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METHOD OF PREPARING GRAY CAST IRON OF IMPROVED CHARACTERISTICS

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This invention relates to a method of preparing gray iron with improved physical characteristics and more particularly to a method of making high strength cast iron in electric furnaces.

Gray cast iron is usually made by casting from a cupola or other combustion type of furnace. In such type of furnace, it is practically impossible to secure temperatures sufficiently higher than the melting points of the cast iron mixtures or alloys to produce the improved physical characteristics desired. We have found, however, that if advantage is taken of the high temperatures available in electric furnaces to raise the temperature of the molten iron mass considerably above its normal pouring temperature, a cast iron having greatly improved physical characteristics can be obtained. We ascribe this result to the fact that the solubility of carbon in iron increases with the temperature, at least up to a point far beyond the range of carbon in gray cast iron, and that therefore by substantially superheating the molten charge, all of the carbon present goes into solution in the iron, or into combination therewith as Fe_3C. The formation, during some stage of the heating operation, of a composition which, if it were then cast under conditions favoring the production of white iron, would produce white iron, has been found to result in a cast iron of very superior physical properties to those of ordinary gray cast iron.

We have further found that it is advantageous to use a movable type of electric furnace for the purpose of automatically and mechanically stirring or agitating the bath. Preferably we employ a rocking, indirect arc type of electric furnace for making the cast iron of our invention. In this type of furnace, the rocking movement tends to produce a product of greater uniformity and the use of the indirect arc makes it possible to control the composition of the metal much more closely than is possible in other types of electric furnace, such as the direct arc type. In this latter type, there is a possibility of overheating the metal locally and burning out the carbon and possibly the silicon, or under some conditions there is a possibility of increasing the carbon content due to inclusion in the melt of carbon particles from the electrodes or to dissolution in the metal bath of carbon from the electrodes. In all of the commercial types of electric furnaces, however, the higher temperature attainable and the ease with which the composition of the charge may be varied or the composition of the bath be adjusted at will make for greater uniformity and for higher quality products than is possible in the ordinary cupola-furnace.

It is therefore an important object of this invention to provide a method of making cast iron of improved characteristics by a special heat treatment carried out in an electric furnace.

It is a further important object of this invention to provide a method of producing gray cast iron of improved physical characteristics by superheating the iron metal in a rocking type indirect electric arc furnace.

Other and further important objects of this invention will become apparent from the following description and appended claims.

The charge for the electric furnace in making gray cast iron of our invention may be of either gray iron or white iron composition, the necessary ingredients, if any be required, to insure the condition of white iron analysis at some stage during the heating operation and of gray iron analysis prior to pouring, being added at appropriate stages of our process. If the initial composition were that of gray cast iron, then steel scrap or the equivalent would be added to lower the carbon and silicon content prior to the step of superheating the charge. For the sake of heat economy or other economic conditions, the electric furnace may be charged with molten iron of either gray iron or white iron composition; or solid materials, such as cast iron and/or steel scrap and/or pig and/or borings of either composition may be used solely or in combination with the molten iron in any proportion.

After the electric furnace has been charged, the charge is heated to a temperature at which the metal mass is molten, if the mass is not already in this state at the start. As previous-

ly stated, we prefer to use a rocking type of electric furnace employing an indirect arc for heating, since the combination of the rocking movement and the use of the indirect arc makes possible the production of a cast iron of superior quality to that which can be produced in other types of electric furnace.

The composition of the molten metal mass at this stage should be such as to produce white cast iron if then poured from the furnace, that is, the mass should contain between 2.00 and 4.00 per cent carbon and should be relatively low in silicon. The molten mass is then superheated to a temperature of between 2800 and 3100° F., preferably to about 2950° F. Such high temperatures as these are obtainable only in an electric furnace and therefore have never been attained in the ordinary cupola-furnace. The purpose of superheating the iron charge is to insure a complete dissolution of the carbon in the iron. At ordinary temperatures of the cupola-furnace, it is known to be practically impossible to effect complete solution of the carbon in the iron but because of the greater solubility of carbon at higher temperatures and due to the movement imparted to the electric furnace used in our process, as well as to the fact that the metal composition is adjusted to within a range most favorable to the dissolution of carbon in the iron, complete dissolution of the carbon in the iron can be obtained. It will be understood, however, that although we prefer to obtain complete solution or combination of the carbon at some stage in our process, it is nevertheless possible to secure within the scope of this invention some of the benefits thereof if instead of complete dissolution only substantial dissolution of the carbon is effected.

We attribute the improved physical characteristics of the gray iron resulting from our process largely to this ability to put all of the carbon into solution or into combination with the iron at some stage of our process. These improved characteristics are believed to be due to the fact that the graphite upon being precipitated during cooling of the melt is more regularly distributed, more uniformly dispersed and in finer more nodular-like condition throughout our product than is the case in ordinary gray cast iron.

Preferably, the electric furnace is oscillated at about two to four oscillations per minute from the time the metal becomes molten until the time of pouring. It will be understood that the process may be operative either as an intermittent or batch process, or as a continuous one. In the former case, a heat or charge of metal may be processed, tapped, the furnace emptied and the operation repeated. In the continuous process, definite quantities of materials may be charged in during the working day in accordance with a more or less regular schedule, alternately charging and tapping a portion of the contents of the furnace while maintaining throughout the day a residual bath of metal in the furnace.

After the charge has been heated to a temperature of between 2800 to 3100° F. for a short period of time, the necessary ingredients, if any be required, to convert the white iron composition into gray iron upon pouring are added. For instance, if the silicon content is low, a silicon containing substance, such as ferro-silicon, is added to bring it up to the content required to produce a gray structure in the castings to be poured. Since the compositions of white and gray cast iron are well known, the method of procedure at this point will be understood by those skilled in the art. By virtue of the movement of the charge during the heating operation, any contained gases, slags or other inclusions that may be in the metal are released.

The charge is poured in the usual manner. For instance, if castings of approximately ½″ cross-sectional thickness are to be poured in green sand molds, it would be found desirable for purposes of maximum physical strength to have a total carbon content of approximately 2.50% and silicon content approximately 2.30%. Castings of ¼″ cross section would require approximately 2.60% total carbon and 2.75% silicon and ⅛″ sections would require approximately 2.60 to 2.75% total carbon and 3.00% silicon, the other ingredients in the iron being properly proportioned. It will be understood that the foregoing figures merely serve to illustrate specific compositions in typical cases and are not to be taken as in any way limitations on our invention.

The following is given as a typical heat carried out in accordance with our invention:

Example

The furnace is charged with 1000 lbs. of pig iron containing approximately 4.20% carbon, 2.0% silicon and 0.65% manganese, besides the other metalloids commonly present. This pig iron is melted and when it is substantially all in a fused condition, steel scrap is added to the molten metal in the furnace until 650 lbs. of steel scraps have been introduced. Since the silicon and carbon content of steel are very low, they may for practical purposes be ignored. After addition of the steel scraps, the analysis of the melt will then be approximately 2.54% carbon, 1.21% silicon and 0.51% manganese.

Assuming that the physical properties desired and the nature of the casting to be poured are such as to call for a composition of approximately 2.50% total carbon, 2.25% silicon and 0.9% manganese, it is evident that additional manganese and silicon must be added to the metal charge. The additional quantity of manganese is supplied by adding 8.04 lbs. of ferro manganese containing

80% manganese. The ferro manganese may be added at various stages of the heat but we prefer to add it before the superheating period rather than after the metal has been superheated. The requisite additional amount of silicon is added after the molten mass has been superheated to above 2800° F., say 2950° F., before tapping. To insure the proper gray iron structure in the casting to be poured, 34.2 lbs. of ferro silicon of 50% silicon content are added to bring the silicon content in the final casting to approximately 2.25%.

The product of our invention is a gray cast iron having higher tensile strength, higher transverse strength, higher impact value and improved deflection value over the usual grades of gray cast iron. Furthermore, our product has improved wearing qualities, improved machineability, greater resistance to shock and improved pressure qualities.

Other advantages of our process reside in the absence or retardation of "growth" and warpage in castings subjected to repeated heating and cooling.

The following table will serve to illustrate specifically the improved transverse and tensile strengths of our product as compared with (1) ordinary cupola gray cast iron, and (2) ordinary gray cast iron that has been superheated but not otherwise treated in accordance with this invention:

	Transverse strength	Tensile strength
	pounds	*lbs./sq. in.*
(1) Cupola gray cast iron	4000	30-35,000
(2) Superheated gray cast iron	4800	40,000
(3) Our product	5-8000	50-70,000

These superior results are obtained through the improved grain structure, the form and distribution of the graphitic carbon in the iron and the thorough homogeneity of the metal, which is of pearlitic or sorbitic structure. It is our theory that the presence of white iron composition at some stage of the process is essential in producing gray cast iron of maximum physical characteristics. The ability to convert from white iron composition to gray iron composition is essential and inherent in our process. Insofar as a high degree of superheat is esential in producing iron of maximum physical characteristics, the use of an electric furnace or other device for obtaining such degree of superheat is essential to the carrying out of our method. The use of an electric furnace not only affords means for accurately adjusting the composition of the molten metal at will but also enables the obtaining of a much purer product than is possible of obtention in a fuel fired furnace. Furthermore, the mixing action of the rocking, indirect arc type furnace is highly advantageous in insuring the highest quality results.

We are aware that numerous details of the process may be varied through a wide range without departing from the principles of this invention, and we, therefore, do not purpose limiting the patent granted hereon otherwise than necessitated by the prior art.

We claim as our invention:

1. In the method of preparing gray cast iron of improved characteristics, the steps which comprise superheating by means of an electrically developed heat to a temperature of from 2800 to 3100° F. a molten mass having the composition of white iron, simultaneously agitating said molten mass during continued superheating until substantially all of the carbon present is dissolved in the iron and graphitizing to form gray cast iron.

2. In the method of preparing gray cast iron of improved characteristics, the steps which comprise superheating by means of an indirect electric arc to a temperature of from 2800° to 3100° F. a white iron melt, simultaneously rocking said melted mass during continued superheating until substantially all of the carbon present is dissolved in the iron, and graphitizing the mass to form gray iron upon pouring.

3. In the method of preparing gray cast iron of improved characteristics, the steps which comprise superheating to a temperature of from 2800° to 3100° F., a molten mass of iron having the analysis of a white iron and simultaneously agitating said molten mass during continued superheating until substantially all of the carbon present has been dissolved in the iron and graphitizing the mass to form gray cast iron.

In testimony whereof, we have hereunto subscribed our names at Chicago, Cook County, Illinois.

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