REQUIRED ALLOY ADDITION FOR NODULAR GRAPHITE IN A 1" SECTION

BASE IRON SULFUR CONTENT

% SULFUR

0 .02 .04 .06 .08 .10 .12

% ALLOY ADDED

0 .50 .50 1.00 1.50 2.00 2.50 3.00

MEECHMETAL: MEECH METAL
MEECHMETAL: 15% CUNDERMET
MEECHMETAL: 15% CUNDERMET
MEECHMETAL: 3% CUNDERMET
MEECHMETAL: 3% CUNDERMET
MEECHMETAL: 5% CUNDERMET
This invention relates to the production of cast iron with nodular graphite structure.

It has been heretofore known to add magnesium in the form of copper-magnesium alloy or nickel-magnesium alloy to the molten cast iron in sufficient amount to obtain in the melt a magnesium addition of about 0.04%, whereby the final sulphur content will not be more than about 0.015%. Nickel-magnesium alloys containing between 10% to 25% magnesium have been used to provide for such addition of magnesium, as copper-magnesium alloy apparently has had a harmful or inconsistent effect on the production of nodular graphite due to the presence of copper. It has been found that such addition of magnesium influences the production of cast iron with respect to the carbon, manganese, phosphorus, sulphur and nickel contents and therefore magnesium was not always suitable in producing the desired nodular graphite effect. Lead, antimony, bismuth, arsenic, selenium, tellurium, copper and like elements were found to interfere with or to be detrimental to the aim of producing nodular graphite in cast iron.

It has also been known to add substantial amounts of cerium or so called mischmetal containing to a large amount cerium, to the cast iron melt in order to obtain nodular cast iron. However, the results obtained were not always consistent, although cerium apparently acted to a certain degree as a desulfurizer.

The present invention tends to overcome the aforesaid and other disadvantages while making use of definite advantages inherent in these alloys.

It is one of the objects of the present invention to provide means affording considerable improvements in regard to the grain structure and other properties of cast iron and in particular in regard to the formation of nodular graphite structure which ensures increased tensile strength and hardness of the cast.

It is another object of the invention to provide means causing control of the sulphur content in cast iron and simultaneously attaining nodular graphite structures in said cast iron.

Still another object of the present invention is to provide means avoiding the formation of flake graphite or the reversion of nodular graphite to flake graphite in cast iron during production of the latter.

Yet another object of the invention is to provide means leading to the elimination of harmful elements or constituents in cast iron, such as titanium, lead, bismuth, antimony, aluminum, copper and like residual ingredients and to provide further means acting as powerful carbide stabilizer.

It is still another object of the invention to provide means economizing cast iron production and enabling ready employment of inexpensive raw materials regardless of their provenance and their inherent content of undesirable ingredients, for obtaining nodular cast iron, whereby any danger of sulphur segregation in the cast iron is eliminated.

Still a further object of the invention is to provide means conducive to the attainment of nodular cast iron, the melt of which in the presence of certain combined additives being subjected to deoxidizing and reducing effect, and further to scavenging and purifying action, while the fluidity of the cast iron is prolonged thereby resulting in products of denser and improved grain structure.

Still another object of the invention resides in the provision of means affording the employment of a readily castable and brittle alloy in connection with consistent production of nodular cast iron, which alloy can be uniformly and easily distributed in the cast iron melt without endangering the same through solidification or explosive or vigorous reactions.

A further object of the present invention is to provide means rendering the possibility of employing a considerable amount of magnesium in an alloy charge for obtaining nodular cast iron, whereby the explosive or undesirable reactive character of magnesium has been eliminated.

Still a further object of the present invention is to provide means contributing to the production of nodular cast iron by the employment of substantially pure magnesium-cerium (mischmetal) alloys, free from copper, lead and nickel, whereby the cast iron melt to which such alloy is added will not be contaminated by ingredients heretofore used as a carrier for cerium and/or magnesium.

Still another object of the present invention is to provide means avoiding any marked disturbance in the temperature conditions of the iron melt when magnesium-cerium (mischmetal) alloy is added to the melt, whereby transformation of cast iron with nodular graphite structure is accelerated without impairing desirable initial composition of the gray cast iron.

Another important object of the present invention is to provide means redounding to a new nodulizing, economical and bright, stable agent in the form of an unadulterated alloy which can be readily produced, brings about considerable beneficial results and may be made sufficiently brittle to allow crushing thereof and its even distribution in the melt without considerable efforts.

In further explaining the nature and underlying principle of the present invention, reference will now be made to examples hereinafter given, which are typical of the novel gray cast iron made according to the invention.

In making up substantially pure alloys of cerium and magnesium, the components may be melted together. For all practical purposes, the material known as "mischmetal" may be used in place of the pure cerium. Ordinarily, the mischmetal is figured as 50% cerium in computing the amount to use.

While the magnesium may safely constitute a major proportion of the alloy, it is important to maintain this ingredient at a low enough value to definitely avoid the danger of explosion in contact with the molten iron. On the other hand, having this safety factor in view as a primary consideration, the proportion of cerium must be substantial and may even exceed magnesium. It is usually desirable to economize in the use of cerium, mainly on account of its higher cost.

A magnesium-cerium alloy made by combining about 73% magnesium and 27% mischmetal has been successfully used, without showing excessive reactivity. Another alloy which has given even better results, and does not exhibit any dangerous properties of magnesium, is made by combining about 55% magnesium and 45% mischmetal. The amount of this alloy required to effect the conversion of the flake graphite of a sample of gray cast iron to the nodular form was considerably less than any of the other addition agents tried with the possible exception of the straight mischmetal.

Still another safe alloy of magnesium and cerium tried was made up of about 43% magnesium and 57% mischmetal. This gave results very similar to those obtained by
the alloy composed of 55% magnesium and 45% mischmetal. The magnesium-cerium alloys of the present invention may advantageously be applied to any of the known gray cast irons.

My present invention does not contemplate any particular change in the inoculation treatment or the physical aspects of handling the charge, but is concerned more particularly with the selection of the nodulizing addition.

An important advantage offered by these magnesium-cerium alloys is their brittle nature, which enables them to be very readily disintegrated (granulated) and distributed throughout the molten iron.

The retention of magnesium when using the magnesium-cerium alloy is more complete and more consistent than when using magnesium alone. For this reason, the alloy is more economical to use. Unlike cerium alone, the magnesium-cerium alloy can be satisfactorily used with cast iron containing relatively high amounts of sulphur, and the iron need not be hypereutectic as to carbon.

Because of their efficiency, the used of magnesium-cerium alloys requires relatively small amounts. For example, comparative tests made show the following percentages:

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Percentage required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper-magnesium</td>
<td>1½</td>
</tr>
<tr>
<td>Magnesium-mischmetal</td>
<td>0.3 to 0.5</td>
</tr>
<tr>
<td>Ferro-silicon-magnesium</td>
<td>3</td>
</tr>
</tbody>
</table>

An important consideration here is that the quantity of magnesium-mischmetal alloy to be added is so small that there is little or no tendency to chill the melt. For a melt of one ton (2,000 lbs.) the following quantities would consequently be required:

<table>
<thead>
<tr>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>60</td>
</tr>
</tbody>
</table>

This small percentage of the magnesium-mischmetal (cerium) alloy required helps to bring the cost of using it into the price range of less expensive alloys.

Nodular irons of high quality, which do not require immediate pouring and which do not revert upon remelting, can be produced according to the invention.

EXAMPLE

An alloy of about 45% mischmetal and about 54% magnesium for producing nodular iron was tested as a nodulizing agent in cast iron.

It was found that nodular iron was produced by additions ranging from about 0.3 to 0.4% of the above mentioned alloy. This is an advantage over previously tested alloys in that a lower total addition is required. The recovery of the magnesium was around 20%. The reactivity of the magnesium in addition to molten iron was considerably reduced by alloying with about 45% mischmetal.

Three induction pots of low phosphorus containing base iron were used in testing the above alloy. In each heat several ladles were poured and varying quantities of the alloy crushed to ⅛ of one inch to ½ of one inch in size were added to the individual ladles. No molten metal was thrown from the ladle, although a flare or flash was produced which quickly subsided. Following the alloy addition the usual 0.4% silicon as 75% ferro-silicon was added as the inoculant.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ladle</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Table II

<table>
<thead>
<tr>
<th>Ladle</th>
<th>Mg Added</th>
<th>Mg Anal.</th>
<th>Mg Rec.</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.28</td>
<td>0.36</td>
<td>32.5</td>
<td>3.3</td>
<td>2.34</td>
<td>0.06</td>
</tr>
<tr>
<td>2</td>
<td>0.64</td>
<td>0.64</td>
<td>5.9</td>
<td>5.6</td>
<td>21.5</td>
<td>122</td>
</tr>
</tbody>
</table>

Table III

<table>
<thead>
<tr>
<th>Ladle</th>
<th>Mg Added</th>
<th>Mg Anal.</th>
<th>Mg Rec.</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.34</td>
<td>0.68</td>
<td>32.1</td>
<td>3.1</td>
<td>2.55</td>
<td>0.06</td>
</tr>
<tr>
<td>2</td>
<td>0.67</td>
<td>0.67</td>
<td>5.3</td>
<td>5.3</td>
<td>20.1</td>
<td>123</td>
</tr>
</tbody>
</table>

Alloy added to ladle 1 at 2600° F. and to ladle 2 at 2500° F.

Micrographs showed that there was little or no pearlite present. The annealing temperature lasting approximately one hour was at about 1350° F.

From a comparison of Tables I, II and III it may be readily gathered that the alloy here under consideration has the property of producing nodular iron as micrographs have shown and that the physical properties have been markedly improved, although a relatively low amount of alloy is required to produce such nodular structure.

The attached drawing shows a chart from which the required alloy addition for obtaining nodular graphite in a ⅛ section of iron having varying sulphur content is apparent. The chart further clasifies the additions of various known alloys compared with the mischmetal-magnesium alloy made in accordance with the invention and containing approximately 50% magnesium.

It is also to be noted that recent tests further have shown that the employment of 10 to 73% magnesium with about 90 to 27% mischmetal as a nodulizing agent was useful in producing nodular iron, although the high percentage of mischmetal leads to a rather expensive compound.

It is to be understood that the above description is by way of example only and that various modifications may be made within the scope of the invention.

This application is a continuation-in-part of application Serial No. 155,343, filed April 11, 1930, and now abandoned.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. The process of producing gray cast iron with improved physical properties, which consists in adding as a nodulizing agent to said cast iron in molten form an alloy which is carrier-free and consists of about 55% magnesium, the remainder being mischmetal.

2. In the process of producing gray cast iron with im-
proved physical properties, the step of adding as a nodulizing agent to molten cast iron an alloy consisting of magnesium ranging from 10% to about 73% magnesium, the remainder being mischmetal.

3. In the process of manufacturing gray cast iron with improved physical properties, the step of adding to said gray cast iron in molten form a nodulizing agent magnesium-mischmetal alloy, magnesium being present in the alloy in an amount of approximately more than 50% and less than 75%, the remainder being solely mischmetal.

4. In the manufacture of a gray cast iron product having carbon in nodular form, which consists in adding to a gray cast iron base metal in molten form a substantially unaltered magnesium-mischmetal alloy consisting of about 43% by weight of magnesium and 57% by weight of mischmetal.

5. The process of manufacturing an improved gray cast iron product which consists in adding to a gray cast iron base metal in molten form a magnesium-mischmetal alloy substantially free from any carrier and consisting of about 73% by weight of magnesium, the remainder being mischmetal.

References Cited in the file of this patent

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263,755 Great Britain -------------- Nov. 4, 1926

OTHER REFERENCES