COPPER-CHROMIUM ALLOY

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2 Claims. (Cl. 75--160)

Copper and chromium are frequently added to ferrous alloys to improve the physical and chemical characteristics of the alloy. In the past it has been necessary to make the additions of copper and chromium separately, in the form of copper andchromium castings or chromium, since copper will not alloy in large proportions with either chromium or ferrochromium. Neither copper, because of its low rate of solubility in iron, nor chromium and ferrochromium, because of their high melting points, go readily into solution in ferrous alloys.

The chief object of the present invention is to provide a series of alloys having a relatively large content of copper and chromium, and at the same time a melting point sufficiently low to adapt the alloy for such uses as a pre-alloy for adding copper and chromium to ferrous metals and a coating alloy to be applied, for example, by placing the pulverized alloy upon a sand mold and casting a ferrous metal within the mold.

Another object of the invention is to provide a process for making such alloys.

It is found that by the addition of sufficient silicon, relatively large amounts of copper may be dissolved in chromium or ferrochromium to form a substantially homogeneous alloy. Copper and silicon are not miscible in all proportions with chromium and ferrochromium, and investigation has led to the discovery of the ranges of composition within which alloys are formed, and also the minimum amount of silicon required to obtain a homogeneous alloy having any desired relative proportions of copper and chromium or ferrochromium.

In the accompanying drawing, the single figure is a miscibility diagram by which the above-described relationships may be determined. Iron and chromium are therein treated as a single component, inasmuch as it is found that chromium and ferrochromium behave with practical similarity in dissolving copper and silicon. The diagram represents alloys made from commercially pure materials, namely, bar or scrap copper, high-carbon ferrochromium containing from 4% to 8% of carbon and 60% to 72% chromium, and commercial ferrosilicon. If a lower-carbon material is substituted for the high-carbon ferrochromium, somewhat less silicon will be required as a minimum to render the resulting composition homogeneous.

Compositions within the part of the diagram marked "Zone of miscibility" form a single homogeneous liquid phase at or slightly above the melting point of the composition, and this liquid when cast forms a substantially homogeneous ingot. For any given desired ratio of copper to ferrochromium or chromium, the minimum amount of silicon which must be added to render the alloy homogeneous is to be found at the intersection of the line separating the two zones with the lines representing percentages of copper and chromium or ferrochromium in the final alloy.

Compositions which, from the relative proportions of the materials melted together, would give an alloy within the portion of the diagram marked "Zone of immiscibility", do not form homogeneous ingots of the desired analysis, but tend to separate into two phases. When cast very hot and cooled slowly in a sand mold, such compositions form ingots having two distinct sections which may be separated cleanly at a more or less smooth interface. Each section of one of these "duplex" ingots is homogeneous, but the analysis of one section differs from that of the other. In general, the upper section tends to be the richer in respect to chromium content, and the bottom section the richer in respect to copper content. The composition of each section may be estimated from the diagram as follows: mark the point within the zone of immiscibility which corresponds to the average composition of the mixture to be melted, through this point draw a line parallel to the silicon percentage ordinate, the two intersections of this line with the line separating the two zones will then represent the respective analyses of the two layers of the ingot.

The alloys of the invention may be made by melting a portion of chromium or ferrochromium, adding a portion of silicon or ferrosilicon, and then making additions of copper and silicon or ferrosilicon alternately. The temperature of the melt should be kept high, preferably above 1500° C., and melting may suitably be done in an electric arc furnace or induction furnace. The above described order of additions has many advantages in producing sound and homogeneous alloys. If the order is changed, difficulties in securing homogeneous compositions without lengthy heating are encountered.

The invention comprises substantially homogeneous alloys of copper, silicon, chromium, and iron, within the ranges of composition: 40% to 70% copper, 5% to 27% chromium, 30% to 11% silicon, small amounts of carbon not over about 3%, and the balance iron except for the common impurities such as sulfur and phos...
phorus. Preferably, the chromium is at least 12%. The iron content is preferably no more than that introduced with the ferrochromium (60% to 72% chromium) and the ferrosilicon (70% to 80% silicon).

Examples of alloys which have been made according to the invention, using bar copper, high-carbon ferrochromium containing about 65%–68% chromium and about 4% to 8% carbon, and ferrosilicon containing about 75% silicon, are listed in the following table:

<table>
<thead>
<tr>
<th>Percent Cu</th>
<th>Percent Si</th>
<th>Percent Cr</th>
<th>Percent C*</th>
<th>Percent Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.22</td>
<td>13.00</td>
<td>12.02</td>
<td>1.1</td>
<td>Remainder (15.50)</td>
</tr>
<tr>
<td>16.36</td>
<td>11.57</td>
<td>9.09</td>
<td>0.9</td>
<td>Remainder (8.78)</td>
</tr>
</tbody>
</table>

*(Carbon content estimated).

It is to be noted that all of the alloys in the above table may be made from relatively inexpensive materials; hence the alloys are economical to produce and are suitable for use even where cost of materials is controlling, for example, in making inexpensive iron castings.

Alloys having compositions within the scope of this invention may thus be prepared from economic raw materials by proportioning the raw materials either so as to give one homogeneous ingot or so as to give two homogeneous layers in the same ingot.

This application is a division of my copending application Serial Number 670,673, filed May 12, 1933.

I claim:
1. A substantially homogeneous alloy having a composition within the limits: 40% to 70% copper, 30% to 11% silicon, the remainder chromium and the impurities iron and carbon; the silicon being at least sufficient to make the alloy homogeneous, the chromium being between 5% and about 27%, the carbon being present in an appreciable amount but not over about 3%, and the iron and carbon being present only in the amounts introduced by the use of commercial ferrosilicon (about 70% to 80% silicon, and the remainder iron) and commercial ferrochromium (about 60% to 70% chromium, and the remainder iron) as the sole sources of silicon and chromium in said alloy.
2. An alloy as claimed in claim 1 and in which the chromium content is at least 12% of the alloy.

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