and oxygen from the charge materials entered the melt; part of it dissolved into the metal, while the rest oxidized other elements, forming slag. The remaining oxygen in the molten metal caused intensive stirring and further oxidation reactions within the melt [12, 13].

To accelerate the reaction process, a certain amount of flux was added to the induction furnace. The temperature of the molten metal in the furnace was raised to 1580–1590 °C, which facilitated the rapid oxidation of carbon and the reduction of iron, according to the following reaction:

$$[FeO] + [C] \rightarrow CO + [Fe] - Q \qquad (1)$$

The carbon monoxide gas (CO) released in the form of bubbles stirred the molten bath, ensuring uniform composition and temperature, while simultaneously purifying it from harmful gases (H_2, N_2, O_2) and non-metallic inclusions. It is important to note that two immiscible liquid phases – the metal and the slag – come into contact with each other. Compounds dissolved in both phases, particularly FeO, are distributed between them in a certain ratio under the given temperature conditions [14]. This distribution remains constant at a specific temperature, expressed by the following relationship:

$$L_{FeO} = \frac{\text{FeO in the slag}}{\text{FeO in the iron}} = \text{const.} \qquad (2)$$

During the process, the FeO content in the slag changed, which consequently altered its amount in the metal bath as well. The reactions of FeO with Si, Mn, and P in the metal were discussed earlier. Phosphorus anhydride (P_2O_5), like FeO, also dissolved and distributed between the slag and the metal:

$$L_{P2O5} = \frac{P_2O_5 \text{ in the slag}}{P_2O_5 \text{ in the iron}} = \text{cosnt.} \qquad (3)$$

At high temperatures, phosphorus anhydride (P_2O_5) in the slag can be reduced by carbon and transferred into the metal. Therefore, to retain this harmful element in the slag, a certain amount of limestone and quartz sand was added to the bath. In this case, P_2O_5 reacted with lime to form a compound that is insoluble in metal and transferred into the slag:

$$(FeO)_3 \cdot P_2O_5 + 4CaO = (CaO)_4 \cdot P_2O_5 + 3FeO + Q \qquad (4)$$

Most of the [FeS] dissolved in the metal reacted with (CaO) in the slag and transferred into the slag in the form of (CaS):

$$[FeS] + (CaO) = (CaS) + [FeO] + Q \qquad (5)$$

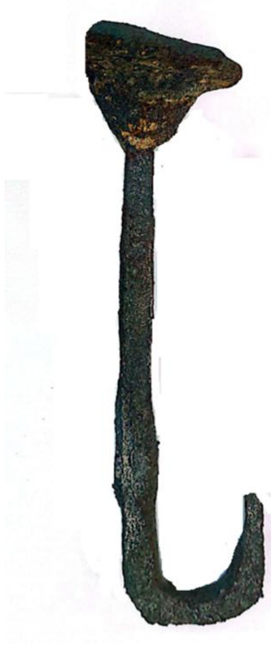
Thus, the higher the CaO content and the lower the FeO content in the slag, the more effectively the steel alloys are purified from harmful phosphorus (P) and sulfur (S) elements.

After that, the molten metal was cleaned from slag and poured into a preheated ladle. During the pouring process, when approximately 20% of the molten metal had been transferred, 0.2% aluminum (calculated based on the weight of the molten metal) was added to the ladle. The remaining 80% of aluminum was then added to the molten metal in the ladle. Aluminum was introduced in this sequence at concentrations of 0.2%, 0.4%, 0.6%, and 0.8% relative to the weight of the molten metal [15]. The main purpose of 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 bottom of the ladle. Dividing the aluminum addition into two stages ensured that the first portion reacted with oxygen (O_2) in the molten metal, forming Al_2O_3 and transferring into the slag. The second portion of aluminum improved the fluidity of the steel alloy. After treatment with aluminum in the ladle, the molten metal was poured into pre-prepared sand-clay molds.

After casting the samples into the sand-clay molds, they were allowed to cool in the molds for one hour. Then, the castings were removed from the molds, and the sand adhering to their surfaces was cleaned off. After surface cleaning, the castings of 65Г steel were analyzed to evaluate how the addition of different percentages of aluminum affected the fluidity of the molten metal, using the U-shaped samples.

When 0.2% aluminum (by weight of the molten metal) was added to the low-carbon 65Г steel alloy, the length of the U-shaped cast sample was measured to be 270 mm (Figure 4a). When 0.4% aluminum was added, the sample length increased to 330 mm (Figure 4b). With 0.6% aluminum addition, the sample length reached 460 mm (Figure 4c). However, when 0.8% aluminum was added, the sample length decreased to 410 mm (Figure 4d).

a)



b)

Figure 4. Results obtained from U-shaped samples of low-carbon 65Г steel after adding four different amounts of aluminum.

CONCLUSION

According to the research results, the fluidity of low-carbon 65Г steel alloy is directly dependent on the amount of aluminum added. The optimal fluidity was observed when 0.6% aluminum was introduced into the molten metal. Adding aluminum beyond 0.6% intensified oxidation on the metal surface, leading to a decrease in fluidity. Therefore, for 65Г steel alloys, an aluminum content of 0.6% is recommended as the most technologically and economically optimal. These findings are of significant scientific and practical importance for ensuring resource efficiency and improving the quality of castings during metal casting processes.

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 ta'sirini 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. – T. 2. – №. 8. – C. 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. – T. 3268. – №. 1. – C. 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.