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NODULAR CAST IRON AND PROCESS OF MAKING SAME

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The art of producing an improved hypo-eutectic cast
iron by means of the addition of magnesium is now well
known. Under appropriate conditions now well under-
stood, magnesium converts the lamellar flake graphite
of normal cast iron into a nodular form sometimes re-
ferred to as spheroidal or spherulitic graphite, and so
gives a cast iron which has much improved properties
and which may be ductile. After the addition of the
magnesium it is the practice to inoculate the molten
metal with a graphitisating inoculant such as ferro-solution. It
is now well established by the practised art that the
magnesium can be added to the molten cast iron in the
form, for instance, of a nickel-magnesium-carbon alloy
having between 5 and 20% magnesium. It has also
been realised that magnesium can be added to cast iron
as a copper-magnesium-alloy having, for instance,
between 5 and 25% magnesium. It has been less well
appreciated, however, that copper alloyed with the
iron, certainly in amounts in excess of 1%, inhibits the
ability of magnesium to give nodular structures. This is an
important limitation of the process whereby nodular cast
irons are produced by adding magnesium to the molten
cast iron, particularly since some cast irons have copper
as an integral part of the composition; for instance,
cast irons having about 12–15% nickel, 2% chromium and
6–7% copper find many applications on account of
their resistance to corrosion and heat. Moreover the
use of a copper-magnesium alloy for the introduction of
magnesium may at the same time raise the copper
content of an otherwise suitable iron to beyond 1%.

It is the object of the present invention to provide a
means whereby the effect of copper in inhibiting the
production of nodular graphite structures in magnesium-
treated irons containing copper may be eliminated, and
to provide a means whereby nodular irons containing
more than 1% of copper can be produced.

The invention involves the addition of cerium prior to,
simultaneously with or after the addition of mag-
nesium, but preferably simultaneously with the
magnesium. After treatment and solidification the iron may
contain 0.001% to 0.20% cerium and 0.02%–0.20%
magnesium but in general the iron will have 0.01% to
0.02% cerium and 0.04% to 0.06% magnesium. The final
copper content of the solidified casting may have
any value up to 7% and may be present as an alloying
element in the iron before treatment, or may arise wholly
or in part from the addition of the magnesium as a
magnesium-cerium-magnesium alloy. The
magnesium may be added by any convenient method
and the cerium may be added as any alloy or as
micronodules or nodules, which alloy or
micronodules may be provided with a
suitable graphitisating agent such as
ferro-solution or ferro-silicon.

The iron will solidify grey or the composition
may vary within wide limits as indicated below:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>Up to 4.3–5%</td>
</tr>
<tr>
<td>Silicon</td>
<td>Up to 7%</td>
</tr>
<tr>
<td>Manganese</td>
<td>Up to 7%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Up to 2%</td>
</tr>
<tr>
<td>Sulphur</td>
<td>Before treatment up to 0.25%</td>
</tr>
</tbody>
</table>

The elements nickel, chromium and molybdenum may
also be present either singly or in any combination
provided the iron will solidify grey.

Whilst the sulphur content of the untreated metal can
have any value up to 0.25% it is good practice to keep
this value as low as possible. In general the sulphur
content of the treated metal will be somewhat reduced
by the magnesium addition but it will not necessarily be
reduced to such a low value as would be achieved if the
magnesium was added without the cerium. For instance,
with an iron having initially 0.1% sulphur treated in
accordance with this invention the final sulphur content might
assume a value of 0.035%, whereas with magnesium
unaccompanied by cerium it would have to be reduced
to about 0.015% before a nodular structure would be
produced.

The invention is illustrated but not limited by the
following examples.

Example 1

An iron having the following composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total carbon</td>
<td>3.1</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.9</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.06</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.02</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>6.8</td>
</tr>
<tr>
<td>Chromium</td>
<td>2.01</td>
</tr>
<tr>
<td>Iron</td>
<td>Remainder</td>
</tr>
</tbody>
</table>

was melted and the melt divided into two portions. One
portion was treated with a nickel-magnesium alloy and
then inoculated with ferro-silicon. The other portion
was treated with a nickel-magnesium-cerium alloy
and similarly inoculated.

A test bar cast from the first portion was found to con-
tain 0.062% magnesium and had a tensile strength of
14.1 tons/sq. in. A test bar cast from the second portion
contained 0.062% magnesium and had a tensile
strength of 22.6 tons/sq. in.

Example 2

An iron of the following composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total carbon</td>
<td>3.34</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.86</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.48</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.123</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.05</td>
</tr>
</tbody>
</table>

was melted and divided into two portions, which were
treated, respectively, (a) with 2.5% of a copper-
magnesium alloy (15% magnesium), and (b) with 2.5%
of a copper-magnesium-cerium alloy (14.2% magnesium,
2.2% cerium), each being then inoculated with ferro-
silicon (80% silicon). Test bars cast from the two
portions gave the following results.

<table>
<thead>
<tr>
<th>Test</th>
<th>Me. %</th>
<th>Cu. %</th>
<th>Co. %</th>
<th>Tensile strength, Tons/in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.055</td>
<td>2.1</td>
<td>0.1</td>
<td>13.0</td>
</tr>
<tr>
<td>65</td>
<td>0.055</td>
<td>2.03</td>
<td>0.010</td>
<td>43.7</td>
</tr>
</tbody>
</table>

Flake graphite in a matrix of pearlite. Graphite nodules in a
matrix of pearlite.

I claim:
1. A process for the production of grey cast iron which
contains copper, is hypoeutectic in relation to carbon, and
in which the graphite is present at least predominantly
in the form of nodules, which process comprises adding

Total carbon: 3.1%
Silicon: 1.9%
Manganese: 1.06%
Sulphur: 0.02%
Nickel: 0.05%
Copper: 6.8%
Chromium: 2.01%
Iron: Remainder

Total carbon: 3.34%
Silicon: 1.86%
Manganese: 0.48%
Sulphur: 0.123%
Phosphorus: 0.05%

Tensile strength: 13.0 tons/in. (60)
Tensile strength: 43.7 tons/in. (65)
magnesium and cerium to a molten iron which contains coppet, is hypoeutectic in relation to carbon and which on casting gives a grey cast iron, and casting the treated melt; the treated melt having a copper content of about 2% to 7% which would substantially interfere with the nodularizing action of the magnesium in the absence of cerium.

2. Process as claimed in claim 1 in which the cerium is added before the magnesium.

3. Process as claimed in claim 1 in which the cerium is added after the magnesium.

4. Process as claimed in claim 1 in which the magnesium and the cerium are added together in the form of an alloy containing both metals.

5. Process as claimed in claim 1 in which the magnesium and the cerium are added together in the form of an alloy containing both these metals and a metal selected from the group consisting of nickel and copper.

6. Process as claimed in claim 1 in which the amounts of magnesium and cerium added are such that the iron after casting contains at least 0.001% and at most 0.20% of cerium, and at least 0.02% and at most 0.20% of magnesium.

7. Process as claimed in claim 1 in which the copper content of the iron after casting is at least 1% and at most 7%.

8. Process as claimed in claim 1 in which after the addition of magnesium and cerium and immediately before casting there is added an inoculant.

9. Process as claimed in claim 1 in which, after the addition of magnesium and cerium and immediately before casting there is added as inoculant ferrosilicon.

10. Grey cast iron, hypoeutectic in relation to carbon, and containing copper, magnesium and cerium, the graphite in the said cast iron being at least predominantly in the form of nodules, the content of magnesium and cerium taken together not exceeding about 0.40%, and the copper content being about 2% to 7%.

11. Grey cast iron as claimed in claim 10, in which the copper, magnesium and cerium are present in the following proportions: copper from 2 to 7%; magnesium from 0.02 to 0.20%; cerium from 0.001 to 0.20%.

12. Grey cast iron as claimed in claim 10, in which the copper, magnesium and cerium are present in the following proportions: copper from 2 to 7%; magnesium from 0.04 to 0.06%; cerium from 0.01 to 0.02%.

References Cited in the file of this patent

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 24, for "ferro-solution" read -- ferro-silicon --.

Signed and sealed this 4th day of November 1958.

(SEAL)

Attest:

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Attesting Officer

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Commissioner of Patent