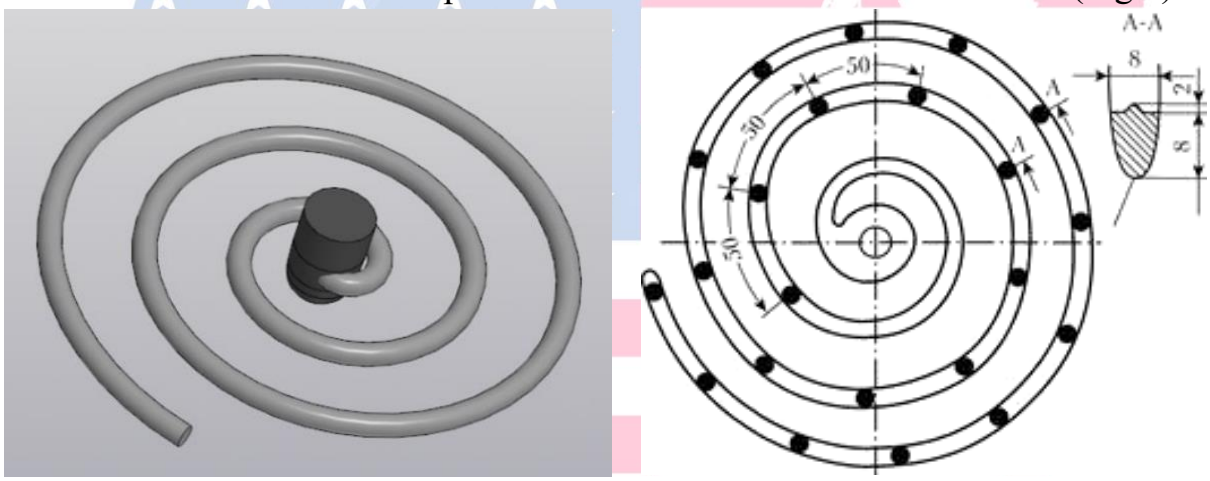
IMPROVING FLUIDITY AND STRENGTH OF THIN-WALLED GRAY CAST IRON CASTINGS

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One of the current global challenges in materials science is the production of high-quality and cost-effective thin-walled castings. The focus is on improving the strength, performance, and durability of components for mechanical engineering and manufacturing industries through casting methods. At the same time, the demand for lightweight yet strong products is continuously increasing, driven by the need to reduce fuel and energy consumption.

A key parameter in this regard is fluidity, which reflects the capacity of molten metals and alloys to completely fill a mold while maintaining dimensional precision. To evaluate the fluidity of cast iron alloys, spiral mold tests are typically carried out, where the extent of the filled spiral channel serves as the main indicator (Fig 1).



a) b)

Figure 1: *Spiral sample for fluidity determination a) spiral sample 3D view b) spiral sample dimensions*

An increase in the content of carbon (C), silicon (Si), and phosphorus (P) within certain limits enhances the fluidity of cast iron. However, when the sulfur concentration rises above 0.15%, the fluidity noticeably decreases. Phosphorus plays a distinctive role: while it has little influence on the graphitization process, it significantly improves cast iron's fluidity. In gray cast iron, phosphorus contributes to the formation of a ternary eutectic, which melts relatively easily at around 950 °C. During solidification, this eutectic consists of phosphorus-rich austenite, cementite (Fe_3C), and iron phosphide (Fe_3P). The presence of this low-melting eutectic phase explains the superior

fluidity of phosphorus-containing cast irons. Additionally, iron phosphide inclusions in the structure contribute to increased hardness and enhanced resistance to corrosion. The liquid flow capacity of gray cast iron, depending on the thickness of the casting walls, can be determined using spiral sample tests. The calculation method is presented in Table 1 [1–5].

Table 1. *Dependence of the length of thin-walled details on thickness*

Fluidity length, mm	Wall thickness, mm
500– 700	3 – 6
400 – 500	6 – 15
300 – 400	16 – 25
200 – 300	Above 25

For the preparation of the molding material, the sand was initially sieved, after which the required proportions of quartz sand and bentonite clay (as indicated in the table) were added and thoroughly mixed. The mixture was then compacted into a wooden mold, and the sequence of these steps is illustrated in Figure 2. The sand used in the preparation of the mold material was first sieved, quartz sand and bentonite clay were added in the amount specified in the table and mixed, then it was molded into a wooden block and the sequence of this process is shown in fig 2.



a) b) c)

Figure 2: *A mold made using a spiral model to determine the ductility of modified gray cast iron a) model ready for rammering with sand b) the inner part of the mold based on the prepared spiral pattern c) mold ready for casting*

Based on the provided data, experimental studies aimed at improving the fluidity of gray cast iron were conducted in the laboratory of the “Casting Technologies” Department at Tashkent State Technical University named after Islam Karimov. For the melting process, 2 kg of metal was charged into a BF-TB2 induction furnace, while the charge materials. The molding mixture was formulated in line with the proportions given in Table 2, after which the laboratory tests were carried out.

Table 3. *Table of composition of used mold material*

Used sand, %	70 – 80
Quartz sand, %	5 – 10
Kaolin clay, %	6– 8
Water, %	3 – 7

The kaolinite binder used as the molding clay, described in Table 3, is derived from the mineral composition $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$. Its specific gravity ranges between 2.0–2.5, with a true density of about 2.58–2.60 g/cm³, and its melting point lies within 1750–1790 °C. When heated to 100–140 °C, kaolin clay becomes hygroscopic, while at 350–580 °C it loses chemically bound water, transforming into metakaolinite ($Al_2O_3 \cdot 2SiO_2$). This stage, where the binding capacity of clay diminishes, is referred to as "clay deactivation." At 900–1050 °C, metakaolinite undergoes further changes, leading to the formation of mullite ($3Al_2O_3 \cdot 2SiO_2$). Upon heating to 1200–1280 °C, it decomposes into amorphous Al_2O_3 and SiO_2 phases [6–12].

For the production of thin-walled gray cast iron castings, technologies of both out-of-furnace and in-furnace treatment of molten alloys have been developed. As a result, the fluidity of the liquid alloy can be improved by 9–11%, while the hardness of the final cast products increases by 10–12%.

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