

UNITED STATES PATENT OFFICE

2,207,350

METHOD OF MAKING ALLOYS

Clarence H. Lorig and Harry B. Kinnear, Columbus, Ohio, assignors to Battelle Memorial Institute, Columbus, Ohio, a corporation of Ohio

No Drawing. Application July 4, 1939,
Serial No. 282,826

2 Claims. (Cl. 75—122)

Our invention relates to method of making alloys. It is especially directed to an alloyed, high silicon pig iron and more particularly to a high silicon pig iron suitable for use as a master alloy designed for introduction into cast iron, steel, malleable iron and other related engineering products.

Heretofore, in the production of alloyed cast iron from cupola metal it has been customary to employ the alloying elements in concentrated form as additions to the cupola or to the metal in the ladle. In the case of irons alloyed with copper, adding of the copper to the cupola as pure copper pig, scrap, shot, wire, et cetera is responsible for the fact that the copper content of the cupola metal sometimes fluctuates appreciably. The fluctuations are occasioned by the melting of the copper in the early stages of melt down of the cupola charges and the accumulation of part of this molten copper in metal from previously melted charges that is still in the cupola. Thus the cupola charge containing copper in concentrated form does not melt uniformly, but the copper with a melting point lower than the melting point of any of the other constituents in the charge tends to melt ahead of the pig iron and scrap and to pass into the hearth of the cupola considerably before the iron with which it is intended to alloy. The result is that the lower layers of the charge are more rich in copper than the upper layers thereof.

Since there has been no satisfactory procedure for alloying copper to iron in the cupola, the practice of adding copper to the forehearth or ladle has been resorted to. This practice has not been satisfactory. In the first place, the addition of the copper in the ladle tends to unduly chill the metal in the ladle below the casting temperature, which places a limit upon the maximum amount of alloy that can be added. In the second place, there results a lack of uniformity of distribution of the copper in the cast iron unless vigorous stirring or reladling is resorted to, which results in practical drawbacks or increased costs or both. In the third place, this practice requires accurate knowledge of the weight of the cast iron in the ladle in order to insure the addition of a definite and proper percentage of the copper.

The non-uniform distribution of the copper in the ladle charge is partially due to the differences in densities of copper and iron. Unless precautions are taken to thoroughly mix the copper and iron and to obtain uniform distribution of the copper in the iron, the composition of the metal

in the top and bottom of the ladle are likely to be different.

One object of our invention is the attainment of cast iron, steel, malleable iron and other related products which contain copper and wherein the copper is substantially and uniformly distributed therethrough.

Another object of our invention is the introduction of copper into metals of the type indicated by such a method as to insure that the copper will be uniformly distributed throughout.

Another object of our invention is the introduction of either molybdenum or nickel, or copper either separately or together into cast iron, steel, malleable iron and other related products.

Other objects and advantages of our invention will become apparent from the following description and claims.

Our invention contemplates the provision of a novel constituent for furnace charges in the form of a master alloy or of a plurality of elements in dilute form and having a melting rate and temperature substantially the same as the other ferrous constituents of the charge. More specifically, we have found that an alloy containing a high silicon pig iron and containing copper can be added to the furnace charge and that, if the proper proportions of materials are utilized to form the master alloy, the melting point of this alloy will be substantially similar to the melting point of the ferrous metal in the furnace or at least sufficiently so that in cupola practice the master alloy will not melt ahead of the pig iron and scrap and, therefore, will not pass into the hearth of the cupola materially before the iron with which the copper is intended to alloy.

High silicon pig iron, commonly known as silvery iron, is made in the blast furnace and has a silicon content in the range from 4.5 to 17 per cent. It contains 0.5 to 3.5 per cent carbon, the carbon content decreasing with an increase in silicon content, 0.2 to 4.0 per cent manganese, 0.01 to 1.5 per cent phosphorus, and very small amounts of sulfur. We have found that as much as 20 per cent copper can be added to such silvery iron without having the copper segregate.

In pig irons of normal silicon contents, i. e., between 0.5 and 3.5 per cent silicon, the amount of copper that can be added is limited by the fact that there is a limited solubility of copper in molten iron in the presence of carbon. Some authorities give this limit for copper in normal pig iron compositions as lying between 4 and 5 per cent. The excess copper separates from the iron and because of its greater density settles out

forming a distinct layer at the bottom of the pigs on solidification. Therefore, pig irons of normal silicon content are limited to rather low copper contents; whereas we have found that high silicon pig iron of the silvery iron type may keep in solution much higher copper contents. In excess of 4 per cent, we found that silicon increases the solubility of copper in molten iron-carbon base alloys very markedly so that in silvery iron grades the copper content of pig iron may be raised as high as 20 per cent.

Pigs of silvery iron six inches deep cast in sand molds were used to demonstrate the absence of segregation of copper. As examples of the absence of segregation of copper silvery irons of the 6 per cent and 10 per cent silicon grades were alloyed respectively with 6 per cent and 10 per cent of copper. The top and bottom of the pigs were then analyzed for carbon, silicon, manganese and copper as shown.

	6% silicon+6% copper		10% silicon+10% copper	
	Top of pig	Bottom of pig	Top of pig	Bottom of pig
Total carbon.....	Percent 2.46	Percent 2.43	Percent 1.74	Percent 1.74
Silicon.....	6.8	6.8	10.10	10.20
Copper.....	6.4	6.4	10.40	10.30
Manganese.....	1.21	1.20	2.13	2.13

There was no concentration of the copper toward the bottom of the slowly cooled pigs showing that the copper was in solution in the molten iron before its solidification.

High silicon or silvery pig iron is made in the blast furnace from iron ore and silica by reduction with coke and coal. Control of silicon is effected through the composition of the charge and the temperature of operation. In preparing the alloyed grades of silvery iron the alloying constituents may also constitute part of the blast furnace charge. Copper for example may be incorporated into high silicon pig iron by charging suitable amounts of virgin or scrap copper or copper ores with the usual silvery iron blast furnace charge. If copper ores are used as a source of copper, they will be reduced completely to metallic copper none of which would be lost in the slag. The copper bearing silvery irons may, of course, be prepared by mixing solid or molten copper with molten silvery iron in a ladle.

Many of the high strength cast irons contain alloy combinations of copper and molybdenum, or copper and nickel, or copper, nickel and molybdenum. We have found that silvery irons containing various combinations of these elements in correct proportions for foundry use are producible in the blast furnace or by mixing in the ladle.

Molybdenum may be introduced into the high silicon or silvery iron by adding ferro-molybdenum, molybdenum oxide, calcium molybdate, or suitable molybdenum-bearing ores to the blast furnace charge. Recoveries of molybdenum are complete and there is no effect of the molybdenum on the blast furnace operation. Either copper or nickel can be incorporated with the molybdenum by adding them as metals or ores in the same charges as the molybdenum. None of the molybdenum or nickel are lost to the slag and both elements are soluble in pig iron in all proportions.

The invention therefore includes a high silicon pig iron alloyed with copper, copper and nickel, copper and molybdenum, or copper, nickel and

molybdenum for use in the preparation of alloyed cast irons in which substantially all the alloy is obtained from the high silicon pig iron.

The composition range for the alloyed, high silicon pig iron is set forth as follows:

	Per cent
Carbon.....	0.5 - 3.5
Silicon.....	4.5 -17.0
Manganese.....	0.2 - 4.0
Phosphorus.....	0.01 - 1.5
Sulfur.....	0.005- 0.2
Copper.....	5.0 -20.0
Iron.....	Balance

The iron may be further alloyed with nickel, molybdenum, or nickel and molybdenum in amounts up to 10 per cent nickel and up to 7 per cent molybdenum.

In the following table some of the typical compositions of alloyed silvery iron are listed. It is understood that these compositions are merely typical examples of a few of the large variety of grades of alloyed silvery pig iron coming within our invention.

Carbon	Silicon	Manganese	Phosphorus	Sulfur	Copper	Nickel	Molybdenum
Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
2.6	6.0	1.0	0.03	0.02	6.0		
2.6	6.0	3.0	0.03	0.02	6.0		
1.75	10.0	1.0	0.03	0.02	10.0		
1.75	10.0	4.0	0.03	0.02	10.0		
0.85	15.0	1.0	0.03	0.02	20.0		
1.75	10.0	1.0	0.03	0.02	10.0	8.0	
1.75	10.0	1.0	0.03	0.02	10.0	8.0	5.0
1.75	10.0	1.0	0.03	0.02	10.0		5.0
1.75	10.0	3.0	0.75	0.02	10.0		

It should be understood that we preferably use from 5 to 20 per cent copper in our high silicon pig iron. However, it is within the scope of our invention to use copper in percentages ranging from 2 per cent to 20 per cent.

The use of alloyed, high silicon pig iron in the foundry obviates such difficulties as are experienced in adding the alloying materials in concentrated form to the furnace or cupola or in the ladle. The alloyed, high silicon pig iron has substantially the same melting temperature as the rest of the ferrous constituents in the charge, hence it melts at the same rate as the remainder of the charge, and as it is distributed uniformly in each of the individual metal charges in the cupola it assures uniform melting and distribution of the alloy constituents in the cast iron. The alloy content of cast iron is accurately controlled by varying the grade and proportions of alloyed, high silicon iron used in the cupola charge. The practice of using copper-bearing silvery iron in preparing copper-bearing cast iron likewise obviates the chilling of the metal in the ladle, a condition met with in the existing method of alloying copper to cast iron in the ladle.

The application of the alloyed, high silicon pig iron of our invention in cupola melting involves no departure in cupola operation from present practice. The proportions used may vary up to 25 per cent of the total metal in the charge.

It will be understood that while we specifically describe alloying of cupola iron with copper, copper-nickel, copper-molybdenum, or copper-nickel-molybdenum by means of alloyed, high silicon pig iron, such applications are to be considered as merely typical of a variety of applications for the pig iron. It may also be used to introduce alloying elements into electric and air furnace cast

irons, into malleable iron, into steel and into other related ferrous engineering materials.

It will be seen from this that we have provided a novel master alloy embodying high silicon pig iron and which may embody one or more of various alloying elements, which master alloy will have substantially the same melting point as the metal into which they are to be introduced so that the elements thereof may be uniformly distributed throughout the metal of the cupola charge. It will also be seen that we have provided a novel method which comprises introducing various alloying elements into a cupola charge through the medium of a master alloy containing high silicon pig iron.

As a result of our invention, it is possible to produce copper-bearing cast iron of better and more uniform quality than at present. Likewise, this copper-bearing cast iron may be produced at a cheaper price, thus increasing the demand and use of the product.

Having thus described our invention, what we claim is:

1. A method of making copper-containing ferrous alloys having a substantially uniformly dis-

tributed copper content, which comprises preparing a cast ferrous-base master alloy containing 4.5 to 17 per cent silicon, 0.5 to 3.5 per cent carbon, and between 2 and 20 per cent copper, said master alloy being further characterized by having substantially the same melting temperature range as other ferrous constituents in a melting charge, charging the said master alloy and other ferrous constituents into a melting furnace in such proportions that the master alloy supplies sufficient copper to bring the copper content of the charge to the desired total, and melting the said master alloy and other constituents substantially simultaneously, thereby forming a molten ferrous alloy having the desired copper content substantially uniformly distributed therein.

2. The method of claim 1, wherein said master alloy is composed of 0.5 to 3.5 per cent carbon, 4.5 to 17 per cent silicon, .01 to 1.5 per cent phosphorus, .001 to 0.2 per cent sulfur, 0.2 to 4 per cent manganese, 5 to 20 per cent copper, and the balance substantially iron.

CLARENCE H. LORIG.
HARRY B. KINNEAR.