DESCRIPTION FOR THE GENERAL PUBLIC

The present Project is concerned with the effect of the straining rate on the microstructure and mechanical properties of materials subjected to cold severe plastic deformation under high pressure. Nowadays, in view of the increasing competition, the production processes are intensified, and there is growing demand for the materials with precisely defined mechanical properties. The intensification of the plastic working processes and search for new unconventional methods of volumetric shaping of materials impart the need for very high straining rates and the adoption of dynamic way of plastic straining. In order to fully control the plastic deformation process conducted under dynamic loading, it is necessary to know how the straining rate affects the mechanics of the plastic flow (yield stress, deformation non-homogeneity etc.). It is commonly known that the stress induced in the material increases with increasing straining rate and that this tendency is an intrinsic feature of a given material. Therefore, under dynamic loading, the individual materials differ in their behaviour, especially in dependence on their crystallographic structure.

The authors of the present Project are planning to use unconventional techniques of volumetric shaping i.e. severe plastic deformation processes (SPD) such as hydrostatic extrusion HE and equal channel angular pressing ECAP, conducted with the straining rate varied within a wide range, for examining its effect on the microstructure (morphology, density of defects, grain refinement) and mechanical properties (deformation strengthening) of materials. The numerous studies, available in the literature, which report on the investigations of this type, utilize the standard tensile Or compression tests for analysing the properties of materials untreated or deformed with the strain rate varied within a wide range. The effects of the plastic straining rate on the deformation strengthening of the material are estimated after the deformation process using the characteristics recorded during the test, and the microstructural properties are also examined after the deformation by e.g. analysing the fracture of the sample or the texture of the material. The factor affecting most adversely the results obtained by using this procedure is the adiabatic heating which usually occurs in dynamic tests conducted at high straining rates. In the present Project we propose that the effects of the straining rate will be examined during real SPD processes (ECAP and HE) with the adiabatic effect being considerably limited by cooling intensively the material, and that the strengthening of the material will be estimated after the SPD process using the static tensile test conducted at the standard straining rate. During the SPD processes, the plastic straining rate will be changed within a very wide range (at least 5 orders of magnitude).

The innovatory procedure proposed in our Project will permit analysing precisely the structure of the material by observing its changes in a transmission electron microscope (TEM) during a real SPD process. This will ensure better reliability and accuracy of the results than those possible to achieve when using the standard post-deformation static mechanical tests. Another advantage is that, thanks to the possibility of cooling the materials during the SPD process, the proposed procedure permits eliminating in a great measure the adiabatic effects which falsify the results. Moreover, in view of the known fact that the response of a given material to the straining rate depends on its crystalline structure, we are planning to examine three different materials with different crystalline lattices (FCC – copper Cu, BCC – iron Fe α, and HCP – zinc Zn). These investigations should give an insight into the mechanisms that underlie the differences in the sensitivity of these materials to the straining rate. The proposed procedure will give a precise tool for examining, within a wide range of the straining rates, the SPD-deformed materials whose strongly refined microstructure ensures a considerable improvement of the mechanical properties compared to those achieved in coarse-grained materials.