Specialty of Carbon-carbid-cilicic Mixture using (UKKS) as Substitute of Recarburizing Agent and Ferrosilicon for Grey Iron Melting

Kukartsev Viktor Alekseevich[1, a], Kukartsev Vladislav Viktorovich[1, 2, b], Tynchenko Vadim Sergeevich[1, 2, c *]

[1]Siberian Federal University, Svobodny 79, Krasnoyarsk 660041, Russia

[1] Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., 660037 Krasnoyarsk, Russia

[a]sarabernar777@mail.ru, [b]vlad_saa_2000@mail.ru, [c]vadimond@mail.ru

Keywords: Iron melting, induction kiln, recarburizing agent.

Abstract. In the transition to modern high intensive processes of smelting had been reversed technologies structures to get carbon content in cast iron. A recarburizing agent can be one of the most significant reasons of occurrence of defects of the cast and deformed metal and decrease of the level of properties have been identified. It is not only made the decarburizing agent of modern technology of production of pig-iron an essential element (particularly synthetic) but also resulted in many of variants of his realization from the standpoint of level decarburizing, type of used recarburizing method of decarburizing technological phase, where enter of carbonaceous materials. Particularly sharply process of execution recarburizing influences receipt of synthetic pig-iron in induction crucible furnaces of industrial frequency from metal works, in which 80-90% of steel breakage are contained. Then it is necessary to raise the content of carbon from 0,3 to 3,0-3,8% (depending on the pig-iron mark). It forces foundry enterprises to approach with big care at a choice of existing materials which it is possible to use as decarburizing and carefully to verify, which is appearing on the market. In work application are considered variants of using carbon-carbide-silicon mixture UKKS-31 at melting of grey pig-iron in induction, crucible furnaces, intended for pig-iron melting. The cost comparison is presented between traditional technology and with using mix UKKS-31.

Introduction

In the transition to modern high intensive processes of smelting had been reversed technologies structures to get the necessary content of carbon at manufacturing casting made of pig-iron or steel. A recarburizing agent can be one of the most significant reasons of occurrence of defects of the cast and deformed metal and decrease of the level of properties have been identified. It is not only made the recarburizing agent of modern technology of production of pig-iron an essential element (particularly synthetic) but also resulted in many of variants of his realization from the standpoint of level recarburizing, type of used recarburizing method of carburizer technological phase, where enter of carbonaceous materials. As a carburizer are used electrode battle, graphite chip, coke trifle, coal granulate and another. Reduction of sizes of grains decarburizing promotes an increase of contact surface carburizer with metal and accelerates the process, but at excessively small sizes of particles recarburizing agent it is increased of their blowing by ascending currents of air and pollution of the atmosphere on the melting platform. In a practice work was found, that an optimal size of particles recarburizing agent should be 3... 6 mm. The main part recarburizing specify together with a blend to the bottom of the tub under the layer of steel breakage. At the same time process recarburizing goes simultaneously with melting, it is mean that does not increase duration fusible. However, at polluted blend and plenty of slags a significant part recarburizing is entangled in slag and is removed together with him, and a factor of assimilation recarburizing decreases at the same time. The correction of carbon melting is conducted on the result of chemical analysis of metal at the end of melting. If necessary recarburizing is feed to the mirror of metal after removal of slag. Mostly at choice recarburizing of quality of material judge on specified content in him of carbon, and in process route - on assimilation from it of carbon with corium.

Materials and methods

Particularly sharply process of execution recarburizing influences receipt of synthetic pig-iron in induction crucible furnaces of industrial frequency from metal works, in which 80-90% of steel breakage are contained. These metal works were used since 2000 because pig-iron breakages on enterprises were absent. Then it is necessary to raise the content of carbon from 0,3 to 3,0-3,8% (depending on the pig-iron mark). As speed recarburizing at temperature 1400-1470 C approximately 0, 12% per minute than to get the necessary content of carbon it is necessary 22 minutes to hold this temperature. At the same time 1% carbon assimilation is a lower temperature of corium at 50 degrees. In the total temperature of corium will fall down to 1250-1320C, but it isn't enough, needs 1410-1450C. Because of this, they are forced corium temperature to raise up to 1550-1600C, but it results in a sharp drop of stability acid lining of traditional composition, therefore we need to enter additional additives preserving her stability [1-3]. It forces foundry enterprises to approach with big care at a choice of existing materials which it is possible to use as decarburizing and carefully to verify, which is appearing on the market [4-7].

On the website http://amus-ukks-ukkb.ru/ [3], the company named "Metallurgical mixes" offers a carbon-carbide-silicon mixture for use as a partial substitute for ferrosilicon and carburizing agent in the smelting of cast iron, and steel with an economic effect of 10 - 300 dollars per 1 ton of metal refilling.

The attached technological instruction for melting of pig-iron in induction crucible furnace (Fig. 1) that the maximum economic effect is achieved when using CCSM as an additional material, replacing 50% of ferrosilicon in the charge. Let's consider it on the basis of the practical application.

Fig. 1. Induction crucible furnace of the production frequency

We take as the base that the condition that the materials used in the metal scrap, for smelting cast iron SCH20 have a constant quality [8, 9] and correspond to the properties given in Table 1.

The cost of materials on the market is is presented in Table 2: Ferro Silicon 45 – 35-40 thousand rubles, per 1 ton; Carbon-containing material – 4.8 thousand rubles, per 1 ton; CCSM-31– 25-30 thousand rubles, per 1 ton. (transport costs are not counted).

We are making the calculation of charge materials for the grey cast iron smelting SCH20 on the lower limiting content of silicon, since the smelting of cast irons in induction furnaces is performed using acidic lining [10, 11], and in this case, silicon does not burn, and we determine the content of the metal scrap and the costs of ferrosilicon, the carburising agent, and the mixture CCSM.

Table 1. Properties of materials used in metal scrap, for smelting cast iron SCH20

Brand of material	GOST, TR	Mass fraction [%]			Assimilation, [%]
		of silicon	of carbon	of manganese	
		No more			
Steel scrap	1050 - 88	0,37	0,23	0,6	95
Ferro Silicon 45	1415-93	44	0,2	1,0	98
Ferro Manganese 70	4755 - 91	6,0	7,0	65	90
Carbon-containing material carburiser	ТУ У 10.1-23472138-432:2010		80		90
CCSM-31	ТУ 1914-002-54936548-2006	31	55		90 80

Table 2. Calculation of the application options for the CCSM-31 mixture with the replacement of 50% Ferro Silicon 45.

Material for metal working	Smelting technology with “swamp“		Smelting technology with full drain	
	Content of the material, %			
	Traditional technology	Technology with usage of CCSM	Traditional technology	Technology with usage of CCSM
“Swamp“	30	30	--	
Return	20	20	--	
Steel scrap	46	46,4	92,5	94,25
Ferro Silicon 45	1,3	0,65	2,5	1,25
Ferro Manganese 70	0,3	0,3	0,5	0,5
Carbon-containing of material carburizer	2,4	1,7	4,5	2,0
CCSM-31	--	1,0	--	2,0
Costs for the Ferro Silicon 45 carburizing	13*40+24*4.8 =635,2 [rubles].		25*40+45*4,8= 1216 [rubles].	
Costs for the CCSM and carburizer		6,5*40+17*4,8 +10+30=641,6 [rubles].		12,5*40+20*4,8+20*30=1296 [rubles].

The above calculations do not allow us to conclude that there is any effect. Consider the options for using a mixture of CCSM-31, which completely exclude the use of ferrosilicon. All data are given in Table 3.

Finally, the option of smelting cast iron without a return, on one steel scrap. This technology is used very often, especially in foundries located from Russia to the Far East [13, 14, 15]. This is explained by the economic feasibility are made cheaper synthetic pig-iron [16, 17]. All data are presented in Table 4.

Table 3. Variants of application of the mixture CCSM-31, which completely exclude the use of Ferro Silicon 45.

Material for metal working	Smelting technology with “swamp“		Smelting technology with full drain	
	Content of the material, %			
	Traditional technology	Technology with usage of CCSM	Traditional technology	Technology with usage of CCSM
“Swamp“	30	30	--	
Return	20	20	20	20
Steel scrap	46	46,6	74,0	74,7
Ferro Silicon 45	1,3	--	2,0	--
Ferro Manganese 70	0,3	0,3	0,5	0,5
Carbon-containing of material carburizer	2,4	1,1	3,5	1,8
CCSM-31	--	2,0	--	3,0
Costs for the Ferro Silicon 45 carburizing	13*40+24*4.8 =635,2 [rubles].		20*40+35*4,8= 968 [rubles].	
Costs for the CCSM and carburizer		11*4,8+20+30= 652,8 [rubles].		18*4,8+30*30= 986,4 [rubles].

Table 4. The use of the CCSM-31 mixture in the smelting of cast iron, using steel scrap only.

Material for metal working	Smelting technology with “swamp“		Smelting technology with full drain	
	Content of the material, %			
	Traditional technology	Technology with using of CCSM	Traditional technology	Technology with using of CCSM
“Swamp“	30	30	--	--
Steel scrap	65,1	65,5	92,5	93,2
Ferro Silicon 45	1,7	--	2,5	--
Ferro Manganese 70	0,3	0,3	0,5	0,5
Carbon-containing of material carburizer	3,2	1,5	4,5	2,3
CCSM-31	--	2,7	--	4,0
Costs for the Ferro Silicon 45 carburizing	17*40+32*4.8 =833,6 [rubles].		25*40+45*4,8= 1216 [rubles].	
Costs for the CCSM and carburizer		15*4,8+27+30= 882 [rubles].		23*4,8+40*30= 1310,4 [rubles].

Results

Therefore, the economic effect of using a CCSM-31 mixture in the melting of cast iron is only observed when using the smelting technology mandatory presence "swamp" and return to the furnace charge, and may be approximately 50 rubles with one ton of molten iron. But following technological changes cannot be ignored. Ferrosilicon is available in the soft container sling capacity of 1 ton, which is then poured into a bin at the site of the furnace, to further traditional application. The mixture CCSM-31 is supplied in bags of 25-30 kg, which are also delivered to the furnace platform (Fig. 2).

Fig. 2. Bags with CCSM-31.

Subsequently, the additive to the furnace is produced by loading the bags manually in a low-capacity furnace or placing them in a loading device [20, 21]. If the calculation requires the addition of material is not a multiple bag, it must be cut, and measure the required amount which complicates melting of pig-iron to necessary quality [22]. The remaining mixture must be stored on site before the next melting.

Summary

Assimilation of carbon in corium with using of CCSM-31 accounts for 80%, that corresponds the level of mastering of the most used graphite-containing materials.

About the fact, that using steel breakage does not have guaranteed chemical compound is impossible to conduct an accurate additive, on calculation, CCSM-31 for receipt of the appropriate chemical composition of pig-iron - is necessary also ferrosilicon.

Application CCSM-31 is resulting in increased costs of metal output.

Thus, a conclusion follows that use of the mix CCSM-31 when smelting SCH-20 of cast iron in the induction furnaces of industrial frequency allowing making complete full drain of ready melting is inexpedient. Besides, it is necessary to consider technological conditions of melting at the entity, delivery conditions of materials, their remoteness and the prices which developed for this period of time.

References

[1] V. A. Kukartsev, A. K. Abkaryan, V. G. Babkin, Study of the Phase Composition of Spent Quartzite Lining from a Crucible-Type Industrial Frequency Induction Furnace by X-ray methods, Refractories and Industrial Ceramics. 6 (2015) 14-15.

[2] K. Janerka, M. Kondracki, J. Jezierski, J. Szajnar, M. Stawarz, Carburizer Effect on Cast Iron Solidification, Journal of materials engineering and performance, 23 (2014) 2174-2181.

[3] Information on http://www.ukks-ukkb.ru.

[4] K. Edalati, F. Akhlaghi, M. Nili-Ahmadabadi, Influence of SiC and FeSi addition on the characteristics of gray cast iron melts poured at different temperatures, Journal of Materials Processing Technology. 160 (2005) 183-187.

[5] B.P. Platonov, A.D. Akimenko, S.M. Bagutckaja, Induction furnaces for cast iron melting, Mechanical engineering. 160 (1976) 176.

[6] V.A. Kukartsev, Melting of steel in induction crucibles of industrial frequency, Litejshik Rossii. 12 (2012) 35-36.
[7] M. Chaabet, Steelmaking based on inductive melting heat processing, Vulkan Verlag Seiten. 10 (2012) 49-58.
[8] K. Janerka, D. Bartocha, J. Szajnar, Quality of carburizers and its influence of carburization process, Archives of Foundry Engineering. 9 (2009) 249-254.
[9] A.G. Panov, T.V. Rogojina, To a question of the choice of a recarburizing agent by production of synthetic cast irons, Chelyabinsk Publishing house, Chelyabinsk, 2007.
[10] V.S. Shumichin, Synthetic iron, Chelyabinsk Publishing house, Chelyabinsk, 1971.
[11] V.A. Kukartsev, V.G. Babkin, A.I. Cherepanov, Features of smelting of synthetic cast iron in IChT V furnaces, The modern technologies in mechanical engineering and foundry production materials of the II international scientific and practical conference. (2016) 153-157.
[12] V.S. Shumichin, Behavior of carbon in cast iron melts, Foundary. 5 (1979) 4-6.
[13] I. Riposan, M. Chisamera, S. Stan, Enhanced Quality in Electric Melt Grey Cast Irons, ISIJ International, 53 (2013) 1683-1695.
[14] V.A. Kukartsev, Features of smelting of wear-resistant IChH28N2 cast iron in an induction crucible furnace of IChT10, Litejshik Rossii. 5 (2013) 22-23.
[15] A.K. Achamyeleh, B.A. Samuel, Minimization of Casting Defects IOSR, Journal of Engineering. 3 (2013) 31-38.
[16] I. Riposan, M. Chisamera, S. Stan, Enhanced quality in electric melt grey cast irons, ISIJ International. 53 (2017) 1683-1695.
[17] M.V. Jelneus, Melting of synthetic cast iron in induction furnaces and its technology at the Kaunas foundry, Kaunas, 1974.
[18] K. Brokmayer, Induction melting furnace, Energy, Moscow, 1972.
[19] A.A. Prostyakov, Induction furnaces and mixers for cast iron melting, Energy, Moscow, 1977.
[20] A.M. Vanberg, Induction flowing furnaces: manual for higher education institutions, Energy, Moscow, 1967.
[21] V.S. Shumihin, B.A. Zamiatin, A.K. Baum, Cast of iron graphitization, Foundary. 6 (1978) 3-5.
[22] K. Janerka, J. Jezierski, D. Bartocha, J. Szajnar, Heredity of the structure and properties of grey cast iron melted on a basis of steel scrap, Advanced Materials Research. 622 (2013) 685-689.