Increasing the Efficiency of Production of Synthetic Cast Iron Castings

Kukartsev Viktor Alekseevich[1], Cherepanov Aleksandr Ivanovich[1], Kukartsev Vladislav Viktorovich[1,2], Mikhalev Anton Sergeevich[1] and Makarchuk Ivan Yurievich[1]

[1]Siberian Federal University, Krasnoyarsk, Russia

[2]Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russia

Introduction

The development of a modern foundry involves the use of marketing strategies. One of the main components of any marketing strategy is customer acquisition. For this reason, when developing a strategy, it is necessary to consider the concept of the mission of the enterprise (production). For a foundry (enterprise), one of the types of marketing strategy is to conquer the sales market for its products by achieving greater profitability and product efficiency using advanced technologies. This allows the enterprise to become a leader by saving on production costs and, first, such as reducing downtime and increasing the productivity of the main equipment. When developing a company's strategy, it is necessary to define its mission, which is understandable for potential buyers of their products.

It is generally accepted that the mission of the foundry is to produce castings that meet customer requirements. However, modern realities lead to the fact that the mission of the foundry begins to consider the requirements for environmental safety in the production of castings, increasing resource efficiency, more efficient use of recycling in the production of alloys, and reducing harmful emissions. All this is continuously associated with a constant increase in labor productivity using technological processes that have a positive impact on the technological and economic profile of modern foundry production [1]. Fig. 1 shows the volume of smelting of foundry alloys in Russia today and the smelting equipment used to produce cast iron.

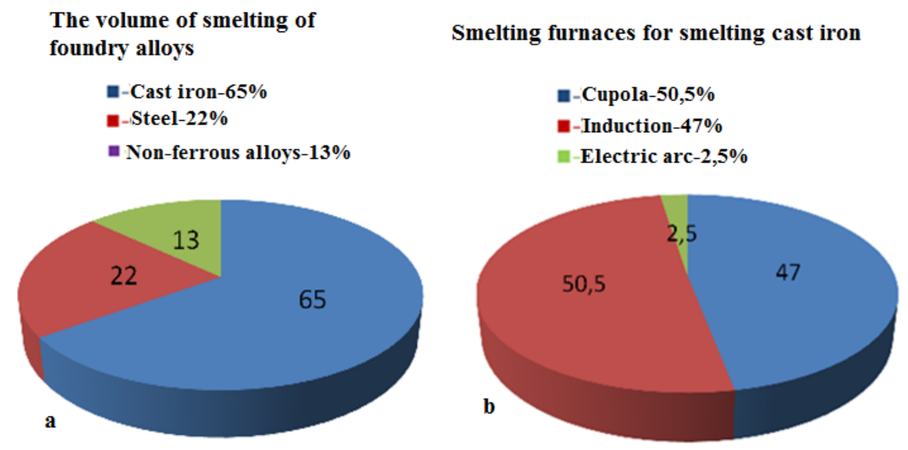

Fig. 1. The structure of the melted casting alloys: a - The volume of melted casting alloys, b - Used melting furnaces.

During the operation of the furnace, all these zones are reborn, the lining is worn out and the time comes for its replacement - after 300-350 melting, but this is only if the melting regime is not >1450 ° C. In order to increase the resistance of the acidic lining (when operating at a higher temperature), numerous studies have been carried out aimed at the use of additional additives in its composition. An additive was used in the form of ZrO2, Cr2O3, alumina slag. It was proposed to use an additive in the form of a mixture of calcium oxides, sodium oxide, etc. However, they did not find industrial use, since they did not provide the necessary durability of the lining.

Materials and Methods

In the production of castings, cast iron is the most common alloy. The main reason for its widespread use is its low cost compared to other ferrous alloys. The main melting unit for its production, until now, is a cupola, as the cheapest design of a melting furnace. However, it does not allow to obtain, stably, an alloy for castings from gray iron grade SCh-20 GOST 26358-84 and higher.

In Russia, until 2000, the metal filling for the smelting of synthetic iron in induction furnaces consisted of 25-30% of steel scrap, and the smelting of the alloy was carried out (as it was laid down by the designer) at temperature less than 1450 °C (Fig. 2).

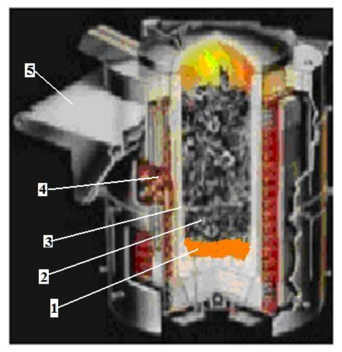

Fig. 2. An induction crucible furnace with a metal filling machine:1 - sump (liquid residue), 2 - metal filling, 3 - lining, 4 - inductor, 5 - furnace body.

The problem of maintaining the durability of the lining is of great importance. The high durability of the traditional acidic lining based on quartzite was ensured by the fact that after sintering, 3 zones are formed in it - sintered, semi-sintered and free-flowing (Fig. 3).

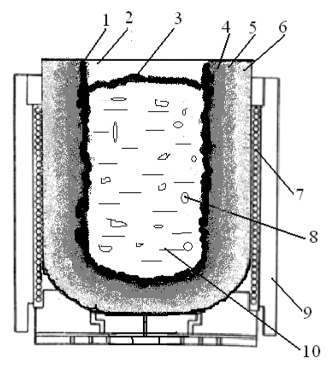

Fig. 3. Layout of quartzite lining zones in the IChT furnace: 1 - slagged sintered lining crust, 2 - furnace gas phase, 3 - liquid slag on the surface of the melt, 4 - sintered lining zone, 5 - semi-sintered lining zone, 6 - non-sintered mass zone (buffer), 7 - furnace inductor, 8 - gas contained in the melt itself, 9 - furnace body, 10 – melt

During the operation of the furnace, all these zones are reborn, the lining is worn out and the time comes for its replacement - after 300-350 melting, but this is only if the melting regime is not >1450 ° C. In order to increase the resistance of the acidic lining (when operating at a higher temperature), numerous studies have been carried out aimed at the use of additional additives in its composition. An additive was used in the form of ZrO2, Cr2O3, alumina slag. It was proposed to use an additive in the form of a mixture of calcium oxides, sodium oxide, etc. However, they did not find industrial use, since they did not provide the necessary durability of the lining.

Experimental Study and Discussion

This paper proposes a fairly simple way to solve the problem that does not require capital expenditures. It consists in the introduction of high-temperature technology for smelting synthetic iron at 1500-1600 ° C [9]. This technology presupposes the use of up to 70-90% of steel scrap in the metal filling station, that is, to switch to the smelting of pig iron from a charge entirely consisting of steel scrap. The resistance of the acidic lining is provided by a new composition, in which electrocorundum is used as an additive. It allows you to reduce the consumption of materials and electricity due to the use of cheap steel scrap instead of cast iron, preserve the lining resistance in the amount of 300 heats, and get away from high-temperature furnaces for heat treatment of initial quartzite and heat-resistant containers. The introduction of this technology makes it possible to obtain significant savings in the purchase of charge and lining materials.

The cost savings calculation is presented for the IChT-1 melting furnace in Table 1.

Materialname, GOST, TU.	Material image	Market value, RUB / kg	Consumption, kg / rub per 1ton of iron	
			Traditional technology	Hightemperature
Sump (liquidresidue)		50% ofcasting	300-350/12000-14000	100/4000
Returnofproduction		80% ofcasting	220-280/14080-17920	–
Foundry pig iron and pig iron scrap		25-40	170-200/4250-8000	–
Ferromanganese, ferrosilicon		48-54	5-10/250-500	10-15/500-750
Steelscrap		9-12	300-350/3000-3500	885-890/8850-8900
Carburizingagent		2-3	5-6/12,5-15	10-20/25-50
Quartzite		7-9	2,83/22,64	1,9/15,2
Electrocorundum		32-35	–	0,08/2,72
Totalcosts			34335,14-43957,64	13392,92-13717,93

The initial data for the calculation are:

1. The number of heats per shift - 3 (700 kg each for traditional technology and 900 kg for high-temperature technology).
2. Continuous work schedule.
3. Durability of the lining - 300 heats.
4. The required mass of raw materials for making one lining is 600 kg.
5. Market value of gray iron castings - 75-86 rubles / kg.

As a result, the cost savings amounted to 34335.14-13392.92 (43957.64-13717.93) = 20942.22 / 30239.71 rubles. for 1 ton of liquid iron or costs are reduced by 61-68.8%. So, the cost of a stainless-steel sheet is 3-5 times more expensive than carbon steel, the electricity consumption per 1 ton of charge in the SDO 15.15.10 / 12 furnace.

Conclusions

The use of the proposed technology makes it possible to completely abandon the use of foundry and pig iron in the metal filling station. Smelting of synthetic iron allows to reduce by 60-70% the cost of charge materials and materials for lining.

Despite the increase in the temperature regimes of smelting, the lining life does not change. The use of this technology makes it possible to abandon the use of high-temperature heating furnaces and heat-resistant containers required for drying quartzite.

References

[1] I. Riposan, M. Chisamera, Enhanced quality in electric melt grey cast irons, StelianStan, ISIJ International 53 (2013) 1683-1695.

[2] O.A. Antamoshkin, V.V. Kukartsev, Combined method of making decision for reproduction capital reproduction funds, Problems of mechanical engineering and automation 2 (2011) 56-60.

[3] B.P. Platonov, A.D. Akimenko, S.M. Bagutskaya, Induction furnaces forecast iron melting, Mashinostroenie, Moscow, 1976.

[4] P. Futas, A. Pribulova, J. Petrik, M. Pokusova, A. Junakova, The study of synthetic cast iron quality made from steel scrap, International multidisciplinary Scientific GeoConference surveying geology and mining ecology management 18 (2018) 321-329.

[5] O. Yu. Levkina, Model of effective management of foundry production of an aircraft-building enterprise, News of the Samara Scientific Center of the Russian Academy of Sciences 4-2 (2012) 82-94.

[6] A.K. Dey, Energy efficiency model for induction furnace, IOP Conference Series: Materials Science and Engineering 302(1) (2018) 012047

[7] V.A. Kukartsev, V.V. Kukartsev, A.V. Kukartsev, Effect of the temperature treatment of quartzite on the lining resistance of commercial-frequency induction crucible furnaces, Refractories and Industrial Ceramics 59(3) (2018) 252-256.

[8] V.A. Kukartsev, A.I. Trunova, A.V. Kukartsev, Thermal analysis of quartzite used to line a crucible-equipped industrial-frequency induction furnace, Refractories and Industrial Ceramics 54(11) (2014) 220–222.

[9] V.A. Kukartsev, Effect of the addition of electro corundum on structural-phase transformations in the quartz lining of an industrial-frequency crucible-type induction furnace, Refractories and Industrial Ceramics (2015) 151-154.

[10] M. Chaabet, E.D. Verlag, V. V. Seiten, Steelmaking based on inductive melting heat processing, Ausgabe 1 (2012) 49-58.