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METHOD OF MAKING MALLEABLE CAST IRON

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This invention relates to improvements in the production of malleable iron castings. More specifically it relates to a charge for forming malleable iron castings of a high silicon content.

It is known that a large amount of silicon in an iron reduces the time of annealing, because silicon tends to promote the breaking up of iron carbides during annealing into temper carbon and ferrite. The time of annealing is reduced as above stated with a high silicon content so long as the casting upon cooling and before annealing is free from flake graphite precipitation. However, there has been considerable difficulty in obtaining this condition, since a high silicon content normally causes graphite precipitation. Several methods have been devised to obstruct the flake graphite precipitation.

One method has been to chill the casting as rapidly as possible by the use of a chill mold. The disadvantage of this method is that only certain shapes and designs of castings may be produced with a chill mold. Another method involves the use of certain metals in the melt which inhibit the formation of graphite. However, such ingredients are expensive, and the size of section of casting in which these ingredients are effective is limited.

An object of the present invention is to produce an improved malleable iron casting.

A further object is the production of a malleable iron casting which requires a relatively short annealing period.

Another object is to produce a malleable iron casting of high silicon content in large sections with only a short annealing time.

Still another object is the production of a malleable iron casting of high silicon content without the use of a chill mold or of ingredients obstructing the formation of graphite.

According to my invention I produce malleable iron castings of high silicon content by employing a charge of raw materials in the melt which are completely free or substantially completely free from graphite flakes, nodules, and nuclei. I have discovered and proved that ferrous metals will retain, to a certain extent, the characteristics of the metals melted, and that the presence of graphite flakes or nodules in the raw materials which go to make up the melt causes the formation of graphite in the melt upon solidification. Appreciable amounts of graphite flakes, etc. in the charge produce appreciable amounts of graphite flakes in the final product. Conversely, if the charge is free from graphite flakes originally, there is nothing to start the formation of flakes, and the casting upon solidification is free from graphite.

The raw materials which form the charge for iron castings containing silicon normally include pig iron and malleable iron scrap, the carbon of which is mainly graphitic. An example of a typical charge is as follows:

	Percentage	Carbon	Silicon
Pig iron	30–40	3.80% (3 to 3.25 graphitic carbon).	1–3
Hard iron sprue	40–50	2.40	1
Steel scrap	0–10	.2	.2
Malleable scrap (either railway malleable or agricultural malleable).	10–30	2 (graphitic carbon)	1

The use of materials containing graphitic carbon in the above charge would prevent the use of a large amount of silicon, since there would result a flake graphite precipitation.

When raw materials forming the charge are free from graphite flakes, nodules, and nuclei, the melt solidifies without flake graphite precipitation. Castings of relatively large section may be produced and possess a strength superior to castings produced under the old process with a long period of annealing. I have found that the following raw materials, free from graphite flakes, nodules, and nuclei, may be used: white cast iron sprue or remelt, steel scrap, white cast pig, chilled sections of car wheels, and silvery pig.

Following is a summary of tests carried out under my invention:

Heat No. 1

Charge	Weight	Charge	Carbon	Silicon
	Pounds	*Percent*		
White cast iron remelt	530	43	2.40	1.00
Steel scrap	260	21	.20	.20
Silvery pig	112	9	.60	19.00
White cast pig	330	27	3.30	1.00
	1232			

Analysis of Heat

Carbon	1.79
Silicon	2.45
Manganese	.25
Sulphur	Not determined
Phosphorus	Not determined

Tensile strength	lbs./sq. in.	69,820
Yield point	do	51,666
Elongation	Per cent	17.18
Brinell		146

Time for annealing was about ten hours.

A test bar 4" x 4" x 9", poured into a sand mold, solidified white. This shows absence of carbon in graphite form. Similar results were obtained with a test bar of the same size, 0.2% of ferro-silicon being added to raise silicon to 2.65%.

Heat No. 2

Charge	Weight	Charge	Carbon	Silicon
	Pounds	*Per cent*		
White cast iron remelt	540	45	2.40	1.00
Steel scrap	180	15	.20	.20
Silvery pig	120	10	.60	16.00
White cast pig	360	30	3.30	1.00
	1200			
Carbon raiser	1¾			

Analysis of heat

Carbon	2.03
Silicon	2.31
Manganese	.25
Sulphur	.085
Phosphorus	Not determined

Tensile strength	lbs./sq. in.	68,200
Yield point	do	49,200
Elongation	percent	17.18
Brinell		166

The time of annealing was 7½ hours, as follows:

2 hours 10 minutes	to 1750°
2 hours	at 1750
20 minutes	to 1400
1 hour	at 1400
2 hours	to 1320
Then withdrawn from oven.	

One test bar was bent 160° before failure.

A test bar, to which were added .40% molybdenum and .60% manganese, making a total of .85% manganese, to produce a pearlitic malleable iron, showed the following properties after a 13 hour annealing cycle:

Tensile strength	lbs./sq. in.	79,010
Yield point	do	57,360
Elongation	percent	11.3
Brinell		187

Heat No. 3

Charge	Charge	Carbon	Silicon
	Per cent		
Silvery pig	8	.60	19.00
White cast pig	35.5	3.30	1.00
White cast iron remelt	47	2.40	1.00
Steel scrap	9.5	.20	.20

Analysis of heat

Carbon	2.14
Silicon	2.38
Manganese	.26
Sulphur	Not determined
Phosphorus	Not determined

Range of four test bars

Tensile strength	lbs./sq. in.	63,000 to 66,000
Yield point	do	44,000 to 46,500
Elongation	percent	15 to 19
Brinell		155 to 156

Time of annealing was about ten hours.

Heat No. 4

Charge	Charge	Carbon	Silicon
	Per cent		
White cast iron remelt	40.5	2.40	1.00
Hard iron high silicon remelt	40.5	2.20	2.30
Steel scrap	1.00	.20	.20
Silvery pig	6.00	.50	19.00
White cast pig	12.00	3.30	1.00

Analysis of heat

Carbon	2.07
Silicon	2.22
Manganese	.23
Sulphur	Not determined
Phosphorus	Not determined

Range of four test bars

Tensile strength	lbs./sq. in.	63,000 to 66,000
Yield point	do	46,500 to 48,000
Elongation	percent	15 to 17½
Brinell		163 to 166

Duplicate bar bent 155° before failure.

Time of annealing was about ten hours.

The bars tested for strength from the above heats were of the size conforming to A. S. T. M. standards.

In each of the above heats, test bars measuring 4" x 4" x 9" in size appeared white under fracture. This indicates the absence of graphitic carbon, and, consequently, that an iron is being produced which will be of satisfactory strength after the short annealing time of 8 to 10 hours.

A typical charge for production under commercial operating conditions is as follows:

Charge	Charge	Carbon	Silicon
	Per cent		
Silvery pig	7.00	.60	19.00
White cast iron remelt	45.00	2.40	2.30
Steel scrap	21.00	.20	.20
White cast pig	27.00	4.30	1.00

It is, of course, to be understood that the various constituents making up the charge may be varied as desired, depending upon the amount of each constituent available and the percentage of carbon and silicon to be present in the casting. The constituents might well be kept within the following limits:

	Percent of charge
White cast iron remelt	30–60
Steel scrap	10–50
Silvery pig	3–20
White cast pig	15–50

In the above the white cast iron remelt may have up to 2.5% silicon and from 2 to 2.5% carbon in combined form, the steel scrap about .2% silicon and .2% carbon, the silvery pig from 15 to 20% silicon, and the white pig iron up to 1% silicon and from 3 to 4.3% carbon in combined form.

It is not necessary to use all of the above ingredients or any one of them. The important thing is that there be substantially no carbon in the ingredients in graphitic form.

I have stated that the raw materials forming the charge should be free from graphite flakes, nodules, and nuclei. This condition need not be maintained too strictly, for I have discovered that small amounts of graphitic carbon may be present in the charge without affecting the casting. There appears to be a point in percentage of graphitic carbon below which graphitic carbon will not form in the casting, while above this point graphitic carbon will begin to appear. It is to be noted that the carbon raiser of Heat No. 2 is entirely graphitic carbon. I introduced this into the charge with the hope of finding out how much graphitic carbon could be present in the charge without graphitic carbon in the casting. The white cast pig in the charge was considerably mottled and so also provided some

graphitic carbon. However, test bars from this heat were white and free from graphitic carbon.

It will be appreciated from the foregoing description that I have discovered a novel way of producing a malleable cast iron of a high silicon content. The novelty lies in the use of a charge for the casting which includes the usual raw materials containing iron, carbon and silicon, but which materials are completely free from graphitic carbon or are free to the point where the small amount of graphitic carbon does not cause the formation of graphitic carbon in the casting. A casting, formed in this manner, has the decided advantage of requiring a much shorter annealing time for malleabilization. Furthermore, the castings produced under my invention have a very high tensile strength and yield point strength as is evident from the results of the heats tabulated above. These strengths are considerably higher than those obtained with casting produced prior to my invention.

The intention is to limit the invention only within the scope of the appended claims.

What is claimed is:

1. In a method of making malleable cast iron, the step of melting a charge consisting of materials containing in addition to normal impurities only iron, silicon, and carbon, and being substantially free of carbon in graphitic form and proportioned to produce a white cast iron, when cast in a sand mold, containing at least 1.75% carbon and at least 2% silicon.

2. In a method as specified in claim 1, the amount of graphitic carbon in the charge being so small as to be without effect in causing the production of graphitic carbon in the cast iron before malleabilizing.

3. In a method of making malleable cast iron, the step of melting a charge consisting of portions of steel scrap, metal of the group consisting of white cast iron remelt and white pig iron, and iron containing in addition to carbon only a high amount of silicon sufficient to produce the amount of silicon required for an analysis of at least 2% silicon in a white cast iron, when cast in a sand mold, containing also at least 1.75% carbon, there being substantially no graphitic carbon in all the aforementioned portions.

4. In a method as specified in claim 3, the amount of graphitic carbon in all the aforementioned portions being so small as to be without effect in causing the production of graphitic carbon in the cast iron before malleabilizing.

5. In a method of making malleable cast iron containing at least 1.75% carbon and at least 2% silicon, the step of melting a charge consisting of 30 to 60% of material containing up to 2.5% silicon, 2 to 2.5% carbon in combined form, and the balance substantially all iron; 10 to 50% of material containing about .2% silicon and about .2% carbon and a balance substantially all iron; 3 to 20% of material containing 16 to 19% silicon and the balance substantially all iron; and 15 to 50% of material containing up to 1% silicon, 3 to 4.3% carbon in combined form, and the balance substantially all iron, the above ingredients being so proportioned as to produce a white cast iron, when cast in a sand mold, containing at least 1.75% carbon and at least 2% silicon.

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