MECHANICAL PROPERTIES OF URANIUM

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The paper describes the results of mechanical tests on uranium at room temperature and at elevated temperatures. Data are given on the hardness of uranium in the temperature range 20–600°C, flow pressure on extrusion in the α- and γ-phase ranges, tensile properties and impact strength at temperatures of the α-, β-, and γ-phases. The anisotropic behavior of the individual grains of coarse-grained uranium during mechanical tests has been elucidated. It is shown that the existence of allotropic transformations and the difference in the crystal structure of the modifications of uranium influence its mechanical properties to a marked degree. It is also shown that the mechanical properties depend upon the carbon content of the uranium.

The mechanical properties of uranium are described in papers [1] and [2], but these papers do not give any characteristics of its composition. The material studied was uranium rolled at temperatures of the γ-region with a total reduction of 90% and air cooled. The impurity contents of the metal are given in Table 1. Specimens from one melt were used for studying the variation of mechanical properties with temperature. The influence of carbon on the mechanical properties was studied on specimens from different melts with approximately the same contents of the other impurities.

TABLE 1
Typical Analysis of a Uranium Melt

<table>
<thead>
<tr>
<th>Content of element, %</th>
<th>Fe</th>
<th>Si</th>
<th>Ni</th>
<th>Mn</th>
<th>Co</th>
<th>Cu</th>
<th>B</th>
<th>N</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.10^{-3}</td>
<td>5.0.10^{-3}</td>
<td>4.0.10^{-4}</td>
<td>7.0.10^{-4}</td>
<td>3.0.10^{-4}</td>
<td>7.0.10^{-4}</td>
<td>2.0.10^{-4}</td>
<td>3.0.10^{-4}</td>
<td>0.05</td>
</tr>
</tbody>
</table>

The hardness of uranium at elevated temperatures was determined in a vacuum (pressure 10^{-3} mm Hg) in a specially designed apparatus (Fig. 1). The load equal to 50 kg was checked by means of a control dynamometer. The duration of its application was 15 sec in all cases and the load was maintained for 30 sec. The indenter was a "pobedit" (carbide alloy) cone with an apex angle of 90°. The diameter and height of the specimen were 6 mm. The Kubasov hardness number (HK) was determined by dividing the load by the area of the indentation:

\[ HK = \frac{50}{\pi d_{\text{mean}}^2} \text{ kg/mm}^2, \]

where \(d_{\text{mean}}\) is the mean diameter of the indentation.
It was found that the hardness of the specimens decreased with increase in temperature. Heating to 600° C resulted in a drop in hardness of for instance 350 to 50 kg/mm² (Fig. 2). No regular variation of hardness with carbon content from 0.07 to 0.24% was observed. Figure 3 shows the variation of persistent hardness with the duration of loading at constant temperature.

Fig. 2. Variation of transitory hardness of uranium (carbon content 0.24%) with temperature.

Fig. 3. Variation of persistent hardness of uranium with the time of application of the load at 600° C.

Fig. 4. Variation of flow pressure of uranium (at a temperature of 650° C) with carbon content (degree of deformation 75%).

The flow pressure of uranium was determined by extrusion in the vacuum apparatus (see Fig. 1), the hardness testing instrument in the working space being replaced by an extrusion instrument. Specimens 8 mm in diameter and height were tested.

The experimental results showed that the presence of carbon affects the value of the flow pressure of uranium on extrusion in the α-phase. It follows, from Fig. 4, that the pressure increases with increase in the carbon content of the uranium from 0.09 to 0.24%. For example, at a temperature of 650° C and a degree of deformation of 75%, the flow pressure is increased by about 60%.

Figure 5 shows the variation of flow pressure with the degree of deformation in the α-phase range for uranium containing 0.13% carbon. Fig. 6 with temperature in γ-phase region for uranium of the same composition, with a degree of deformation of 69%. For uranium in the α-phase state, the flow pressure is reduced from 4 kg/mm² at 830° C to 1.6 kg/mm² at 1050° C. Figure 7 shows the variation of flow pressure of uranium with degree of deformation at 900° C.