STAINLESS STEELS

PROPERTIES OF STAINLESS Cr - Mn STEELS WITH A DIFFERENCE IN THE STABILITY OF AUSTENITE DURING DEFORMATION

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In some stainless Cr - Ni steels the martensitic transformation occurs with formation of an intermediate hexagonal e phase by the reaction $\gamma \rightarrow e \rightarrow a$ [1, 2]. In some Fe - Cr - Mn alloys the e martensite is stable and is retained at room temperature [3, 4].

We investigated* the properties of Cr - Mn steels with different amounts of manganese, due to which the stability of the austenite varied with regard to the martensitic transformation during plastic deformation. The chemical and phase compositions of the steels are given in Table 1.

After quenching from 1050°C and with cooling to -253°C all the steels were austenitic, with a grain size of grade 5-6.

Deformation at temperatures below room temperature induces the transformation of austenite to martensite in some steels. The phase composition was determined by x-ray and magnetometric analysis. X-ray powder patterns were made in the URS-60 apparatus with unfiltered K$_\alpha$ Cr radiation. The presence of e phase was indicated by lines (100), (101), and (102), and $\alpha$ phase by line (110), which practically coincides with line (002) but is much more intense.

Final conclusions on the presence and the amount of $\alpha$ phase were drawn on the basis of magnetometric measurements.

Figures 1-3 show the mechanical properties in tension of round samples (GOST 1497-61) and the toughness of samples of types I and IV at +20°C (GOST 9454-60) and at -196°C (GOST 9455-60); impact tests were also

*With the assistance of V. I. Fedorova.

TABLE 1

<table>
<thead>
<tr>
<th>Steel</th>
<th>Main alloying elements</th>
<th>Phase comp. after deform. at -196°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mn</td>
<td>Ni</td>
</tr>
<tr>
<td>G14</td>
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<tr>
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<td>1</td>
</tr>
<tr>
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</tr>
<tr>
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<td>18</td>
<td>5</td>
</tr>
<tr>
<td>G18N7</td>
<td>18</td>
<td>7</td>
</tr>
</tbody>
</table>

Fig. 1. Effect of manganese content on the strength, ductility, and amount of strain martensite at +20 and -196°C.

made at -253°. The change in the strength characteristics shown in Fig. 1 is typical for steels of the transition class [5]. Magnetometric measurements of the amount of martensite after tensile tests showed that strain martensite ($\alpha''$ phase)* is formed in steels with 14, 16, and 18% Mn, the amount decreasing with increasing amounts of manganese. Magnetometric measurements indicated no $\alpha''$ phase in the steel with 22% Mn.

Thus, the reduction of the ultimate tensile strength at +20° with increasing amounts of manganese is due to a smaller quantity of strain martensite.

Strain martensite is formed in the region of plastic deformation and has practically no effect on the yield stress, which in this case is determined only by the amount of manganese in the steel.

The ductility of all these steels is high at +20°, but with decreasing stability of the austenite during deformation the relative elongation decreases somewhat.

At -196° the variation of the strength with the manganese concentration is different – raising the manganese concentration from 14 to 22% substantially increases the ultimate strength and yield strength, while the steels with 14 and 16% Mn have a lower ultimate strength than at +20°; the ductility of steels with 14, 16, and 18% Mn is low at -196° ($\delta \approx 14\%, \psi \approx 7\%$).

Evidently this is the reason for the lower ultimate strength of steels with 14 and 16% Mn at -196°, since the extent of the martensitic transformation is considerably smaller at -196° than at +20° due to the small plastic deformation. The ductility and strength at -196° are highest for the steel with 22% Mn.

In connection with the fact that stable martensitic $\varepsilon$ phase may be formed in steels with a high manganese concentration [3, 4], the phase compositions of the steels were determined after deformation. It is difficult to determine the phase composition after tensile tests by means of x-ray analysis, and therefore the formation of $\alpha''$ and $\varepsilon''$ phases during deformation was determined by another method – wire samples 1.5 mm in diameter were deformed by drawing 30% at -196°, which matched the deformation of the steel with 22% Mn in tensile tests at -196°. The phase composition of these samples was then determined by x-ray analysis.

Deformation of steels with 14, 16, and 18% Mn at -196° leads to the formation of cubic ($\alpha''$) and also hexagonal ($\varepsilon''$) martensite.

When the manganese concentration is varied from 14 to 18% the tendency to form $\varepsilon''$ martensite increases; the largest quantity of $\varepsilon''$ phase is formed in the steel with 18% Mn. Raising the manganese concentration

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*Here and below, $\alpha''$ and $\varepsilon''$ refer to strain martensite as opposed to $\alpha'$ and $\varepsilon$ martensite obtained during cooling.