METHOD FOR OVERCOMING EMBRITTLEMENT OF STEEL ALLOYS

Leroy Fink, Beaverton, Oreg., assignor, by mesne assignments, to Electric Steel Foundry Company, a corporation of Oregon

No Drawing. Application December 24, 1954, Serial No. 477,576

4 Claims. (Cl. 75—130)

This invention relates to a method for overcoming embrittlement of steel alloys, and is particularly useful in combating the embrittlement or cracking tendency known as "hot shortness" in low carbon corrosion-resistant austenitic stainless steel castings.

In the manufacture of low carbon corrosion-resistant austenitic stainless steels, it is found that the alloy is difficult to cast, weld, or hot work, without the tendency to be "hot short." "Hot shortness" may be defined as a brittleness which occurs in the metal when hot, the metal separating in most cases at the grain boundary. In the casting operation, as the casting cools from the liquid state to the solid state in the mold, the mold sets up a restriction to the contracting metal. Many steels and alloys are strong enough to resist this restriction, but considerable difficulty is found with austenitic stainless steels, and tearing occurs in the casting, which must be welded. Welding also becomes a problem, since the metal adjacent the weld is heated, and frequently cracking will occur in this adjoining portion, requiring continual repairs, and eventually the product must be scrapped.

I have discovered that such austenitic stainless steel alloys may be effectively treated to prevent "hot shortness" by adding to the alloy while molten a compound of vanadium, titanium and boron. I prefer to add the vanadium and titanium as ferro-compounds, and I find it desirable to employ the vanadium and titanium as a combined ferro-compound.

The combination of vanadium, titanium and boron may be added to the molten alloy while in the furnace, as, for example, in an arc or induction electric furnace, just before tapping. If desired, it may be added to the ladle during tapping.

The proportions of the compounds are preferably employed within certain limits which are effective in producing the best results. For example, the vanadium is preferably used in the proportion of 0.02% to 1.07%, the titanium in the proportion of 0.01% to 0.65%, while the boron is added in a very small amount, ranging from a trace to 0.002%. I have found that best results are obtained when the vanadium is used in the range of 0.05% to 0.25%, the titanium in the range of 0.01% to 0.15%, and the boron in about 0.002%.

In general, the vanadium employed is about twice that of the titanium, although I find that best results are obtained when the titanium is about three-fifths of the vanadium. I find that all three materials, namely, the vanadium, titanium and boron, cooperate in eliminating the "hot shortness," and when used in the percentages shown, the finished tested product shows practically no cracks even after the flame test and Zygro inspection. In the test generally referred to as the "flame test," one end of the specimen is subjected to a torch for one minute, and thereafter a green fluorescent penetrant dye is applied and developed so as to disclose the presence of minute cracks, etc. Since such tests are well known, a detailed description herein is believed unnecessary and it is sufficient to say that under such rigorous tests the products treated in accordance with the present invention disclose very few, if any, perceptible cracks.

In the operation of the process, the austenitic stainless steel alloy is brought to a molten condition within the furnace and the ferro compound of vanadium and titanium and the boron are added to the metal in the furnace or, if desired, to the ladle during tapping. Aluminum may be added in the dioxidizing procedure, in accordance with general furnace practice, and silicon may also be added for the maintenance of the physical properties and to promote fluidity. If desired, the aluminum and silicon may be added simultaneously with the titanium, vanadium and boron, and the proportions of these will be the proportions usually added according to general furnace practice.

Specific examples of the process may be set out as follows:

Example I
A stainless steel alloy having the following analysis:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>max. 0.07</td>
</tr>
<tr>
<td>Manganese</td>
<td>2.00</td>
</tr>
<tr>
<td>Silicon</td>
<td>max. 1.5</td>
</tr>
<tr>
<td>Chromium</td>
<td>6.0</td>
</tr>
<tr>
<td>Nickel</td>
<td>29.3</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>2.4</td>
</tr>
<tr>
<td>Copper</td>
<td>3.3</td>
</tr>
</tbody>
</table>

was heated in an electric furnace to molten condition, and to the molten metal just before tapping was added ferro vanadium and titanium in the proportions of 0.05% vanadium, 0.01% titanium, and 0.002% boron. The casting test bars made from the alloy were subjected to the flame test and to the fluorescent dye penetrant (Zygro) test, and it was found that there were practically no perceptible cracks, thus showing the elimination of hot shortness.

Example II
The operation was carried on as described in Example I, except that the vanadium was in the proportion of 0.23%, the titanium in the proportion of 0.15%, the boron remaining at about 0.002%. The results obtained were comparable to those described in Example I.

Example III
The process was carried out as described in Example I except that the austenitic stainless steel had a different composition, containing 24% chromium, 20.5% nickel, 0.08% carbon, about 1.5% manganese, and 1.0% silicon.

The procedure as described in Example I was found to eliminate hot shortness in the above-described alloy.

Example IV
The process was carried out as described in Example I, except that the stainless steel alloy treated had about 13.65% chromium content, 13.65% nickel, 2.65% molybdenum, 0.08% carbon maximum, about 1.25% manganese, and about 1.0% silicon. Hot shortness was eliminated by the addition of the materials described in Example I.

Example V
The process was carried out as described in Example IV, except that the stainless steel alloy treated had about 18.7% chromium and 10.5% nickel, the carbon, manganese, and silicon contents being the same as shown in Example IV. Comparable results were obtained.

Example VI
The process was carried out as described in Example IV except that the stainless steel alloy, which was other-
3 wise the same, had a chromium content of 15% and a nickel content of 35%. The same results as described in Example IV were obtained.

In the treatment of low carbon, corrosion-resistant austenitic cast stainless steels, the three added materials, namely, vanadium, titanium and boron, appear to produce together, as a total effect, the elimination of the hot shortness, and while the proportions of these may be varied within a substantially wide range depending upon the analysis of the particular austenitic cast stainless steel material being treated, the important new result of eliminating hot shortness is achieved by the use of all three materials.

While in the foregoing description I have set forth in detail specific steps and proportions for the purpose of illustrating preferred embodiments of the invention, it will be understood that such details of procedure, proportions, etc., may be varied widely by those skilled in the art without departing from the spirit of my invention.

I claim:

1. In a process for preventing “hot shortness” in a low carbon, corrosion-resistant austenitic cast stainless steel alloy, the steps of heating the alloy to a molten state and then adding thereto vanadium, titanium and boron in the proportions of .05 to .25% vanadium, .01 to .15% titanium, and about .002% boron.

2. The process of claim 1, in which the vanadium and titanium are combined in a ferro-compound.

3. In a process for treating a low-carbon, corrosion-resistant austenitic cast stainless steel alloy to prevent “hot shortness” therein while effecting a minimum change in the alloy, the steps of heating the alloy to a molten condition and thereafter adding to the molten mass a ferro-compound of vanadium, titanium and boron in proportions substantially less than .5% of the total alloy, the vanadium being from .05 to .25%, the titanium being from .01 to .15%, and the boron being from a trace to .002%.

4. The process of claim 3, in which the vanadium, titanium and boron are added to the ladle during tapping.

References Cited in the file of this patent:

UNITED STATES PATENTS
2,432,618 Franks et al. December 16, 1947
2,587,613 Payson March 4, 1952
2,602,028 Urban July 1, 1952