

New concept of cast iron melting technology in induction crucible furnace

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Abstract. The article considers methods for reducing harmful impurities in the composition of synthetic cast iron (SCI) and improving the strength characteristics of cast iron. A new method for smelting SCI using steel scrap as charge materials in induction crucible furnaces is proposed, including filling of metal charge, together with transfer cast iron, return of own production, carburetors, and ferroalloys to carburize and alloy up to the required chemical composition. It is revealed that with an increase in steel scrap in the metal charge, the melting time, specific power consumption, melting duration, hardness of the experimental sample increase, and the yield of usable liquid cast iron decreases. To achieve the required hardness of the experimental sample, it is necessary to have металлошихте from 10 to 40% of steel scrap in the metal charge.

1 Introduction

A new stage in the development of cast-iron production can be represented by the smelting of SCI, which is the main means of raising production to a qualitatively new level. The score can be attributed to structural materials, which differ significantly from those used in strength properties and the nature and technology of production [1-2].

The process of smelting consists in enriching liquid iron with carbon and silicon in calculated proportions, as well as in the use of high-temperature processing, which allows you to obtain alloy with a predetermined chemical composition and properties, which will allow you to obtain an alloy with a certain chemical composition and property. To form an improved property in casting, it is necessary to eliminate the imperfect structure of the initial materials as part of the charge. Using induction furnaces to obtain the score allows deep heat treatment, processing, modification, and alloying of liquid metal [2].

2 Objects and methods of research

Induction furnaces have a high technological characteristic; with their help can be produced, cast iron by any chemical composition to obtain metal under certain conditions and parts; the metal obtained does not change the properties for a certain time, and the processes of swimming are mechanized and automated. In the Cub, steel and cast-iron scrap of its waste, chips of leaf metal, and other low-quality metal waste are mainly used.

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Currently, 30 % of the metal remains in waste, and the use of metal in engineering is 70 %, i.e., the main part of the waste has a low volumetric density, while further processing is difficult [3].

To date, the problem of the effectiveness of obtaining an account made from metal waste directly depends on the composition and volume of the metal. The advantage of this method of obtaining accounts is the ability to use waste directly during its receipt (smelting) in foundries. Using cheap metal waste to melt the iron score reduces the cost by 25 ... 30% compared to the usual cast iron of secondary melting. It was recommended that the authors use the score for producing high-quality cast iron, especially with the help of spherical graphite, considering the low content of unmodified impurities in its composition [3].

SCI is used for the production of various details and specialized parts in railway transport, friction wedges, brake pads, crankshaft, cylinders, internal combustion chambers that are very resistant to friction and wear of the parts of the machine, etc., which can take on large loads at elevated temperatures [2].

An important factor that determines the content of impurities in the development of modern foundry production is modern technological processes. This mainly applies to producing metal castings, which make up 65% of the mass of all alloys. Since 2000, in Russia, there has been a sharp decrease in the amount of pig iron scrap; the cost of foundry and pig iron and the cost of their transportation have increased significantly. This led to increased material costs in producing castings from synthetic iron, which was mainly obtained in crucible induction furnaces of industrial frequency (ICT). In addition, problems began to arise with using acidic lining as the cheapest and most durable since an increased amount of steel scrap began to be used in the metal charge. For this reason, the melting temperature was raised above 1450 ° C. The durability of the lining has sharply decreased, and downtime associated with its replacement has increased. All this hurt the efficiency of the production of synthetic iron castings [4].

Cast iron, the oldest ferrous material for injection molding, is currently the most widely used material in foundries. In particular, this good technological property (excellent fluidity, low tendency to shrinkage and their formation, low propensity for stress), acceptable mechanical properties and good workability. Similarly, its physical properties and preference allow production of castings with excellent specific characteristics, particularly heat and heat resistant, wear resistance, and castings with special physical properties. The disadvantage of grey iron is its high fragility. This feature is designed production of spheroidal graphite cast iron. Another drawback is the relatively high variance properties, particularly mechanical, even in the stable composition [5].

Given results in the study of the influence of chromium, molybdenum, and aluminum, as well as heat treatment on the structure and mechanical properties of the cast iron in AS-Cast. The analysis of the produced castings showed an austenite matrix with relatively low hardness, which makes the material more durable. When molybdenum chromium is added, it leads to a very high tilt to solid spots on the structure of the account. But such a factor as adding a small amount of aluminum slightly limits this trend. Thermal treatment consisting of casting at a temperature of 500 ° C for 4 hours led to indicators such as a partial transformation of austenite into acicular ferrite, similar to the button accordion. The degree of transformation of castings depends not only on the equivalent value when the nickel (its composition, to a lower value led to a higher degree of transformation) but also the concentration of CR and MO (the degree of transformation increased with an increase in the total concentration of both elements, which in turn, which in turn It is a good indicator). Pieces with a higher degree of hard spots on the samples showed the highest hardness, while the hardness indicator connected by heat treatment was the largest in castings, with a very high degree of austenite transformation. Adding CR and MO impurities led to the lower

thermodynamic stability of the austenite, so this indicator turned out to be a favorable and optimal correct solution. Therefore, castings (prototypes) containing the largest total addition of CR and MO, with the addition of 0.4% AL (to reduce the tendency to solid spots), showed the highest tensile strength, and this is a very high indicator during the examination [6].

At a given moment, the problems of durability and strength of castings used in general practice were studied in the work [7]. To do this, you need to know in detail all the values of thermal voltage and characteristics. Cast iron, as well as all conditions of thermal voltage (mode of operating temperature and its maximum temperature, that is, thermal regime) for the correct choice of adding a chemical composition and complete. Structures (from macro to microstructure) of the material. We solved the most successful solution to this problem using the modeling program, including its optimization and receiving (casting). This program reads and processes this composition of the material. As well as influence various factors and parameters for this sample [7, 20-22].

The solidification of low sulfur (<0.05%) and very low aluminum (<0.005%) cast iron molten and overheated in induction furnaces without acid crucible linings was examined, and how overheating affects the quality of cast iron in efficient metallurgical processing for use in these conditions [8]. The supercooling during solidification increases with increasing superheat, which is associated with significant changes in the chemical composition, such as C, Si, Mn, Al, and Zr involved in graphite nucleation. The concept in this paper supports the three-stage model of nucleation of flake graphite [(Mn,X)S type nuclei]. Electric iron has three important groups of elements [deoxidizer/Mn, S/modifying] and three process steps [superheating/preconditioning of base iron/final modification]. Various materials have been used to pretreat the iron melt to control oxidation levels and/or stimulate graphite nucleation sites, including carbon materials and metallurgical silicon carbide. Particular attention was paid to maintaining the recovery of Al and Zr in the smelter due to their effect on the iron structure. Dual treatment using strong oxide forming elements such as Al and Zr for pretreatment followed by modification reduced the subcooling parameters of the eutectic. This treatment improved the graphite's characteristics and avoided carbide formation. For foundry applications, it is recommended to provide an (Mn,X)S compound that is compatible with the graphite nucleating agent with less eutectic subcooling. Attention is drawn to the provision of the control coefficient (%Mn) × (%S) in the range of 0.03 – 0.06 at an Al and/or Zr content in the modified gray cast iron of 0.005 – 0.010% [8, 18-20].

3 Results and their discussion

A known method for smelting SCI in electric furnaces is melting a charge consisting of iron-carbon materials, ferroalloys, and a carburizer in electric induction furnaces, heating liquid cast iron in them and fine-tuning it by a chemical composition by introducing ferroalloys and a carburizer [2].

The disadvantage of this method is the increased waste of the charge and elements due to the arbitrary introduction of materials into the charge and liquid metal and their joint melting, which leads to an unstable composition of the cast iron, a decrease in its properties, and an increase in cost.

The most famous method currently is the method of swimming score in the induction furnace, according to data. The charge of the metal heater heats the temperature to (1550-1600) OC, and then ferroalloys. Including Ferrosilicon, presented in the work [9, 13-16].

But this method is less effective because of the need for a constant high overheating of the melt and an increase in energy consumption and high energy consumption.

A better-known method of melting cast iron in electric induction furnaces should be used in the stove more than cast iron with a content of 20-80% of its Canclope AS. The heating element of the charge heats up to 1710-1750 degrees. It remains at a given temperature in the interval of 8 to 12 minutes.

Then iron-carbon scrap is loaded into the furnace, the entire charge is melted, and then ferroalloys and additives are introduced. At a temperature^{of}1470-1600 ° C, ferroalloys and additives are introduced sequentially according to Mn, Ni, Co, Cu, P, Mo, W, and at a temperature^{of}1700-1750 ° C, ferroalloys and additives for finishing cast iron are introduced sequentially according to C, Si, Cr, Sb, Sn, V, Ti, Zr, B, Al, Ce, Mg, Ca, and Ba [10, 12-15].

The disadvantage of this method is that it increases the waste of the charge and elements and increases power consumption due to loading the carburizer and holding at the assigned temperature for 8-12 minutes. The closest to the proposed method is the smelting of SCI from metal waste in induction furnaces; industrial frequency in its crucible is induced by a melt bath with a level of 50-100% height to the upper level of the cut-off of the power coils of the furnace inductor, and then metal chips are loaded into the melt bath, and the chips are loaded in portions of 8-10% each batch is fed into the furnace when the melt reaches 1300-1350OC^o[11, 15-18].

The disadvantage of this method is the presence of cast iron bleaching, which reduces the physical and mechanical properties of the metal due to an increase in inter graphite (up to 80-100%); in addition, holding the metal in a cooling furnace reduces the performance of the induction furnace.

We have proposed a new concept for melting cast iron in an induction crucible furnace, making it possible to obtain SCI using steel scrap as part of a metal charge. The composition of the charge must ensure that after melting, the content of all elements is close to the specified content in the finished metal. Foundry and transfer cast iron, own-made waste, steel scrap and shavings, carburetors, and ferroalloys are used as initial charge materials. To dilute the metal with phosphorus and sulfur, steel scrap is added to the bath. metal charge is advisable to start calculating the metal charge by determining the amount of waste, steel scrap, and carburetors during the melting period, alloying ferroalloys required for additives during the technological period, taking into account the necessary composition of liquid cast iron close to the required one [18-20].

The method of smelting SCI in induction crucible furnaces consists of the fact that it is necessary to calculate the charge considering the share of carburetors, steel scrap, and ferroalloys before melting. Metal melting begins with the filling of cast iron in the amount of 20-30% of the total capacity of the crucible of the induction furnace. The liquid metal is heated to 1350° C for 20-30 minutes according to the amount of loaded pig iron. Then a carburetor is added the consumption rate of which for different proportions of steel scrap is determined using the general calculation of the charge. Table 1 shows the recommended consumption rate of carburetors with different proportions of steel scrap in the metal charge.

Table 1. Consumption rate of carburetors with certain proportion of steel scrap in metal charge, kg

Share of steel scrap in the metal charge, %			0	5	10	15	20	25	30	35	40
Carburetors	(C)	Assimilation, %	Consumption of carburetors, kg								
			Electrode battle	98.5	90	11	26	41	55	70	85
Electrode Powder	93	90	12	27	43	59	74	90	105	121	136
Graphitized coconut	87	80	14	33	52	70	89	108	126	145	164
Silver Graphite	87	75	15	35	55	75	95	115	135	155	175
Black graphite	81	75	16	38	59	81	102	123	145	166	188
Crucible fight	91	80	14	32	49	67	85	103	121	139	157
Charcoal	82	80	15	35	55	75	95	114	134	154	174
Foundry coke	78	70	18	42	66	90	114	137	161	185	209
Metallurgical coke	78	75	17	39	62	84	106	128	150	173	195
Shale coke	84	80	15	34	54	73	92	112	131	150	170
Thermal	anthracite 81	75	16	38	59	81	102	123	145	166	188
Pyrrhic	stone 50	60	33	77	120	163	207	250	293	337	380
Oil pitch	50	50	40	92	144	196	248	300	352	404	456
Durability of IChT-10 lining at different proportions of steel scrap in metal charge,											
melts The proportion of steel scrap in the metalcharge, %	0	5	10	15	20	25	30	35	40	45	50
Durability of lining, swimming trunks	120	15	110	100	95	90	85	80	75	70	60

To avoid strong oxidation of carbon, steel scrap is stored, which keeps the carburetor in the cast iron melt, the total proportion of which should not exceed 40% of the total capacity of the crucible. The temperature of the metal melt must be maintained in the range of 1390-1410 ° C. As the steel scrap is deposited, a basement of our own production with ferroalloys is carried out.

We have conducted experimental studies of the physical and chemical properties of SCI with different proportions of steel scrap in the metal charge, as well as the specific power consumption for melting under production conditions in an induction crucible furnace with

a capacity of 6 tons. An experimental sample with the required hardness from 230 to 300 HB was selected to evaluate the mechanical properties. The share of steel scrap in the metal charge varied from 0 to 40 %. Experimental results of the dependences of the technological parameters of SCI on the share of steel scrap are summarized in Table 2.

Table 2. Experimental results of the dependence of technological parameters of SCI on the share of steel scrap

№	Share of steel scrap, %	Melting time, min	Specific power consumption, kW / h	Hardness, HB	Yield, %
1-experiment	0	65	502	210	97.5
2-an experiment	10	74	510	234	97.33
3-an experiment	20	81	521	247	97.24
4-an experiment	30	88	534	279	97.15
5-experiment	40	94	542	296	97.05

The graphical-analytic method was used to analyze the результатов experimental results of the dependence of the technological parameters of SCI on the share of steel scrap. Graphical dependencies were constructed, which are shown in Figure 1-4.

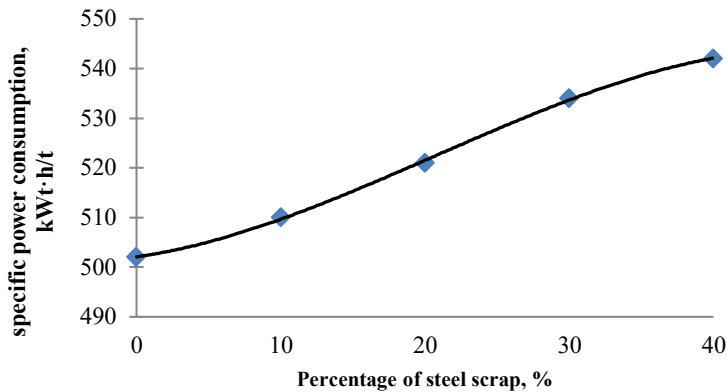


Fig. 1. Dependence of specific power consumption on the percentage of steel scrap

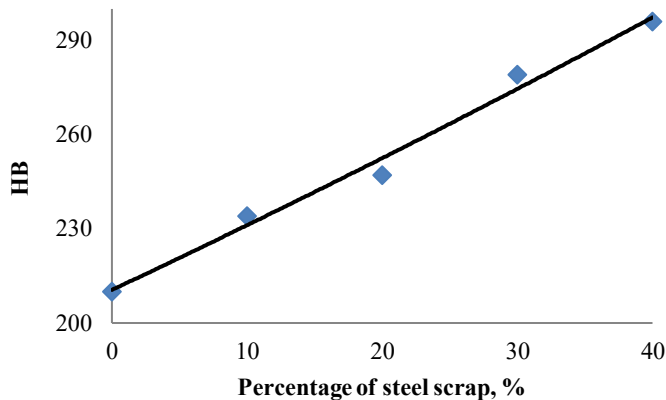


Fig. 2. Dependence of the hardness of the experimental sample on the share of steel scrap

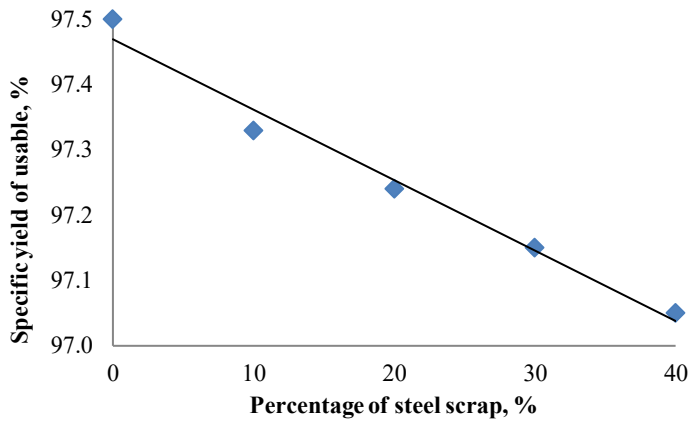


Fig. 3. Dependence of the specific yield of usable liquid cast iron on the share of steel scrap

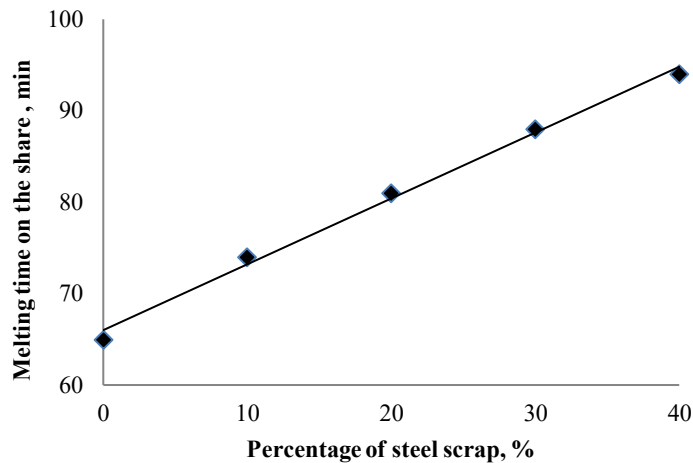


Fig. 4. Dependence of the melting time on the share of steel scrap

Figure 1 shows a graph of the dependence of specific electricity consumption on the percentage of steel scrap in the metal charge. As shown in Figure 1, with an increase in the percentage of steel scrap from 0 to 40% in the metal charge, the specific power consumption for smelting increases from 502 to 543 kWh/t, respectively.

The analysis shows that an increase in the share of steel scrap in the composition of the metal charge positively affects the hardness of the experimental sample. As can be seen from Figure 2, with an increase in the percentage of steel scrap from 0 to 40% in the metal charge, the hardness of the experimental sample increases from 210 to 298 HB, respectively. To achieve the required hardness of the experimental sample, it is necessary to have металлошихте from 10 to 40% of steel scrap in the metal charge.

The dependence of the yield of usable liquid cast iron on the percentage of steel scrap in the metal charge is shown in Fig. 3, where with an increase in the percentage of steel scrap from 0 to 40% in the metal charge, the yield of usable liquid cast iron decreases

Atc, we were interested in the question of the dependence and melting time on the share of steel scrap; it was found that the share of steel scrap in the metal charge is directly proportional, that is, with an increase in the percentage of the share of steel scrap in the

metal charge, there is also an increase in the duration of melting time, the graphical dependence of which is shown in Fig. 4. If the percentage of steel scrap increases from 0 to 40% in the metal charge, the melting time also increases from 65 to 94 minutes.

4 Conclusion

An efficient technology for producing SCI in an induction furnace with different proportions of scrap steel in the metal charge has been developed. The dependences of the specific power consumption, hardness of the experimental sample, yield, and duration of melting on the percentage of steel scrap in the metal charge are established. It is revealed that with an increase in steel scrap in the metal charge, the melting time, specific power consumption, melting duration, hardness of the experimental sample increase, and the yield of usable liquid cast iron decreases. To achieve the required hardness of the experimental sample, it is necessary to have металлошихте from 10 to 40% of steel scrap in the metal charge.

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