thus prevents layering. The treatment with intermediate recrystallization considerably increases the strength of the steel, apparently because of an intense fragmentation of the structure resulting from alternate deformation and formation of new small grains during recrystallization [4].

The increase in strength of austenitic steel is useful provided it is not accompanied by the formation of the \( \alpha \)-phase. Therefore, we determined the presence of the \( \alpha \)-phase by measuring the magnetic permeability of 50G20 steel after different treatments. We found that a high degree of deformation of precooled austenite does not induce the formation of the \( \alpha \)-phase: the magnetic permeability remains practically constant, being 1.003-1.004 G/Oe.

**Conclusions**

1. High-temperature deformation and quenching increase the strength of austenitic manganese steel considerably without the formation of the \( \alpha \)-phase: the yield strength of the steel not subjected to dispersionsal hardening is increased more than three times, while the yield strength of dispersionally hardened steel is increased 25%.

2. The combination of different treatments with dispersionsal hardening makes it possible to change the mechanical properties within wide limits. The strengthening resulting from the combined treatment is due essentially to the increased dispersionsal hardening resulting from preliminary deformation and to the cold hardening of austenitic steel.

3. Alternating deformation and intermediate relaxation or recrystallization of precooled austenite increases the strength considerably. Certain treatments of this type are technically easy and very promising for industrial use.

4. An important condition of the success of this combined treatment of steels which can be dispersionsally hardened is the prevention of the precipitation and coagulation of carbides before deformation of the austenite.

**LITERATURE CITED**


**POLYGONIZATION IN MOLYBDENUM AND MOLYBDENUM ALLOYS**

M. L. Bernshtein, É. L. Demina, E. É. Liberman, and L. G. Chernukha

Moscow Institute of Steel and Alloys
Translated from Metallovedenie i Termicheskaya Obrabotka Metallov, No. 5, pp. 49-54, May, 1963

This investigation concerns sintered and cast molybdenum, and cast alloys of Mo-Zr, Mo-Ti, and Mo-Zr-Ti.

Cast molybdenum and molybdenum alloys were smelted in a vacuum arc furnace with expendable electrodes, and poured into water-cooled copper crucibles. The ingots were forged into rods and then drawn on a swaging machine or rod drawing machine to diameters of 2.15, 2.10, 2.05, and 2.00 mm.
The rods were heated to 1250, 1300, 1400, 1500, and 1600°C for 5, 10, 15, 20, and 30 min.

Fig. 1. Microstructure of sintered molybdenum subjected to 13% swaging at low temperatures and annealing at 1100°C for 20 min. ×1000.

Fig. 2. Microstructure of cast molybdenum subjected to 13% deformation at 1150°C and annealed at 1200°C for 1 h. ×1000.

The optimal annealing conditions, determined from studies of the microstructure, were 10 min at 1250°C for cast and sintered molybdenum, 20 min at 1250°C for Mo–Ti, 10 min at 1600°C for Mo–Zr, and 10 min at 1600 for Mo–Zr–Ti. After this recrystallization annealing all rods were drawn to a diameter of 2 mm, which produced 5, 9, and 13% deformation. The rods were drawn at 200-300°C and also at 1050-1150°C. The drawn samples were heated 5 min-2 h in a hydrogen furnace at 1000-1600°C to study the polygonization and recrystallization processes.

From studies of the microstructure we determined the conditions resulting in maximum polygonization. We also investigated the effect of annealing time on polygonization.

We examined the microstructure of samples after deformation–deformation and annealing at 1000-1600°C, and deformation and double annealing at the polygonization temperature and higher temperatures. We also investigated the variation of the structure as a function of the time for the optimum treatment.

The samples were electrolytically polished in a solution containing 80% sulfuric acid (1.84 g/cm³) and 20% methyl alcohol. The difference of potentials was 17-20 V, the density of current was 3-4 A/cm², and the time was 40-60 sec. The samples were etched in an aqueous solution containing 10% K₃Fe(CN)₆ and 10% KOH for 50 sec to reveal the microstructure, and then electrolytically etched at 5-6 V for several seconds in a solution containing 5% sulfuric acid (1.84 g/cm³) and 95% methyl alcohol to reveal the substructure.

In sintered molybdenum subjected to cold working (200-300°C) the maximum polygonization results from annealing 15-30 min at 1100°C and 5-15 min at 1200°C (Fig. 1).

In cast samples the maximum polygonization resulted from annealing 1 h at 1200°C. However, the number of polygonized grains in samples annealed after cold working is rather small.

After deformation at high temperatures (1050 and 1150°C) boundaries of subgrains are visible in deformed metal both before and after annealing. Deformation at high temperatures favors polygonization even after annealing. As the result of de-