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MANUFACTURE OF MALLEABLIZED WHITE CAST IRON

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Fig. 1

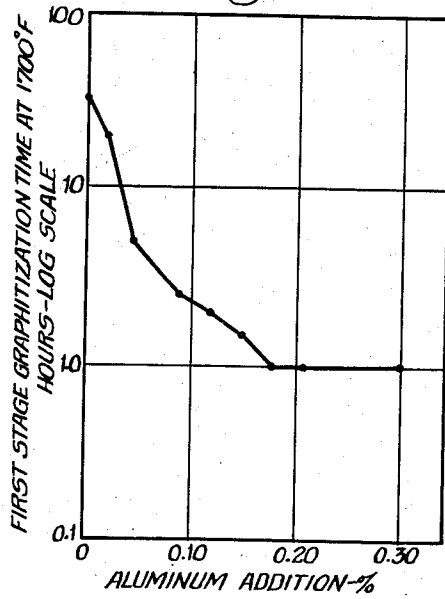
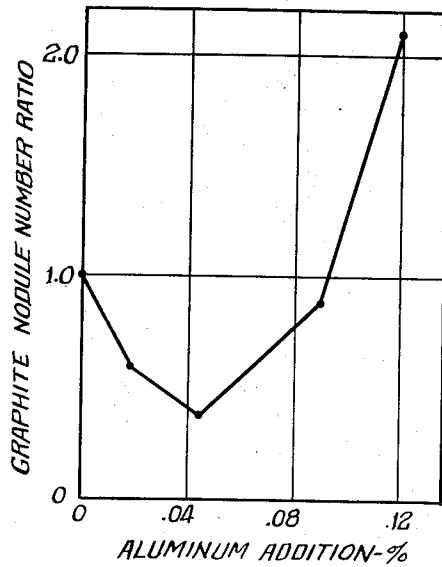


Fig. 2



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## MANUFACTURE OF MALLEABLIZED WHITE CAST IRON

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1 Claim. (Cl. 75-130)

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This invention relates, generally, to the manufacture of white cast iron and it has particular relation to the control of the annealing of graphitized or malleablized white cast iron, and the chemical composition and the physical properties thereof.

In the manufacture of white cast iron for malleable purposes, it has not been normal melting practice to accomplish deoxidation by ladle or furnace additions. It has been considered that the high silicon content of cast iron lowers the oxygen residual in the iron through the formation of silica or silicates to such a value that deoxidation by the addition of another material is unwarranted. One reason for this is that it had not been realized previously that the fixing of the oxygen by a powerful deoxidizer might produce effects of considerable significance in the malleablizing process when applied to white cast irons so treated.

Accordingly, among the objects of this invention are: to determine the time required for the malleablizing heat treatment of white cast iron so that the same will be accomplished in a minimum of time; to control the physical properties over a wide range so as to provide readily those desired for a particular application; to add a deoxidizer to the molten iron in an amount so as to provide the minimum time for heat treatment for a given specification of physical characteristics; to demonstrate how the amount of deoxidizer to be added can be determined for any iron composition and melting practice; and to produce irons with lower silicon contents and faster annealing characteristics than have heretofore been commercially feasible.

Other objects of this invention will in part be obvious and in part appear hereinafter.

For a more complete understanding of the nature and scope of this invention, reference can be had to the following detailed description taken together with the accompanying drawing, in which:

Figure 1 shows a curve which indicates the time required for complete first stage graphitization as ordinates plotted against percentage aluminum addition as abscissae; and,

Figure 2 shows a curve which indicates the ratio of the number of graphite particles in the untreated iron to the number of graphite particles in the aluminum treated iron as ordinates plotted against the percentage aluminum addition as abscissae.

The curves shown in Figures 1 and 2 apply to irons from a particular foundry and should be

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considered typical for that foundry. Other similar curves may be developed for the metal produced in another foundry.

When the present invention is employed, the time required for the malleablizing heat treatment of white cast iron can be reduced to a minimum, the number of graphite nodules developed during the heat treatment may be controlled, and desired physical properties may be obtained ranging from better than grade A to substantially any lesser values that may be desired. Also, a wide variety of pearlitic malleable irons may be produced in this way. The present invention depends for its success upon the relating of the oxygen content of the iron and extent of its deoxidation with a powerful deoxidizer to these variables, and an initially satisfactory melting practice which will produce an iron that will respond to deoxidizing additions according to the manner herein described. Further, this invention shows how to determine whether and when a foundry is producing an iron which is basically satisfactory in containing sufficient oxygen so that it will respond to the deoxidizing treatments as set forth hereinafter. The extent of deoxidation by additions to molten white cast iron determines the time required for its annealing.

In order to practice this invention, curves such as those shown in Figures 1 and 2 are drawn for the particular iron composition to be used, the melting practice employed, and other variable conditions for a given foundry. From these curves the amount of the deoxidizer to be added may be selected so as to obtain any one of the following:

1. Shortest annealing time
2. Maximum physical properties
3. An intermediate effect or characteristic which is a compromise between the shortest annealing time and maximum physical properties.

In practicing the present invention various deoxidizing elements or combinations thereof can be employed. For example, aluminum, zirconium, titanium, magnesium, boron, vanadium, calcium, or silicon can be employed. Combinations of these elements can be used and other elements having a powerful affinity for oxygen in molten white cast iron also can be employed. Specifically aluminum ranging from .005 to .15 per cent, titanium ranging from .02 to .25 per cent, or zirconium ranging from .02 to .30 per cent can be employed.

For the fastest annealing characteristics or shortest annealing time, the addition of the deoxidizing agent should be sufficient to approach

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complete deoxidation and still maintain the physical properties above the minimum values which are required. Such additions for this purpose would range from .04 to .15 per cent aluminum, .05 to .25 percent titanium, and from .05 to .30 per cent zirconium or equivalent amounts of other deoxidizing elements or combinations thereof.

It is preferred that the deoxidizing agent be added to the ladle and that the molten metal then be poured into it. The metal so treated should be cast into molds immediately.

The duration and temperature cycle of the heat treatment may be carried out over a broad range along the lines of conventional malleablizing treatment but keeping in mind that the steps employed should be such as to reduce the time required to a minimum. The minimum time for first stage graphitization may be selected from the curve shown in Figure 1 for a given amount of aluminum addition. For other deoxidizers a similar set of curves would be prepared. Heating to the temperature indicated on this curve may be accomplished as rapidly as furnace equipment and casting design permit. Also, the cooling from the first stage to the second stage graphitization temperature may be accomplished as rapidly as furnace equipment permits. The second stage graphitization is carried out as rapidly as the silicon content and deoxidizer content will cause it to occur and generally would call for the cooling of the casting from about 1450 degrees F. to about 1200 degrees F. at rates varying from 80 degrees F. per hour down to 7 degrees F. per hour. For example, a complete heat treatment cycle may consist of heating the casting to from 1700 degrees F. to 1750 degrees F. in one to three hours, holding at this temperature range for from one to ten hours, cooling rapidly to 1430 degrees F., and then cooling from this temperature to 1300 degrees F. at the rate of from 20 degrees F. to 40 degrees F. per hour. The total heat treating time should range from five to twenty hours or longer.

In practicing this invention it is essential that the amount of the deoxidizing addition required to provide the shortest annealing time and required physical properties be very accurately controlled. If too great an amount of deoxidizer is added, the annealing time is correspondingly reduced but there is an undesired lowering in the physical properties. Accordingly, an important part of the present invention is to show the exact amount of deoxidizing addition that is required to provide the shortest annealing time for a given set of physical characteristics.

The amount of addition agent which is used is not necessarily the same for each heat or batch of molten iron for the reason that the percentage of oxygen in the molten iron prior to the deoxidation is an uncontrolled variable in the usual foundry practice. The oxygen or degree of oxidation in the molten iron may vary from .005 per cent to .20 per cent and, accordingly, the percentage of deoxidizer addition must be correspondingly varied to a chemically equivalent extent. In order to determine the degree of oxidation of the molten metal so as to select correctly the percentage of deoxidizer which must be added, the following test can be conducted on a given batch of molten white cast iron. If a foundry has an unusually well standardized melting practice, where the oxygen is well controlled, this test may not be necessary.

To a series of several small ladles increasing

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percentages of the deoxidizer are added. For example, aluminum in the percentages .02 per cent, .05 per cent, .08 per cent, .11 per cent, .14 per cent, and .17 per cent, are added to the small ladles. Then molten iron from the heat or batch to be tested is poured into each ladle. From each of these ladles having the different percentage of aluminum addition, a test sprue is poured of such a diameter and length that it may be fractured readily. After the test sprues have cooled and solidified, they are broken transversely and the fractures are examined for mottling. The minimum percentage of deoxidizing addition required to produce mottling in the white cast iron establishes the maximum percentage of deoxidizer which is required to deoxidize the metal completely. Experience with this test in a particular foundry ultimately will reduce the number of test sprues required until usually only one or two are required to provide the necessary information. While the oxygen is not completely eliminated from an exact scientific standpoint when mottling is produced, the amount of oxygen remaining is ineffective. The term "complete deoxidation," as used herein, describes that degree of deoxidation which is produced by a deoxidizing addition of aluminum of sufficient magnitude to cause mottling in the test sprue.

It will be apparent that this test determines the degree of oxidation of the molten iron prior to any deoxidation treatment. This, in itself, provides for controlling the physical characteristics of the resulting product. The quality of the malleable iron may be improved by using this test. For example, in a foundry where the melting practice does not introduce sufficient oxygen into the molten metal so that the desired physical characteristics result, the underoxidized character of the molten metal can be determined and the melting practice modified so as to be more oxidizing. Further tests can be made with aluminum as the deoxidizing agent, for example, until the desired physical properties and annealing time are obtained. Thus the test above set forth can be used as a process control by setting up a standard deoxidation specification. For example, the addition of .08 per cent of aluminum could be specified as a minimum for producing the mottling of the iron; this in order to control the physical properties and time of annealing. By specifying a minimum and a maximum per cent of deoxidizer addition necessary to produce the mottling effect, it is possible to control the oxygen content of the molten metal and its annealing characteristics with respect to the physical properties and annealing time required.

In accordance with this invention, the deoxidizing treatment of the molten metal can be practiced when the extent of oxidation thereof has been determined by the test set forth above. It is preferred to have the molten metal sufficiently oxidized so that a minimum of .08 per cent aluminum is required to produce the mottle in the test. The higher the amount of aluminum required to produce mottle in the test, the greater the deoxidizing treatment may become. While aluminum has been mentioned as being employed in the test to determine the degree of oxidation of the molten iron, it will be understood that the other deoxidizing elements mentioned hereinbefore can be employed in lieu of aluminum.

In order to speed up the annealing process and obtain high physical properties such as grade A malleable iron, additions up to .05 per cent aluminum or its chemical equivalent of other de-

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oxidizers may be employed. The amount to use for a given batch on which the test has been run may be found by deducting .10 per cent aluminum, or its equivalent of other deoxidizers from the amount required to produce mottle and then adding the difference as a deoxidizing addition to the molten iron. Ordinarily the aluminum addition would range from .005 per cent to .05 per cent. Additions of this magnitude are employed to provide the best physical properties after a short annealing treatment. The required annealing treatment has been accomplished in as little as twenty-seven hours in a particular foundry, but this time may be decreased. The normal temperatures of malleablizing heat treatment are satisfactory.

When it is desired to obtain a more rapid annealing than outlined above with intermediate physical properties, for example, the production of grade B malleable iron, additions which are greater by .01 per cent to .04 per cent of aluminum over those specified above for producing grade A malleable iron may be used. Instead of aluminum other deoxidizers in amounts chemically equivalent to aluminum can be used. Better physical properties are obtained when smaller additions are employed while faster annealing is obtained by the use of larger additions.

Where the minimum of annealing time is desired and sub-standard physical properties are acceptable, additions up to the amount of aluminum or equivalent amount of other deoxidizer required to produce mottling may be used. As indicated, better physical properties are obtained using smaller amounts of addition agent while faster annealing is obtained when larger amounts are employed.

Where the machineability of the malleablized white cast iron is the important factor, the deoxidizing treatment can be employed. The larger the amount of the addition agent the better the machineability, as long as this agent functions as a deoxidizer.

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Since certain changes can be made in the foregoing process and different steps may be employed in practicing the same, it is intended that all matter shown in the accompanying drawing and described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

What is claimed as new is:

Method of making white iron castings which are subsequently malleablized comprising; melting iron, removing a plurality of samples of the molten iron and adding thereto aluminum in graduated amounts ranging below that necessary to produce mottling to in excess thereof, combining with the molten iron a deoxidizing addition of aluminum equal to said amount required to produce mottling less 0.10%, and thereafter casting the molten metal.

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