EFFECT OF HIGH PRESSURE ON MECHANICAL CHARACTERISTICS OF ALUMINUM ALLOYS

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It is well known that under the action of high pressures metals take on new mechanical characteristics, which may be maintained after removal of the pressure [1-3]. However the question of the effect of lengthy action of high pressure on the subsequent behavior of material under loading under normal conditions remains practically unstudied.

The present study will describe experiments in which the test material was subjected to the action of high pressures at high temperatures for a lengthy period of time. After cooling and removal of pressure specimens were prepared from the material for study of mechanical characteristics, which were then compared to those of the normal material. The high pressure was generated and maintained by the thermal method, making use of the difference in thermal expansions of different metals. The specimen to be processed was placed in a cylinder with closed faces having a coefficient of volume expansion smaller than that of the test material. The cylinders were formed by a container with two inserts. The cylinders were made of 5KhN1M quenched steel. The test materials used were AMg5M and AMg6 aluminum alloys.

The container had the following dimensions: outer diameter 135 mm, inner diameter 40 mm, resting surface diameter 65 mm, height 146 mm.

The pressure was created at T = 723°K. Under these conditions calculations show that for an absolutely rigid container the pressure would reach 3000 MN/m^2. Since the container has some compliance, the theoretically attainable initial pressure was 500 MN/m^2.

The experimental conditions were such that the container was subjected to creep deformation. To minimize the effect of container creep on drop in internal pressure, the inserts were subjected to special processing before assembly [4]. This processing consisted of the following: The outer insert was deformed by internal pressure, and the inner one, by external pressure. Deformation was carried out under creep conditions for 50 h at T = 723°K. The inserts were then processed to the size required for proper fit in the container. The test specimens of AMg6 and Amg5 alloys were then placed in the container. The container was sealed with end plates and placed in a press which was used to compress the specimen. The end plates were held to the container with dowel pins. The loading was chosen so that after removal of load the pressure in the container comprised 500 NM/m^2. The system was then placed in a heater chamber which was raised to 723°K and then maintained for 50 h.

The pressure in the cylinder was measured with a dynamometer (Fig. 1), consisting of a three-step bar 2, held by nut 4 within the container lid 1. Type Ts165-32A adhesive was used to attach a high-temperature strain gauge 3. Thus pressure on the dynamometer was converted into an electrical signal which was recorded with appropriate equipment.

The AMg5M alloy was subjected to pressures of 500 and 1000 MN/m^2 and the AMg6 to 500 MN/m^2. After 50-h maintenance at high temperature the container was cooled, and the aluminum specimen was recorded and cut into sections along the cylinder axis. Specimens were prepared from the sections for experiments testing creep, tensile strength, and density.

The creep specimens were made in the standard form with 55-mm base length and 7-mm diameter. The tensile specimens were 40 mm long and 7 mm in diameter. The specimens to be weighed were solid cylinders 40 mm in diameter and 20 mm high. The same types of specimens were formed of original material not subjected to the temperature regime as references.

Experiments on long-term strength with recording of a creep curve were performed with a TsST-3/É test machine at a strain of 3 tons at T = 433 and 443°K for the AMg5M and AMg6 alloys. Creep test results are shown in Figs. 2, 3, where all curves of deformation ε are arithmetic

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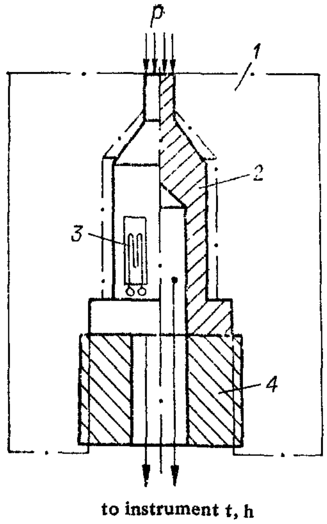

Fig. 1

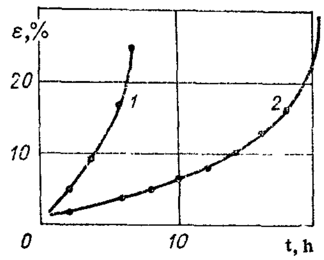

Fig. 2

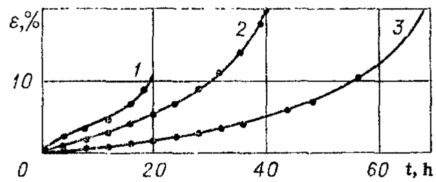

Fig. 3

averages of three experiments. Figure 2 compares creep curves for the alloy AMg6 at T = 443°K and σ = 120 MN/m^2; curve 1 is for material maintained at T = 723°K for 50 h, while curve 2 is for material compressed at p = 500 MN/m^2 and T = 723°K. Figure 3 compares creep curves for AMg5M at T = 443°K and σ = 140 MN/m^2; curve 1 is for material held at T = 723°K, curves 2 and 3 for material pressed at p = 500 and 1000 MN/m^2 at T = 723°K. Determination of the AMg5M mechanical properties was carried out with an Amsler type machine at a strain of 3 ton at T = 293°K. Specimen density was determined by weighing with analytical scales. Weighings were carried out in air and distilled water. Tests showed that the AMg6 density varied from 2644.1 to 2648.7 kg/m^3. Yield and creep points for the AMg5M were increased from 318 to 333 and from 153 to 167 MN/m^2 respectively, and long term strength increased ~3.5 times.

Thus aluminum alloys subjected to the action of high pressure improve their mechanical properties: There is an increase in longevity, deformation in the transient creep segment is reduced, and the steady state creep rate is reduced.

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