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FERRO ALLOY CASTING PROCESS

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ABSTRACT OF THE DISCLOSURE

Method of providing magnesium ferrosilicon in desired sizes with uniform magnesium distribution by controlling the thickness and cooling rate of magnesium ferrosilicon castings.

This application is a continuation-in-part of Ser. No. 523,935, filed Feb. 1, 1966, now abandoned.

The present invention relates to a process for casting alloys. More particularly, the present invention relates to a process for making magnesium ferrosilicon alloy castings which can be crushed to practical industrial sizes without the formation of excessive fines and which castings have a highly uniform magnesium distribution.

In the past it has been the usual practice in making magnesium ferrosilicon for use as an addition agent to pour the molten alloy into large open chills up to about six inches deep and about 5 feet by 5 feet in section. The cast metal was permitted to air-cool and the solid product was then subjected to crushing to obtain a suitable industrially sized product of say 1¼ inches by ½ inch.

In spite of its relative simplicity, there are several serious disadvantages to this prior process, for example the segregation of magnesium is severe and in the usual product the magnesium, for a nominal 9% Mg alloy, would range from 12–15% at the top of the casting to 4–7% at the lower part of the casting. This situation can penalize the user since, after the alloy is crushed to size in order to be on the safe side, the magnesium content of the crushed alloy is frequently assumed to be less than the nominal value.

An additional disadvantage to both producer and user is that the crushing of the aforedescribed magnesium ferrosilicon castings leads to the formation of a large amount of fines, ordinarily at least 20–30% less than ¼×D. On account of this, a fairly large portion of the material is unsuitable for sale since in addition to handling problems, magnesium recovery from the fines, when added to cast iron, is less than from that of the larger particles and uncertain results are obtained.

It is therefore an object of the present invention to provide a process for casting magnesium ferrosilicon whereby the cast product obtained can be crushed to industrially suitable sizes without the formation of excessive fines.

It is another object of the present invention to provide a process for casting magnesium ferrosilicon whereby the cast product obtained has a substantially uniform distribution of magnesium.

Other objects will be apparent from the following description and claims.

A process in accordance with the present invention broadly comprises preparing molten magnesium ferrosilicon and casting the molten alloy in a mold of such dimensions that the thickness of the casting is not more than about 3", and whereby the casting is characterized

by having a highly uniform distribution of magnesium and can be broken into suitable industrial sizes without the formation of excessive fines.

In the practice of the present invention a molten bath of magnesium ferrosilicon is prepared by any conventional technique and at a temperature in the range of 1275° C. to 1350° C. is cast into an elongated mold, e.g. 18 inches or more in length, having a diameter of not more than about 3" or, alternatively slabs are cast having a thickness of not more than about 3".

With higher casting temperatures the alloy becomes unstable, the vapor pressure of magnesium exceeds 1 atmosphere and boiling occurs which results in violent flaring and high losses of magnesium, while at lower temperature the alloy begins to solidify prematurely thus causing serious segregation of magnesium.

Also, with mold diameters, or slab thicknesses larger than about 3 inches, severe segregation of magnesium occurs in the castings.

When the molten metal has been cast, the metal should be quickly cooled in the temperature range of 1250° C. to 925° C. at a rate of at least 50° C./min. in order to avoid segregation of magnesium. It has been found that a copper mold three inches by three inches in section having a circular mold cavity of 1¼ inches in diameter provides a cooling rate of 400° C./min. which is highly satisfactory and preferred. To ensure, in addition to uniform magnesium distribution, good sizing properties, i.e. the absence of fines, the casting should be cooled from temperatures below 925° C. to about 500° C. at a rate of at least 100° C. per minute.

As a result of the foregoing method a magnesium ferrosilicon alloy casting is obtained in which the magnesium is uniformly distributed, and which can be readily crushed to industrial sizes, i.e. 1¼" x ¼" without the formation of excessive fines. Also there is little loss of magnesium due to the fact that the formation of any significant magnesium oxide film is avoided.

Moreover it has been found that when used in the treatment of cast iron significantly higher magnesium recoveries, i.e. 20% and more, are obtained as compared to the use of previously known magnesium ferrosilicon materials.

Table I shows the composition of magnesium ferrosilicon alloys which can be advantageously cast in accordance with the present invention and the following examples further illustrate the present invention.

TABLE I

	Percent
Mg	3–12
Si	40–50
Ce, up to	2.5
Ca, up to	1.75
Al, up to	1.5
Fe	balance

EXAMPLE I

Molten magnesium ferrosilicon containing 6.8% magnesium was prepared and at a temperature of about 1300° C. was cast into a mold. The mold was formed of copper 3 inches by 3 inches in section and having a central circular cavity about 1¼ inches in diameter and about 18 inches long. The cooling rate in the temperature range of 1250° C. to 925° C. was about 400° C. per minute.

Upon solidification of the metal in the mold the casting was placed in a standard tumbling apparatus which comprises a rotatable steel drum about 3 feet in diameter having members attached to the inside surfaces

whereby material inside the drum is repeatedly raised, during rotation, and permitted to drop. After ten drops the material was removed from the drum and was subjected to a screen analysis with the results shown below.

WEIGHT PERCENT OF MATERIAL RETAINED ON SCREEN

Size	Before tumbling test	After tumbling test
1" x ½"	100	98.7
½" x ¼"		0.2
¼" x D		1.1

EXAMPLE II

Following the procedure of Example I, except that the magnesium content of the magnesium ferrosilicon was 7.6%, the results listed below were obtained.

Magnesium analysis

	Percent
Top of ingot	7.4
Bottom of ingot	7.8

WEIGHT PERCENT OF MATERIAL RETAINED ON SCREEN

Size	Before tumbling test	After tumbling test
1" x ½"	100	98.6
½" x ¼"		0.9
¼" x D		0.5

EXAMPLE III

Following the procedure of Example I, except that the magnesium content of the magnesium ferrosilicon was 9.3%, the results listed below were obtained.

WEIGHT PERCENT OF MATERIAL RETAINED ON SCREEN

Size	Before tumbling test	After tumbling test
1" x ½"	100	95.5
½" x ¼"		3.2
¼" x D		1.3

Magnesium analysis of 5 pieces randomly selected from 106 pieces of the 1" x ½" fraction after tumbling test

	Percent
(1)	9.4
(2)	9.4
(3)	9.0
(4)	9.5
(5)	9.3

EXAMPLE IV

Molten magnesium ferrosilicon containing 8% magnesium was prepared and at a temperature of about 1300° C. was cast into molds of different diameter and analyses for magnesium content were made on the castings.

The results were as follows:

Mold	Mg content percent	
	Center	Outside
2 inches square, cast iron	8.3	8.3
4 inches square, cast iron	10.9	7.4

EXAMPLE V

Magnesium ferrosicilon alloy (7.9% Mg) castings were produced following the procedure of Example I and were used to treat twelve ladles from three heats of ductile iron with 0.15% Mg. For comparative purposes one ladle from each heat was treated with 0.15% Mg using regular magnesium ferrosilicon (9.08% Mg) produced by the previous practice of casting molten ferrosilicon into large chills.

The results of chemical analyses conducted on these irons are shown below:

IRON ANALYSES

Heat No.	Ladle No.	Nodularizing alloy	Analyses, percent			Percent Mg recovery	
			TC	Si	Mg	This invention	Regular
X882	1	This invention	3.59	2.46	0.034	22.6	
	2	do			0.035	23.4	
	3	do			0.037	24.6	
	4	do			0.040	26.6	
	5	Regular			0.031		20.6
X883	1	This invention			0.041	27.4	
	2	do			0.039	26.0	
	3	Regular	3.58	2.48	0.031		20.6
	4	This invention			0.045	30.0	
	5	do			0.039	26.0	
X884	1	Regular			0.030		20.0
	2	This invention			0.037	24.6	
	3	do			0.036	24.0	
	4	do			0.036	24.0	

The magnesium ferrosilicon of this invention was found to be more effective in producing the desired nodular structures in that it produced a superior nodular iron microstructure. Also, as shown above, the average magnesium recovery with the material of this invention was 25.4% as compared to 20.4% with the alloy produced by the commercial practice. Allowing for the difference in magnesium content of the alloys, the alloy of the present invention provides a 20% improvement in magnesium recoveries. The use of the expression "diameter" in the foregoing description refers to the diameter of the circle within which the casting cross section can be enclosed and is not intended to exclude castings which are not circular in cross sections.

EXAMPLE VI

Molten magnesium ferrosilicon containing 5.0% magnesium was poured at a temperature of about 1300° C. into a mold 9 inches x 14 inches to a depth of 1 inch. The metal slab was removed from the mold and cooled to about 250° C. at a rate of about 150° C. per minute.

The resulting slab together with others produced in a like manner were placed in the tumbling apparatus described in Example I, allowed to drop 150 times and then subjected to a screen analysis with results shown below.

Size	Before tumbling, percent	After tumbling, percent
+1"	100	5.5
1" x ¾"		34.8
¾" x ¼"		54.0
¼" x 8M		1.4
8M x D		4.4

Five pieces selected at random from the above lot of alloy after tumbling were analyzed for magnesium with the following result.

	Percent, Mg
(1)	5.1
(2)	4.8
(3)	4.9
(4)	5.1
(5)	5.1

EXAMPLE VII

Magnesium ferrosilicon alloy (4.3% Mg) was prepared following the procedure of Example VI and used to treat cast iron as described in Example V. The magnesium re-

covery obtained was 15–20% more than that obtained with chill-cast commercial alloy.

What is claimed is:

1. A process for producing magnesium ferrosilicon alloys comprising:

(1) preparing molten magnesium ferrosilicon alloy

(2) casting the molten ferrosilicon alloy into an elongated mold having dimensions that will result in a casting having a diameter not more than about 3 inches,

the casting temperature of the molten alloy being in the range of about 1275° C. to 1350° C. and the cast alloy being cooled at a rate of at least 50° C. per min. in the temperature range of about 1250–925° C. and at a rate of at least 100° C. per min. from below about 925° C. to about 500° C., the cooling rate being such that an integral casting is obtained.

2. A process in accordance with claim 1 wherein the magnesium ferrosilicon alloy has a composition of about 3 to 12% Mg, 40–50% Si, balance Fe and incidental amounts of cerium, calcium, aluminum and the usual impurities.

3. A process for producing magnesium ferrosilicon alloys comprising:

(1) preparing molten magnesium ferrosilicon alloy containing about 3–12% Mg and 40–50% Si

(2) casting the molten ferrosilicon into the form of slabs having a thickness of not more than about 3 inches

(3) cooling the cast alloy at a rate of at least 50° C. per min. in the temperature range of about 1250–925° C. and at a rate of at least 100° C. per min. from below about 925° C. to about 500° C., the cooling being such that an integral slab is obtained.

References Cited

UNITED STATES PATENTS

1,555,557	9/1925	Darte	75—50 X
2,197,660	4/1940	Glunz et al.	164—136 X
2,452,613	11/1948	Taylor et al.	164—4 X
2,472,071	6/1949	Gathmann	249—111
2,485,492	10/1949	Hubbard et al.	164—4 X
3,197,828	8/1965	Cartoux et al.	164—72
3,221,559	12/1965	Miller et al.	164—4 X
3,236,103	2/1966	Kooken.	
3,323,899	6/1967	Forgeng	164—94 X
3,373,794	3/1968	Crago	164—127
3,382,911	5/1968	Malone	164—94 X
3,429,362	2/1969	Tachimoto et al.	164—70

FOREIGN PATENTS

118,065	1/1944	Australia.

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