POPULAR SCIENCE ABSTRACT OF THE RESEARCH PROJECT

The present Project is devoted to the research in the field of plastic working of titanium. The method employed is the extrusion conducted with the cyclically rotating die (KOBO method). The experimental part of the Project will include several-stage processes of the transformation of titanium in the dispersed form (i.e. chips) into a bulk polycrystalline product in the form of rods. The characteristic feature of the Project is that the transformation of titanium is achieved without its melting. In the investigation part of the Project, the samples thus obtained will be subjected to complex examinations which will permit estimating the results of the experiment. The innovation of the Project lies in the combination of the material to be processed (two different titanium grades), its form (two different chips), and the unconventional technique of its plastic shaping (such that permits the material to be transformed without its melting). The starting materials will be two grades of mono-phase titanium α. Their form will be chips obtained after milling and turning. The technological process of titanium transformation will be conducted in several stages and the key operation will be extrusion at an elevated temperature using the KBO method.

The aim of the Project is to gain new knowledge about the phenomena which take place during the plastic working of titanium chips and also to analyze the transformation process of the material and its effects. An additional aim is to transform the dispersed form of titanium to obtain compact bulk samples in the form of rods. It is planned that the structure and mechanical properties of the rods should be possibly close to those of commercial polycrystalline titanium.

Within the framework of the present Project, titanium will be subjected to non-destructive and destructive investigations. The investigations will include the analyses of the consolidation degree, microstructure, and mechanical properties of the samples. The investigation methods will be based on fluorescent X-ray spectrometry, density measurements, computer tomography, scanning electron microscopy, hardness measurements, and compression tests.

The transformation of metallic chips to a bulk solid form has not been, as far as titanium is concerned, sufficiently investigated till now. The attempt at producing a polycrystalline product from a dispersed form constitutes an exciting scientific challenge and is an interesting theoretical and experimental problem in the field of materials engineering. The proposed study will permit assessing whether it would be possible, using the KOBO method, to transform Ti chips into a bulk solid form, and it will also deliver knowledge about the factors which affect this process and the phenomena which take place during it. The theoretical knowledge and preliminary investigations confirm that the KOBO method may be an effective tool for realizing the successful transformation of Ti chips, i.e. for the production of materials with the structure and properties close to those of commercial polycrystalline titanium. In other words, the KOBO method can enable consolidating mono-phase titanium α within a wide range of its purity and with differing chip geometries. Some obstacle to the consolidation of the chips is their oxidation. The presence of oxides spoils the homogeneity of the microstructure and degrades the mechanical properties of the product. In the case of the consolidation from a dispersed phase, it is necessary that new clean joints between the individual chips should be formed. The specific plastic deformation which occurs in the KOBO extrusion, unveils clean and chemically active surfaces of the chips. The unveiled chip surfaces are non-oxidized and relatively large, which is an undoubted benefit. Moreover, thanks to the rotations of the die there occurs an additional consolidation mechanism, namely diffusion, which promotes the formation of new durable atomic bonds between the neighboring chips.

The research works within the framework of the present Project include extrusion processes and further investigations of the samples obtained. This requires original methods and skills which offer the chance of gaining new theoretical and practical knowledge such that will permit realizing the planned experiments and investigations. From the scientific and cognitive point of view, it is planned to explain the problems associated with the transformation of the form, structure, and properties of titanium such as the effects of the chip geometry, the chemical purity of titanium, and its plasticity, on the possibility of its deformation and on the formation of durable atomic bonds between the neighboring chips.