EMJ MS

EUROPEAN MULTIDISCIPLINARY JOURNAL OF MODERN SCIENCE

ISSN 2750-6274 https://emjms.academicjournal.io Volume: 9 | August-2022

Improvement of the Technology of Pouring Thin – Walled Gray Cast Iron into a Sand – Clay Mold

Saidmakhamadov Nosir, PhD

Candidate, Tashkent state technical university, University Street 2, Tashkent, Uzbekistan

Turakhodjaev Nodir

DSc professor, Tashkent state technical university, University Street 2, Tashkent, Uzbekistan

Khasanov Jamshidbek, PhD

Student, Andijan Machine – Building Institute, Bobur Shox Avenue 56, Andizhan

Zufarova Nilufar

Researcher, Tashkent state technical university, University Street 2, Tashkent, Uzbekistan

Turaev Anvar

Senior teacher, Tashkent state technical university, University Street 2, Tashkent, Uzbekistan

Abstract: In this article, the chemical composition of the alloy for liquefaction of thin – walled cast products was developed. Also, in order to increase the fluidity of the alloy, a modifier was added to the alloy. In addition, the content of silicon in the alloy was increased, as a result, free graphite was separated more in the structure of the alloy. Through these methods, quality casting of thin – walled cast products was achieved.

Keywords: ferrous metal, non – ferrous, carbon, alloy, graphite, ferrite – perlite, nickel, titanium, boron, vanadium, chromium, copper, molybdenum, furnace, liquefaction, gray cast iron.

INTRODUCTION

Today, ferrous metals are widely used in industry due to the high demand for ferrous metals, their important physical and mechanical properties, as well as the fact that iron ores are widely distributed in nature, the production of steel and cast iron is cheaper than other non – ferrous metals and it is easy to produce.

Cast iron differs from steels in its high carbon content and good fluidity. Due to its hardness and brittleness, cast iron cannot be machined under pressure under normal conditions and is a cheap alloy compared to alloy steel. Cast iron contains elements of carbon, silicon, manganese, phosphorus and sulfur. High-quality, refractory and alloyed cast irons contain alloying elements such as nickel, titanium, boron, vanadium, chromium, copper, molybdenum. The alloying elements introduced into the furnace during the liquefaction of cast iron affect the amount and structure of graphite released from the cast iron [1 – 4].

The mechanical properties of cast iron depends on its structure. According to the structure of the metal base in cast iron, it is divided into the following types: pearlite, ferrite, ferrite – perlite, plate copy (flat) graphite and spherical graphite.

Gray cast iron has a carbon content of 3.2 to 3.6%. As the carbon content of cast iron increases, so does the release of graphite. Due to the high fluidity of gray cast iron, it is

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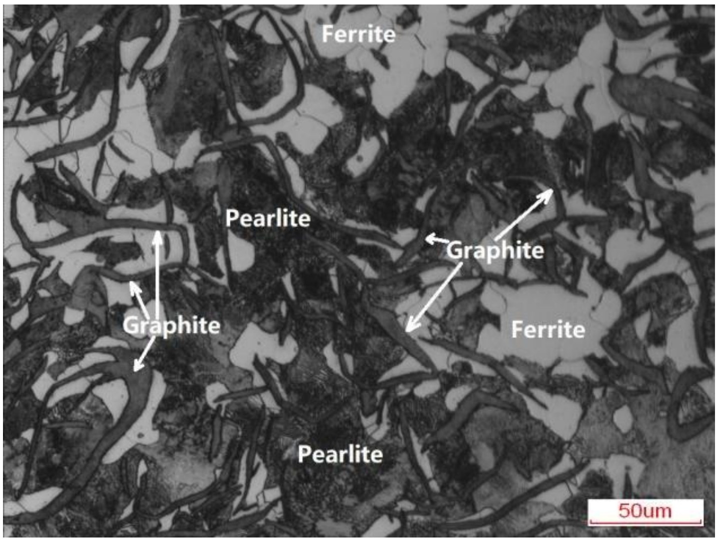
possible to cast thin – walled and complex castings of various shapes.

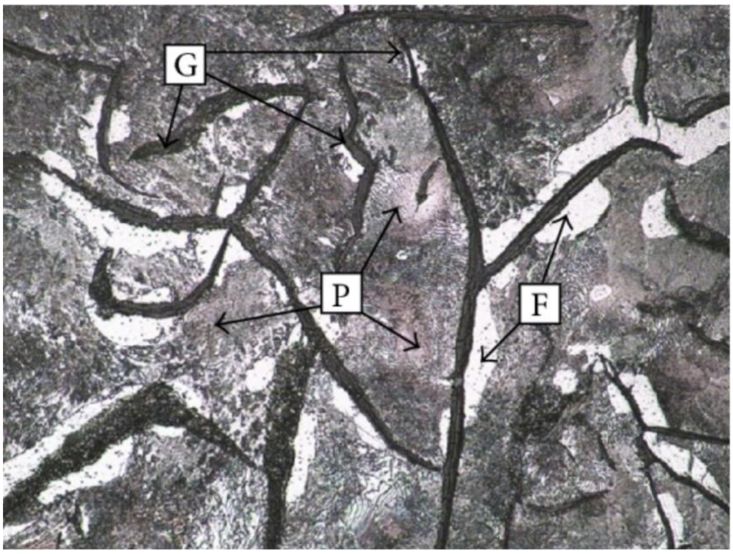
Cast iron structure formation is greatly influenced by the cooling rate of the casting, which decreases as the thickness of the casting wall increases. As the casting cooling rate increases, the amount of cementite in the cast iron structure increases, and as it decreases, the amount of graphite in the cast iron structure increases. Even if the chemical composition of cast iron is the same, the microstructure and mechanical properties of castings with different walls are different [5 – 8].

Due to their good fluidity, gray cast iron is also known as cast iron. Gray cast iron is liquefied in various electric and fuel furnaces and obtained in the form of ingots of various shapes. Gray cast iron is an inexpensive construction material. It has good casting properties, good cutting properties, resistance to warping, vibration damping due to vibration and changing pressures. The property of dampening vibration is called damping property. Figure 1 shows the structures of gray cast iron [9].



1 – picture. Optical microstructure image of gray cast iron

The damping property of cast iron is 2 – 4 times higher than that of steel. Due to the damping properties and high resistance to bending, cast iron is used in the manufacture of frames of various machine tools, tractors and car engines. In accordance with GOST 1412 – 80, the following grades of gray cast iron are produced (numerical values of cast iron hardness (NV) are indicated in parentheses): SCh 10 (143 – 229), SCh 15 (163 – 229), SCh 20 (170 – 241), SCh 25 (180 – 250), SCh 30 (181 – 255), SCh 35 (197 – 269), SCh 40 (207 – 285) [10 – 15].



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2- picture. SEM microstructure image of pearlite gray cast iron

Figure 2 shows the shape of gray cast iron graphite fragments. Gray cast iron is liquefied by adding elements to the liquid metal that promote the decomposition of cementite and the release of carbon in the form of graphite during the furnace liquefaction. For gray cast iron, silicon acts as a graphitizer. After the alloy is free of slag, FeSi 90 ferroalloy is introduced into it, and when up to 5% silicon is added, the cementite of gray cast iron is completely broken down and has a plastic ferritic base and a fine-grained graphite structure is formed. As the amount of silicon decreases, cementite, which is part of pearlite, is partially decomposed and a ferrite-pearlite structure with graphite impurities is formed. As the silicon content decreases further, it forms a gray cast iron structure with a pearlite base with graphite inclusions [16, 17].

The mechanical properties of gray cast iron depend on the composition of the alloy, as well as the shape and size of the graphite inclusions. Pearlitic gray cast irons are stronger and ferritic gray cast irons are more plastic. Due to the low strength of graphite and the fact that cast iron is not bonded to iron, the base metal of the cast iron, the areas occupied by the graphite are voids and cracks can form there. And they show the impact of strength and plasticity of cast iron.

Low – strength gray cast iron has a ferrite or ferrite – pearlite microstructure consisting of plate – like graphite mixtures. The brand of such cast iron with a tensile strength of 300 MPa is SCh 30. The letters on the cast iron brand indicate the abbreviated name of the cast iron, and the following two – digit number indicates the tensile strength limit [18].

High-strength gray cast iron has a pearlite base and very fine-grained graphite. It is suitable for cast iron brands from SCh 35 to SCh 40. Such strong cast iron is obtained by alloying and modifying.

Alloyed gray cast iron has a fine particle structure, and a fine structure of graphite is achieved due to the addition of small amounts of nickel and chromium, molybdenum, sometimes titanium or copper.

The cross – section of the modified gray cast iron has a homogeneous structure and a very fine form of graphite. The chemical composition of the slag is selected for the preparation of modified cast iron. In this case, modifiers such as ferrosilicon, silicoaluminum, silicocalcium are added to unmodified cast iron in the amount of 0.1 – 0.3% of the mass of cast iron at the time of its filling [19].

The structure of modified gray cast iron does not contain ledeburite or cementitious structure. Since the amount of modifier added to cast iron is small, its chemical composition remains practically unchanged. The modified liquid cast iron should be poured into the molds quickly, because the effect of the ferroalloys added as a modification wears off within 10 – 15 minutes [20].

MATERIALS AND METHODS

A 180 kg induction furnace was selected for liquefaction of thin – walled shiber cast. The main purpose of choosing an induction furnace is that the temperature of the induction furnace heats the alloy to a temperature of 1800^0 C. This leads to a reduction in the amount of burning of the cast iron alloy. First of all, chemical composition was recommended by summarizing the samples. The recommended chemical composition is presented in Table 1.

Table 1. Chemical composition of gray cast iron

Cast iron brand	Chemical composition %						
	C	Si	Mn	P	S	Cr	Ni
SCh 24 – 44	2,9 – 3,2	1,2 – 1,6	0,8 – 1,2	0,1 – 0,2	0,10 – 0,15	0,2 – 0,3	0,3 – 0,5

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First, the large solids were loaded into the induction furnace, and after the solids were liquidized, the small solids were loaded into the furnace together with a certain amount of coke. After the furnace was filled with liquid metal, the slag was removed from the furnace. The slag content was 10% of the liquid alloy, and after the liquid metal was separated from the slag, a certain amount of liquid metal was depleted in the furnace, so it was necessary to load more solids into the furnace. As a solid material, once liquidized metal scraps, cast defective parts, casting channel, air outlet channels were loaded into the furnace. The main purpose of loading the above-mentioned solid materials into the furnace is that the solid materials do not contain moisture, corrosion, and various types of oils. If we use cast iron to fill the furnace with liquid metal, due to the presence of moisture, corrosion, rust, and various oils in the cast iron, as soon as it is loaded into the furnace, the liquid metal will splash out.

As a result, it can cause damage to the surrounding people, crack the oven. For this purpose, it is necessary to add solid materials that have returned after removing the slag from the furnace. Then, after the furnace was filled with liquid metal, ferroalloys were introduced into the furnace. FeSi 75 and FeMn 90 brands were introduced as ferroalloys. After keeping the liquid metal at a temperature of 1450 – 1460^0 C for a certain time, the liquid metal was mixed, samples of the liquid metal were taken from three places, and their chemical composition was checked. The chemical composition was prepared in accordance with GOST requirements and poured into the previously prepared sand – clay mixture.

The main purpose of raising the temperature of liquid metal to 1450 – 1460^0 C is to increase the fluidity of cast iron. Because the casting is a thin-walled casting, the thinnest wall of which is 8 mm. In addition, in order to improve the fluidity of gray cast iron, MF 10 copper phosphorus was added to the furnace.

1 – picture. Sand is a raised shingle cast poured into a clay mold

It can be seen in picture 1 that the thin – walled lifting roof casting is poured into a sand – clay mold.

RESULT

After 6 hours of standing in the sand – clay mold, the thin – walled cast product was removed from the mold, the sand on the surface of the cast product was cleaned, and its mechanical and physical properties were checked.

The chemical composition of the sample was determined on a spectral analyzer model "SPECTROLAB – 10 M" and is listed in Table 2.

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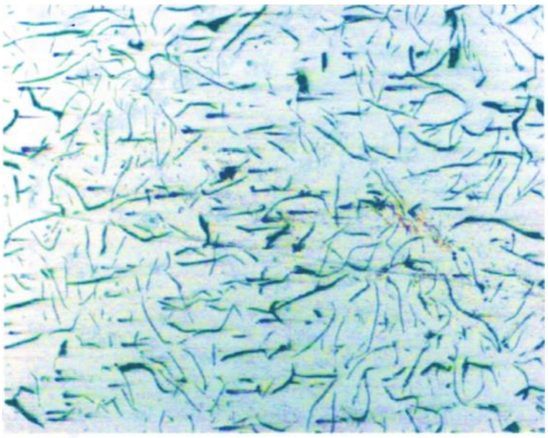
Table 2. Chemical composition of liquefied cast iron SCh 24 – 44

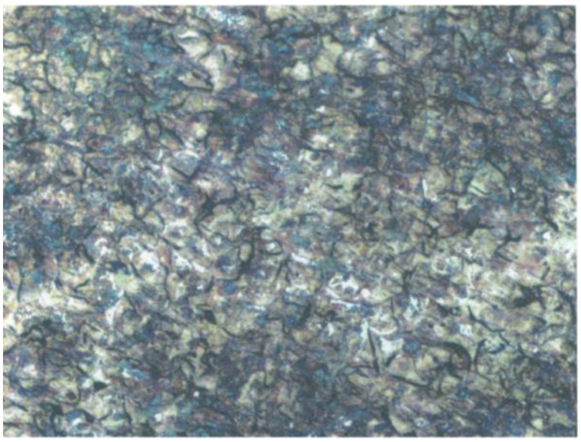
Cast iron brand	Chemical composition, %							
	C	Si	Mn	P	S	Cr	Ni	Cu
SCh 24 – 44	3,0	1,4	1,1	0,2	0,14	0,3	0,4	0,2

The samples were processed step by step using abrasive papers with a surface of 500, 1000, 1500, 2000 and 4000 microns. The surface of the samples was polished using WC (tungsten carbide) paste. After the polishing process, the samples were treated with reagents according to GOST 5639 – 82. Hydrochloric acid (HCl) and picric acid ($C_6H_2(NO_2)_3OH$) were used as reagents. The main purpose of reacting the structure of the samples is to divide the structure of the samples into phases and study them under a microscope.

As a result, it became possible to divide the structure of ductile white cast iron into clear boundaries. The structures of the samples were seen by magnifying x100 and x1000 times on a METAM RV – 23 microscope.

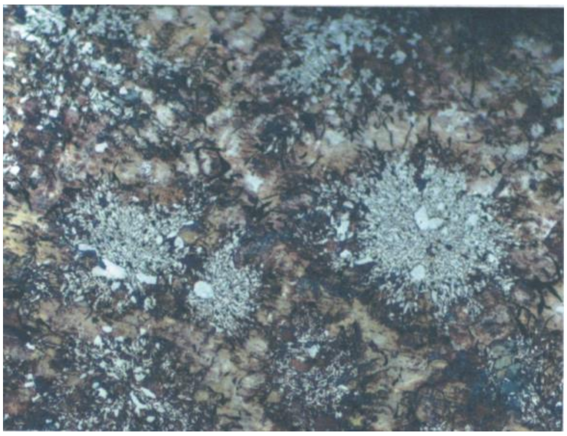


2 – a – picture. Image of the specimen magnified x100



2 - b - picture. Image of the specimen magnified x100

Figure 2 – a shows that the sample is composed of plate graphite, and Figure 2 – b shows the structure of plate pearlite, ferrite and graphite.



3 – c – picture. Image of the specimen magnified x100

3 – g – picture. Image of the specimen magnified x500

3 – c, g – pictures show that the samples are composed of plate pearlite, ferrite, graphite, phosphide eutectic, the upper zone of the sample is seen in 3 – c – picture, and the middle zone is seen in 3 – g – picture.

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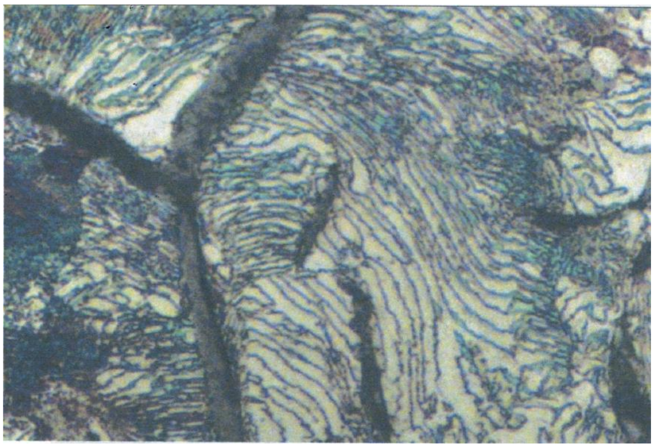

4 – picture. Image of the specimen magnified x100

Figure 4 shows a sample with plate pearlite, ferrite and free graphite.

CONCLUSION

In order to increase the fluidity of gray cast iron for liquefaction of thin – walled casting products, MF 10 copper phosphorus was introduced into the furnace and the fluidity of gray cast iron was increased. In addition, the amount of silicon in the alloy was increased, as a result of which it was observed that free graphite was separated more. As a result, the ductility of gray cast iron increased even more. Also, due to the smallest wall thickness of the cast thin – walled cast products being 8 mm, the temperature of the alloy was increased to 1450 – 1460^0 C in order to better move the alloy between the thin walls and better fill the mold cavity. By raising the temperature of the alloy, the fluidity was further increased, and the mold cavity was well filled. In conclusion, casting of thin – walled cast products was achieved using the methods listed above.

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