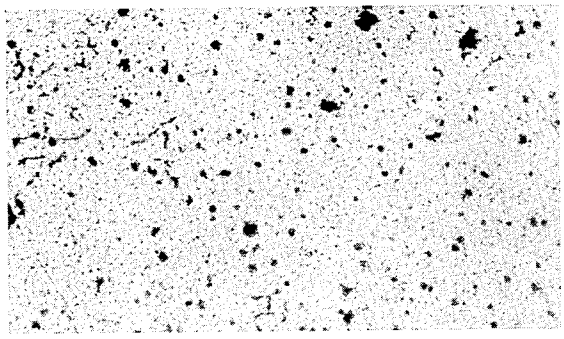
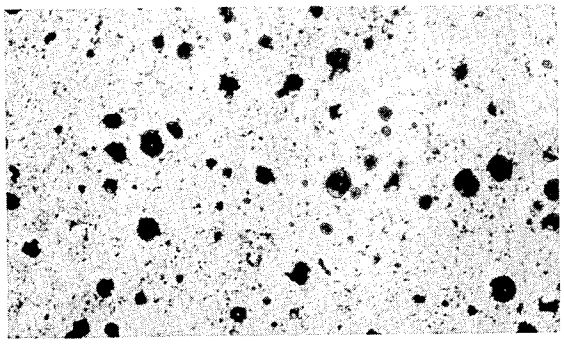
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PROCESS FOR THE PRODUCTION OF ALLOYS USED AS ADDITIVE
IN THE PRODUCTION OF SPHEROIDAL GRAPHITE CAST IRONS
Filed March 1, 1968

NO. 1 MAGNIFICATION : 120X



NO. 6 MAGNIFICATION : 120X



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PROCESS FOR THE PRODUCTION OF ALLOYS USED AS ADDITIVE IN THE PRODUCTION OF SPHEROIDAL GRAPHITE CAST IRONS

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ABSTRACT OF THE DISCLOSURE

A process for the production of a ferrosilicon-base alloy adapted to be used in the production of spheroidal graphite cast irons as an additive, which comprises placing a slag-making material in a ladle lined with a basic refractory material, pouring a molten ferrosilicon from a ferrosilicon furnace directly into said ladle, imparting a shaking motion to the melt in the ladle by eccentrically rotating said ladle and casting the melt into a casting mold.

The present invention relates to a process for the production of a ferrosilicon-base alloy adapted to be used in the production of spheroidal graphite cast irons, which alloy is capable of forming spheroidal graphite in the cast iron more efficiently than those disclosed in Japanese patent publication No. 24,212/64, by the treatment of a ferrosilicon of quality level substantially equal to that of the commercially available ferrosilicons.

For producing spheroidal graphite cast iron most economically, a process has been proposed in Japanese Patent No. 300,442, issued Oct. 13, 1962, which is characterized by subjecting a material iron to a silicon treatment using ferrosilicon-base alloys. However, not all of ferrosilicons are adapted to be used for such a treatment. As suitable ferrosilicon-base alloys, Japanese patent publication No. 24,212/64 proposes those alloys which are composed of not more than 90% of iron and from 10 to 99% of silicon as being the basic components, added with not more than 4% of calcium, not more than 10% of aluminum, the total value of the percentage of calcium multiplied by 10 and the percentage of aluminum being not smaller than 3, not more than 0.05% of silicic acid or silicate and impurities which are inevitably introduced into said alloys.

The ferrosilicon-base alloys used in the process of aforesaid Japanese Pat. No. 300,442 have heretofore been produced by charging lumps of a commercially available ferrosilicon in a magnesia-lined Heroult furnace, melting said ferrosilicon in said furnace with the addition of a slag-making material composed of quick lime, dolomite and fluorite, leaving the molten ferrosilicon to stand still, removing the slag and thereafter casting said molten ferrosilicon into a casting mold. The spheroidal graphite cast iron produced with the ferrosilicon-base alloys obtained in the manner described has a tensile strength ranging from 50 to 80 kilograms per square millimeter. However, the tensile strength varies largely from cast iron to cast iron and it has been extremely difficult to produce a cast iron uniformly with a desired tensile strength. Moreover, since the process is operated using a cold ferrosilicon as a starting material, loss of silicon due to oxidation during the melting operation has been great, the available percentage of silicon being only 90% at highest.

In view of the above difficulties, the present inventors conducted various experiments with a view to obtaining an improved ferrosilicon alloy, by employing a process which comprises charging a molten ferrosilicon from a ferrosilicon furnace directly into a Heroult furnace, instead of starting the process with a cold ferrosilicon, adding to said molten ferrosilicon the aforesaid slag-making material, after heating electrically leaving the melt to stand still, removing the slag and casting the melt into a casting mold. This method, however, was found impractical because the reaction proceeds at an unexpectedly slow and irregular speed and further the tensile strength of the cast irons produced with the use of thus obtained ferrosilicon alloys varies in a wide range from 30 to 70 kilograms per square millimeter, although there were the advantages that the power consumption for heating operation is reduced drastically and that the available percentage of silicon is improved to as high as 95%.

Upon reviewing the cause of failure met in the above-described hot-charging method, it was concluded that the failure could be attributed to unsatisfactory contact between the slag-making material and the molten ferrosilicon. Then, in order to produce a satisfactory contact between the slag-making material and the molten ferrosilicon, the present inventors further conducted the following experiment, in which the molten mixture of the ferrosilicon and the slag-making material was forcibly stirred in a fuel oil-heated ladle.

Namely, the slag-making material was charged in a ladle lined with magnesia layer and heated until the surface of said magnesia lining layer becomes red. Thereafter, a molten ferrosilicon from a ferrosilicon furnace was directly poured into the ladle and immediately thereafter green wood was thrown into the melt in the ladle to effect bubbling of the gases generated. After allowing the melt to stand still and casting the same, the ferrosilicon alloy obtained was tested, with the finding that the tensile strengths of the spheroidal graphite cast irons produced with said ferrosilicon alloy were unexceptionally below 60 kilograms per square millimeter, though the analyses of the metal composition and the slag composition after the process indicated that a considerably satisfactory contact had been effected between the slag-making material and the ferrosilicon.

As a result of this experiment, however, it has been acknowledged that ferrosilicon alloys of the type described could be produced economically by charging a molten ferrosilicon into a ladle and adding thereto a slag-making material. The only remaining problem to be solved was a manner in which the molten ferrosilicon alloy is stirred. The present inventors have conducted further experiments and finally arrived at the present invention.

Namely, according to the present invention, there is provided a process for the production of a ferrosilicon alloy adapted to be used in the production of spheroidal graphite cast irons, which comprises placing a slag-making material consisting primarily of quick lime or limestone in a ladle lined with a basic refractory material containing a minimum amount of silicon oxides, heating the ladle until the temperature of the lining surface is elevated to

about 1,000° C., charging a molten ferrosilicon-base alloy into the ladle, maintaining the melt in the ladle at a temperature not lower than 1,500° C., imparting to the ladle an eccentric rotary motion to shake the melt in said ladle, stopping the shaking at a point at which the color of the spark from the melt has changed from red to bluish white while maintaining the melt at a temperature not lower than 1,350° C. and, after leaving the melt to stand still for a while, casting the melt into a casting mold. The product obtained by the process described above fulfills the requirements for ferrosilicon alloys as set out in Japanese patent publication No. 24,212/64 and further the cast irons produced by the use of the ferrosilicon alloy as an additive have a tensile strength of 60 kilograms per square millimeter as cast, with minimum irregularity. Thus, it is possible, according to the process of the instant invention, to produce an excellent additive alloy which enable spheroidal graphite cast irons of high, uniform tensile strength to be produced.

The inventive process, which has been stemmed from the conventional process using the Héroult furnace as described hereinbefore, is characterized in particular by effecting the stirring of the melt by shaking motion. The present invention has been achieved based on the results of extensive industrial experiments. In order to obtain a satisfactory result according to the present invention, the process must be operated to fulfill the following two conditions.

(1) LINING REFRACTORY MATERIAL

The lining refractory material to be used must be selected from those basic refractory materials which contain minimum amounts of silicon dioxide and alumina. In this view, it is preferable to use magnesia and dolomite type refractory materials but not preferable to use alumina bricks. The basicity of the refractory material used for lining has a great bearing on the spheroidal graphite forming capability of the product alloy, because use of carbonaceous material will result in introduction of carbon, though in a small amount, into the product alloy, with the result that the alloy tends to decay after casting, although there is no change in the spheroidal graphite-forming capability thereof, whereas when the basicity of the slag is acidic or weakly basic upon completion of the reaction, a satisfactory spheroidal graphite-forming capability cannot be expected of the alloy.

The use of a basic refractory material, for instance, of magnesia type, however, will make it inevitable for the lining to react with silicon or for the lining to act as a slag-making material. In order to avoid erosion of the lining, therefore, it is preferable to use as a lining material magnesia bricks or the like which are unsusceptible to erosion, instead of castable materials which are susceptible to erosion.

(2) TEMPERATURE CONDITIONS

The temperature of the melt upon completion of the reaction must be not lower than 1,350° C. In the case of alloys whose melting points are not lower than 1,350° C., the molten alloy after completion of the reaction must be at a temperature not lower than said melting point and yet at a temperature at which the molten alloy has a considerable fluidity. The results of experiments have revealed that an additive alloy having a desired spheroidal graphite-forming capability cannot be obtained at a temperature of the melt not higher than 1,350° C. The reaction between the slag-making material and the ferrosilicon-base alloy in the present invention is an intense endothermic reaction, so that the temperature of the molten alloy drops sharply during the reaction. Therefore, the temperature of the molten alloy of 1,350° C. or higher cannot be obtained upon completion of the reaction, unless the molten alloy is held at a temperature of not lower than

1,500° C. before the shaking operation. In this view, when a ladle of 1 ton or smaller in capacity is used and a molten alloy is to be poured into the ladle at a temperature of 1,700 to 1,800° C. over a period of shorter than 10 minutes, it will be at least necessary to heat the ladle beforehand by auxiliary heating means to a temperature of about 1,000° C. including the slag-making material placed therein.

The process of this invention has such economical advantages over the conventional process that the process can be accomplished in a very short period, that the available percentage of silicon can be improved remarkably since silicon is not wastefully consumed by oxidation as has been in the conventional process and that the power which has heretofore been required for heating a material alloy is not needed because of hot charging. The inventive process is particularly advantageous in that ferrosilicon-base alloys which enable spheroidal graphite cast irons having a tensile strength of 60 kilograms per square millimeter or higher to be produced, can be obtained on a stable basis and further in that when the process is operated under the same conditions, variation in tensile strength value of the spheroidal graphite cast irons produced with the product alloys can be minimized with respect to a desired value, so that alloys capable of bringing about a desired tensile strength in the spheroidal graphite cast irons produced therewith can be produced with a minimum percentage of rejection. In the past, the tensile strength of a spheroidal graphite cast iron has been assured by actually measuring the tensile strength on a sample piece which is taken from each tap. According to the process of this invention, such sampling is not required and the production can be controlled only by the control chart. Consequently, the inspection costs can be saved substantially.

Now, the process of the present invention will be illustrated in detail by way of example with reference to the accompanying drawing which is microscopic photographs showing the structures of the spheroidal graphite cast irons produced with the ferrosilicon-base alloys of this invention.

EXAMPLE

The process of this invention was operated using a ladle which has a capacity of 500 kilograms (computed on pig iron) and is lined with magnesia bricks. First of all, the surface of the lining was heated by a fuel oil burner from one hour before the process. 15 minutes after starting the heating, a slag-making material was placed in the ladle and immediately thereafter the combustion temperature of the fuel oil was elevated by mixing oxygen in the compressed air for the burner to raise the lining surface temperature. When the lining surface temperature had reached a level higher than 1,000° C., a molten ferrosilicon was charged into the ladle. The burner was put off when the amount of the molten ferrosilicon in the ladle reached about 300 kilograms and a ladle shaking device was set in motion immediately to bodily rotate the ladle along a horizontal circular path of 90 millimeters in diameter at the rate of 92 revolutions per minute. The ladle was moved in the path reciprocally in such a manner that it was rotated for 7 seconds in one direction and, after having been held stationary for 1.5 seconds, rotated in an opposite direction for 7 seconds. In the meantime, the color of the spark scattering from the interior of the ladle along with a white smoke changed from red to bluish white and the motion of the ladle was stopped at that point. The ladle was held still and, after the surface layer of the slag had been solidified, the ladle was inclined and the melt was poured from the ladle into a casting mold through a hole bored through the lower portion of the solidified slag. The process described above was repeated using different slag-making materials in different amounts individually, the results of which are shown in the table attached hereto.

Using the alloys thus produced, spheroidal graphite cast irons were produced and the tensile strengths of the individual spheroidal graphite cast irons were measured, in the manner described below:

Namely, in a basic arc furnace of a capacity of 50 kilograms was charged 50 kilograms of scrap steel and molten therein with the addition of carbon in such an amount that the carbon content in the melt, after removing the slag, would wall in the range from 3.8 to 4%. The melt was added with a basic flux for reduction and refining, and thereafter with 800 grams of a ferrosilicon alloy to be tested. The resultant molten metal was cast in the temperature range from 1,470 to 1,500° C. The molten metal was also poured in a separate ladle in an amount of 10 kilograms and, after adding thereto 300 grams of ferrosilicon alloy to be tested, the molten metal was immediately cast into a keel block of 40 millimeters in wall thickness to produce a test piece of Japanese Industrial Standards No. 4 type, on which the tensile strength of the spheroidal graphite cast iron was measured.

In the table, the experiments in Categories I to VI inclusive were conducted with a ferrosilicon containing about 70% of silicon and those in Category VII were conducted with metallic silicon containing about 98% of silicon. The experiments in Category VI were conducted by forcibly stirring the molten metal by means of gases, without shaking the ladle, which were generated intensely upon throwing green wood into the molten metal. In these cases, the tensile strengths of the product cast irons are not higher than 60 kilograms per square millimeter, that is lower than those of the cast irons in the other runs. This fact proves the necessity of the shaking operation. The experiments of Run Nos. 3 and 4 in Category II are the repersentatives of many experiments by which it has been established that a tensile strength of cast iron of 60 kilograms per square millimeter or higher cannot be expected when the temperature of the molten metal upon completion of the shaking operation is not higher than 1,350° C. The structures of the spheroidal graphite cast irons obtained from Run Nos. 1 and 6 are shown in the attached microscopic photographs at a magnification of 120 times.

Category	Run No.	Analysis of molten metal, percent: Si Before treatment	Si After treatment	Ca Before treatment	Ca After treatment	Al Before treatment	Al After treatment
I	1	68.7	67.4	0.11	1.22	0.22	0.65
	2	71.0	68.8	0.44	1.34	0.44	0.72
II	3	72.9	70.6	1.10	1.45	0.39	2.21
	4	67.2	68.5	0.88	1.36	0.64	1.96
III	5	64.5	64.4	0.08	0.88	0.40	1.48
	6	69.1	69.1	1.02	1.31	0.77	1.74
IV	7	70.2	71.4	0.32	1.52	0.82	0.98
	8	71.8	71.4	0.31	0.55	0.60	0.58
	9	71.8	71.0	0.38	0.52	0.67	0.59
V	10	69.7	66.7	1.15	1.48	0.49	0.90
	11	68.7	67.4	1.48	1.48	0.74	0.96
VI	12	71.2	69.6	1.01	1.23	0.68	1.34
	13	69.3	67.5	0.87	1.96	0.67	1.87
VII	14	98.5	97.5	0.15	0.90	0.10	0.53
	15	98.2	97.2	0.20	1.02	0.08	0.61

Category	Run No.	Composition, kg.: Metal	Slag-making material: Quick lime	Alumina	Fluorite	Shaking period, min.	Molten metal temperature, ° C.: Before treatment	After treatment	Tensile strength kg./mm.
I	1	275	15.6	7.5	6.9	5	1,580	1,365	72.4
	2	245	15.6	7.5	6.9	3	1,545	1,380	74.0
II	3	335	18	9	3	3	1,450	1,340	56.2
	4	255	18	9	3	5	1,510	1,360	60.2
III	5	235	18	(1)		2	1,620	1,430	69.3
	6	350	18	(2)		5	1,590	1,400	61.7
IV	7	265	20			4	1,630	1,445	73.5
	8	290	20			4	1,600	1,440	70.7
	9	275	10			4	1,570	1,430	65.2
V	10	275	20			4	1,595	1,420	63.7
	11	300	(2)			4	1,650	1,380	63.9
VI	12	175	11	4.4	4.6		1,470	1,370	62.4
	13	109	30	5			1,580	1,490	35.5
VII	14	300	20		3	2	1,580	1,470	71.3
	15	310	20		3	2	1,610	1,480	74.0

[1] Carbon powder 2.
[2] Limestone 20.
NOTES:
No. 12. The molten metal was forcibly stirred for 3 minutes by throwing green wood therein.
No. 13. The molten metal was forcibly stirred for 5 minutes by throwing greenwood therein.

What is claimed is:

1. A process for the production of a ferrosilicon consisting essentially of iron and silicon and adapted to be used in the production of a spheroidal graphite cast iron as an additive, comprising placing a slag-making material composed primarily of quick lime or limestone in a ladle lined with a basic refractory material containing a minimum amount of silicon oxides, heating the ladle until the temperature of the lining surface is elevated to about 1,000° C., charging a molten ferrosilicon into

the ladle, maintaining the molten metal in the ladle at a temperature not lower than 1,500° C., imparting a shaking motion to the molten metal in the ladle by eccentrically rotating said ladle, continuing the shaking operation until the reaction has been completed while maintaining the temperature of the molten metal at such level that said molten metal will be at a temperature of not lower than 1,350° C. upon completion of the reaction and casting said molten metal into a casting mold.

2. A process in accordance with claim 1 wherein said ladle lining of basic refractory material is formed of erosion resistant magnesia bricks.

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