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SELECTION OF ALLOYS, THEIR STRUCTURE AND PROPERTIES

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Annotation: This study investigates the deformation behavior of various steels and alloys under high-temperature and isothermal conditions. The effects of deformation rate, temperature, and initial microstructure on the mechanical properties and microstructural changes during deformation are analyzed. The use of isothermal conditions allows for improved control over deformation processes, leading to enhanced product quality and material performance. Experimental methods include tensile testing at various temperatures and deformation rates, as well as microstructural analysis. The results provide insights into optimizing thermomechanical processing regimes for better mechanical properties and efficiency in metal forming.

Key words: Isothermal deformation, steel microstructure, mechanical properties, high-temperature testing, thermomechanical processing, tensile testing, alloy deformation

To solve the assigned tasks, technically pure iron, A40G, U8A, and U12A steels were selected. The choice of these materials is justified by the following reasons: firstly, they cover the entire "steel" section of the iron-carbon phase diagram; secondly, these industrially produced materials have a similar composition in terms of main alloying elements and differ primarily in their carbon content (see Table 1.1), which allows for determining the influence of cementite content on the plasticity of steels.

The materials used for the research were wires hot-rolled in the plastic state. The chemical composition of the materials under investigation is presented in Table 2.1.

Table 1.1
Chemical Composition of the Materials Under Investigation

№ t/r	**Steel grades**	*C*	*Mn*	*Si*	*S*	*P*	*Cu*
1.	Technically pure iron	0,04	0,30	0,35	0,01-0,02	-	0,28
2.	Steel grade A40G	0,40	0,80	0,28	0,41	0,016	-
3.	Steel grade U8A	0,79	0,35	0.2	0,03	-	-
4.	**Steel grade U12A**	1.17	0,36	0,18	-	-	-

The microstructure of the steels in the initial sample state was studied in both the longitudinal and cross-sections of the wires.

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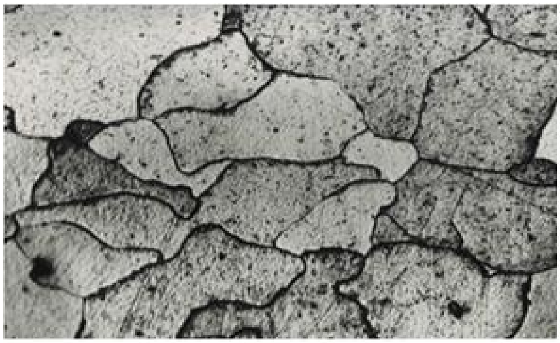
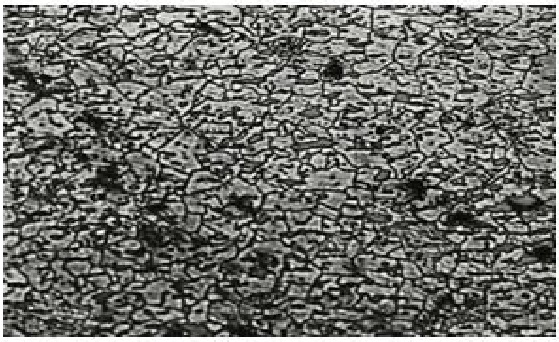
The microstructure of the steels in the initial sample state is shown in Figures 1.1a, b, and c. A40G steel has a ferrite–lamellar pearlite structure, U8A steel exhibits a eutectoid (0.8% carbon) pearlitic structure in the initial state, while U12A steel has a eutectoid structure consisting of pearlite and cementite.

To study the effect of the initial state on high-temperature plasticity, thermal treatment (quenching followed by high-temperature tempering) and prior hot deformation were applied.

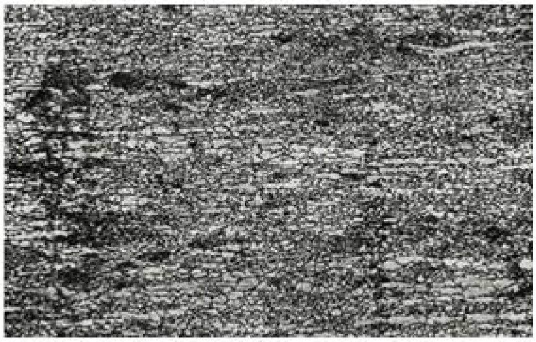


а)

б)



в)



г)

a) Commercially pure iron; b) A40G steel; c) U8A steel; d) U12A steel, 500× magnification

Figure 1.1. Microstructure of steels in the initial condition:

§ 2.2. Methodology of Mechanical Testing by Upsetting

Tensile tests at high temperatures were carried out using a universal testing machine of the brand *Instron*, model TT1114, within a temperature range of **400 to 1000 °C** and deformation speeds ranging from **0.05 to 500 mm/min**. The samples were prepared according to **GOST 1495-73**, with a gauge section diameter of **5 mm** and a length of **25 mm**. Heating of the samples to the test temperatures was conducted in a **three-zone resistance furnace**, ensuring a temperature deviation of no more than **±3 °C over a length of 300 mm**.

To ensure uniform heating and temperature stabilization, the samples were held in the furnace for **20 minutes prior to deformation** at the specified temperature.

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To reduce oxidation of the samples at high temperatures (t > 600–700 °C), a protective enamel coating such as **EVT13 or EVT24** was applied. This coating was rubbed onto the working section of the sample **prior to heating**.

Two groups of samples were used in the experiments. The **first group consisted of small samples** with a **diameter of 10 mm and a height of 15 mm**. These samples were **deformed on a U10 universal testing machine** with a strain (ε) ranging **from 30% to 80%**.

These samples were used in the development of a method for obtaining an ultrafine-grained (UFG) structure, with the aim of **systematically studying structural changes and mechanical properties** during the process.

Preparation of Samples for Mechanical Testing
Another group of larger samples, with dimensions of 30 mm in diameter and 60 mm in height, was subjected to isothermal upsetting in a die block using a modernized RN-100A hydraulic press with a 100-ton capacity. Heating of the samples was carried out by an inductor connected to a PST-100 converter. The deformation rate was **$5\cdot10^{-3}$ s^{-1}**, and the degree of deformation was at least **60%**. From the large preforms (blanks) obtained after upsetting, **standard specimens** for tensile mechanical testing (Figure 2.3) and **samples for microstructural investigations** were cut.

Figure 2.3. *Samples for upsetting, used for tensile mechanical testing and microstructural investigations.*

At each testing point, at least three samples were used. In this case, the **relative elongation (δ)** and the **yield strength (δ20)** were determined.

Based on the **force-time diagram**, the **uniformity of sample deformation**, and the **constancy of the volume of the deformable part of the sample**, the calculated cross-sectional area was determined, and the **true yield stress** was obtained.

$$\sigma = \frac{P}{S}$$

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Here, **P** is the force acting on the sample at a given level of deformation, and **S** is the cross-sectional area at the same deformation level.

Errors in measuring the yield stress mainly arise from the bending of curves due to stepwise changes in strain rates, as well as from the method proposed by Bekofen [71]. Measuring **m** from the bending of curves at a certain fixed level of strain is considered more reliable and convenient.

In determining mechanical properties, the diameters of the specimens were measured with a micrometer to an accuracy of 0.01 mm, and the gauge length was measured with a caliper to an accuracy of 0.05 mm. The scale of the elongation axis on the recording diagram was set at a ratio of 10:1 relative to the strain rate. The plasticity of the specimens was evaluated based on the maximum relative elongation (δ).

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