Impact Toughness and Fracture Mechanisms Nanostructured Materials with BCC, HCP and FCC Lattice Structure in a Wide Temperature Range

N.A. Klevtsova[1] *, R.Z. Valiev[2], G.V. Klevtsov [1], I.P. Semenova[2], R.L. Islamgaliev[2], M.R. Kashapov[1]

[1]Orenburg State University, Orenburg, Russia,

[2]Institute of Physics of Advanced Materials USTU, Ufa, Russia

inshtet@mail.ru

Keywords: strength, impact toughness, fracture mechanisms, equal channel angular pressing, nanostructuring, sub microcrystalline structure, macro-and micro-relief of fracture.

Introduction. It is known that the equal-channel angular pressing (ECAP), forming a metallic material sub microcrystalline structure, increases strength properties of metallic material under static loading and reduces the plastic properties.

The purpose of this paper is to study the impact strength (KCV), and fracture mechanisms of materials with BCC, HCP and FCC lattice structure in the source and sub microcrystalline states.

Materials and Experimental Procedures. Test materials were carbon steel 10 (0.11% C; 0,39% Mn; 0,15% Cr; 0,25% Ni) with the BCC lattice; Titanium Grade-4 as a material with the HCP lattice and aluminum alloy AK6 (2,46% Cu; 1,48% Mg; 0,92% Ni; 0,89% Fe; 0,22% Si; 0,04% Ti; 0,04% Mn) with the FCC lattice structure. A sub microcrystalline state of materials was obtained by different modes of ECAP. The average grain size after ECAP for all investigated materials was about 300 nm. The impact test was carried out on pendulum MK-30. Samples of steel 10 were tested at the temperature interval ranging from -196 to +150 ^{0}C. The samples of titanium Grade-4 were tested at the temperature interval ranging from -196 to +500 ^{0}C. Specimens manufactured from aluminum alloy AK4 were tested at the temperature interval ranging from -196 to +300 ^{0}C. Fractures were investigated by macro-and micro fractographical.

Results and Discussion. The results showed that in comparison with the initial state, the interval of ductile-brittle transition of the steel 10 (a material with a bcc structure) narrows after ECAP at 200 ^{0}C, 4 passes, without changing the brittleness transition temperature of steel. After ECAP at 400 ^{0}C, 4 passes, the range of ductile-brittle transition shifts at 100 ^{0}C to lower temperatures. Following thermal treatment increasing impact toughness without changing strength properties is proposed.

After ECAP the impact toughness of the Titanium Grade-4 (a material with HCP lattice structure) decreases in comparison with the initial state at low and room temperatures and also the temperature interval of increasing impact toughness at high temperatures narrows. Microrelief of the fracture surfaces of titanium after ECAP at all temperatures patching.

Impact strength of the nanostructured aluminum alloy AK4 (material with FCC lattice structure) remains practically unchanged over the entire temperature range. Microrelief of the fracture obtained at all temperatures tested patching.

Conclusions. Influence of ECAP on the impact toughness and also fracture mechanisms of materials with BCC, HCP and FCC lattice in the initial and sub microcrystalline states were investigated.

This work was supported by RFBR (project № 11-08-00208).