CORROSION-RESISTING COBALT-CHROMIUM-
TUNGSTEN ALLOYS

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2 Claims. (Cl. 75—134)

Cobalt-chromium-tungsten alloys having a high abra-
sion resistance and high-temperature stability and con-
taining a relatively large amount of carbon consist in the
as-cast and as-welded conditions substantially of a large
amount of hard chromium-tungsten carbides, which are
embedded in a non-transforming, cubic face-centered,
tough cobalt-chromium matrix. The cooperation of the
hard carbides and the tough matrix is responsible for the
high abrasion resistance and high-temperature stability
of these alloys. The two main constituents of the struc-
ture are also decisive for the corrosion behavior. Whereas
the carbides are hardly susceptible to hydrochloric acid and
sulfuric acid, these acids attack the cobalt-chromium
matrix. As the matrix is dissolved out of the structure,
the carbide lattice loses its coherence and can readily be
detached by mechanical means from the core which has
not yet been attacked. Hence, the resistance to corrosion
ca be improved only by an improvement of the resist-
ance of the matrix in which the carbides are embedded.

The present invention provides cobalt-chromium-tung-
sten alloys which contain additions of copper and, if de-
sired, molybdenum, for a substantially increased resis-
tance to corrosion. Two alloys having the following
composition have been prepared by melting:

<table>
<thead>
<tr>
<th>Alloy Number</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>W</th>
<th>Mo</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.2</td>
<td>0.15</td>
<td>0.22</td>
<td>30.3</td>
<td>20.3</td>
<td>38.4</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>2.3</td>
<td>0.17</td>
<td>0.17</td>
<td>30.3</td>
<td>19.9</td>
<td>40.9</td>
<td>3.0</td>
</tr>
</tbody>
</table>

1 Calculated as the balance.

It is apparent from Table 2 that the resistance to cor-
rosion is much improved by the addition of copper and
molybdenum.

<table>
<thead>
<tr>
<th>Alloy Number</th>
<th>10 percent hydrochloric acid</th>
<th>20 percent sulfuric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Room temperature</td>
<td>Bolling temperature</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>1,120</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>1,120</td>
</tr>
</tbody>
</table>

The weight losses of the alloy which contains molyb-
denum and copper are at room temperature about one
fifth of those of the alloy which does not contain molyb-
denum and copper. The test in boiling sulfuric acid shows particularly that the weight loss is reduced to about
one hundredth by the joint presence of copper and molyb-
denum. The improved corrosion behavior due to copper
and molybdenum has been confirmed by electrochemical
measurements carried out on these alloys in 1N sulfuric
acid at room temperature.

To find out whether a further increase in the resistance
to corrosion can be achieved by larger additions of cop-
per and molybdenum, a number of alloys having the com-
position indicated in Table 3 were prepared by melting.

<table>
<thead>
<tr>
<th>Alloy Number</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>W</th>
<th>Co1</th>
<th>Mo</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.5</td>
<td>0.35</td>
<td>0.35</td>
<td>31.0</td>
<td>13.4</td>
<td>44.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2.5</td>
<td>0.35</td>
<td>0.35</td>
<td>31.0</td>
<td>18.8</td>
<td>41.6</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
<td>5</td>
<td>3.3</td>
<td>0.49</td>
<td>0.49</td>
<td>31.7</td>
<td>13.3</td>
<td>39.8</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>6</td>
<td>4.9</td>
<td>0.29</td>
<td>0.29</td>
<td>31.7</td>
<td>13.3</td>
<td>39.8</td>
<td>4.8</td>
<td>4.8</td>
</tr>
</tbody>
</table>

1 Calculated as the balance.

For a greater latitude regarding the addition of copper
and molybdenum, the tungsten content of these melts
was reduced to about 13%, compared to 20% in the
alloys of Table 1. The cobalt content in the alloys was
calculated to avoid a substantial increase of the iron con-
tent above 2%.

Table 4 shows the weight losses of the alloys of Table
3 in 10% hydrochloric acid and 20% sulfuric acid at
room temperature and bolling temperature.
These alloys were tested for weight losses in the form of welding rods and of samples of welds made from such rods. Table 5 indicates the weight losses of samples of welds of conventional cobalt-chromium-tungsten alloys under corresponding conditions. A comparison of the weight losses indicated in Tables 4 and 5 shows the superiority of the alloys which contain copper, or copper and molybdenum, over the conventional alloys.

The fine structure show that the addition of copper and molybdenum does not appreciably affect the amount and nature of the precipitated carbides. The added copper and molybdenum are enriched mainly in the matrix to improve its resistance to corrosion.

An adverse effect of copper and molybdenum on the abrasion resistance and high-temperature stability is not to be expected. The Rockwell C hardness numbers of the alloys indicated in Table 3 are between 52 and 60 and increase with increasing contents of copper and molybdenum.

It is also known that the high-temperature hardness of cobalt-chromium-tungsten alloys is improved by an addition of molybdenum up to 4% so that molybdenum results in an improvement of two important properties of the alloy.

What is claimed is:

1. A corrosion-resisting cobalt-chromium-tungsten alloy consisting essentially of 2.2–2.5% carbon, 30–32% chromium, 13–20% tungsten, 39–47% cobalt, up to 1% manganese, up to 1% silicon, 0.3–6% copper and up to 6% molybdenum.

2. A corrosion-resisting cobalt-chromium-tungsten alloy consisting essentially of 2.2% carbon, 30% chromium, 14% tungsten, 46% cobalt, 4% molybdenum, 2% copper, up to 1% manganese, and up to 1% silicon.

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