Abstract

The main research objective of this work was to study the structural phenomena occurring in Al-Cu alloys under the influence of SPD deformation using the KoBo method and their influence on the material properties. The literature review shows that the strength of Al-Cu alloys can be increased by the addition of Cu, which with Al forms a hard intermetallic phase resistant to temperature. On the other hand, the presence of a large amount of intermetallic phase in the alloy hinders the deformation process. The solution to this problem is to use the SPD technique. So far, there are not many reports in the available literature regarding the use of SPD techniques to grind these alloys.

The experimental work included the fabrication of boundary, hypoeutectic, eutectic and hypereutectic alloy castings from the Al-Cu system, followed by grinding of the material using the KoBo technique. The work was aimed at: determining the structural changes after SPD application (grain size, dislocation structure, type of boundaries formed), defining the mechanism of structure fragmentation of Al-Cu alloys, formulating the effect of deformation on strength, ductility (superplasticity) and physical properties, and establishing the relationship between structure and mechanical properties.

Microstructure studies including light microscopy, scanning and scanning-transmission electron microscopy and X-ray microstructural analysis were used to accomplish the tasks. The mechanical properties of the material were evaluated by microhardness measurements, static tensile test, static compression test and superplasticity tests. Thermal expansion and electrical conductivity measurements were performed.

Based on the study, it was found that the KoBo method enables the α-Al and Al_2Cu phases to be fragmented to the ultrafine-grained level. The applied strain value (λ) plays an important role in the deformation of KoBo. If the samples are deformed at λ=98, then the grains are fragmented to smaller sizes, in addition, the microstructure is homogeneous. An increase in strain causes an increase in plastic properties with a decrease in strength properties. The consequence of grain fragmentation is an increase in mechanical properties obtained in static compression and tensile tests. A significant improvement in tensile mechanical properties is observed along with an improvement in ductility with increasing strain. The samples deformed especially at 400^{o}C showed superplastic properties. This phenomenon mainly affects Al-25%Cu and Al-33%Cu alloys. The eutectic Al-33%Cu alloy due to its ultrafine-grained structure shows the highest elongation during tensile test. The grain boundary slip mechanism is probably initiated already during KoBo deformation. These microstructural elements under superplastic deformation conditions facilitate deformation by a grain boundary sliding mechanism.