Alloys and Intermetallics

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Influence of thermal treatment on the structure of copper at ECA-pressing

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The process of equal channel angular pressing (ECA -pressing) is one of the ways of metal forming (MF), under which the material undergoes intensive plastic deformation [1]. Unlike traditional methods of metal forming the main goal of this treatment is the accumulation of deformation in the material without changing its shape. The scheme of simple shear provides the ability of repeated deformation by changing the direction of action tangential stress due to which in the whole workpiece volume is uniform structure refinement [2]. Despite all its advantages, the process of ECA-pressing still is not implemented on an industrial scale, and its research is purely laboratory character. In addition, each installation for the process of metal forming itself is unique. This researches are engaged and the department "Metal Forming" of Karaganda State Industrial University. During these studies, scientists of the University has developed a number new technologies which allow produce long-ferrous and non-ferrous metals and alloys with sub ultrafine-grain structure, such as a combined process of "rolling-pressing" [3] and a combined process of "pressing-drawing" [4]. The same way scientists of the University carried out studies on the effect of the preliminary and subsequent thermal treatment on the structure that is formed in metals and alloys at ECA -pressing. This work is performed within the state budget funded theme "Getting high-quality materials by a combination of thermal treatment and intensive plastic deformation" by the program "grant research funding for 2012-2014", is devoted to the influence of intensive plastic deformation (IPD), implemented in pressing copper workpieces in equal-channel step die, and the effect of pre- and post-thermal treatment on microstructure evolution of copper and its strengthening. The material of the study was a technical copper of grade M1 (99.90% Cu). Before ECA-pressing samples were subjected to preliminary heat treatment: annealing, hardening and normalization by the standard mode. Samples of square section 15x15x70 mm were subjected ECA-pressing in the die with an angle of junction channels 125° on the route Bc with tilting the workpiece by 90° around the longitudinal axis [5].

Three types of experiments were carried out in three different modes:

- Mode 1 - pressing temperature 25 °C, 6 cycles;

- Mode 2 - pressing temperature 90 °C, 6 cycles;

- Mode 3 - pressing temperature 180 °C, 6 cycles.

As the number of passes in ECA-pressing resource of plasticity is lost and further deformation, and the use of the metal in the industry is not possible because its destruction occurs. In order to increase resource of plasticity the metal should be subjected to heat treatment. As is known, the heating above temperature the onset of recrystallization leads to a strong grain growth and to a sharp fall of the strength of copper, so it is necessary to determine the temperature of the onset of recrystallization. Calculated the approximate temperature of the onset of recrystallization on accepted formulas [6] a laboratory experiment was conducted. Samples after ECAP were cut into thin plates with thickness of 5 mm and were heated at temperatures in the range 100 - 270^{0}C with duration of exposure 1 hour. Cooling of the samples is in water. Microstructure of copper after 6 cycles of ECA-pressing at different temperatures is presented in Figure 1. Microstructure of copper samples subjected ECA-pressing, change under the simultaneous influence of two factors: the preliminary heat treatment and increasing the pressing temperature. Minimum average grain size obtained during pressing of alloy M1 is 0.6 microns. This grain size is obtained after hardening at 700^{0}C and ECAP at room temperature and 6 cycles of deformation. The use of preliminary hardening allows getting more fine-grained structure and for the alloy M1 also reducing hardness by 15%, which helps to reduce the pressing force on the first pass, with 620 to 510 MPa. The use of combined thermomechanical treatment on a "hardening at 700^{0}C -ECAP low tempering at 200^{0}C" for the alloy M1 allows to improve the characteristics of copper and increases the resistance emergence and spread of cracks.

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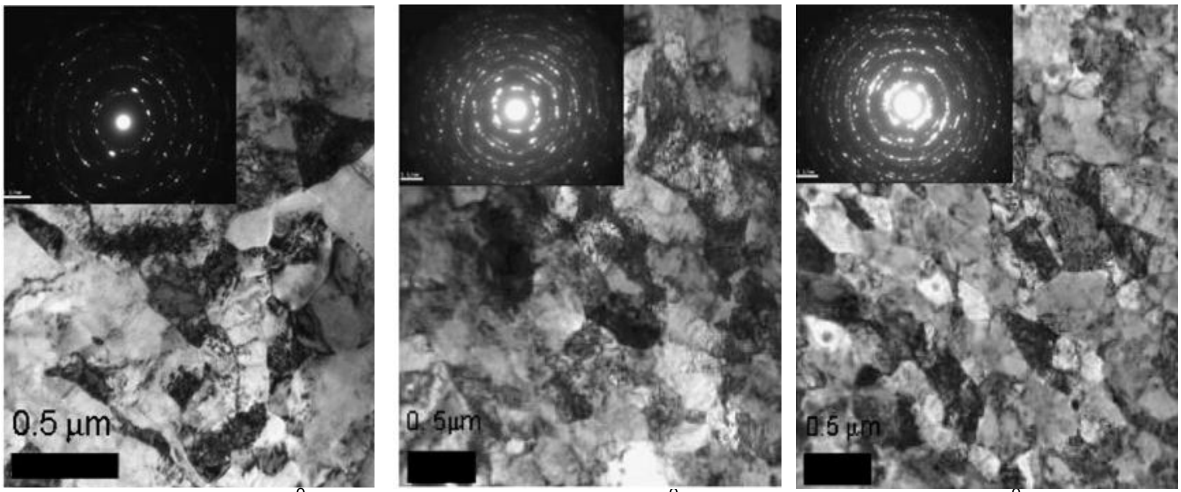

a – at T = 180^0C; в - at T = 90^0C; c - at T = 25^0C;

Figure 1. Microstructure of copper after 6 cycles of ECA –pressing.