In-situ cast composites strengthened with ceramic nanoparticles

The development of new technologies of the material production determinates either linear or abrupt changes of properties of products made with their usage. In case of a linear increase of properties small improvements and small profits are obtained. The abrupt change of properties allows to, obtain essential profits. In the context of obtained profits, investing in technologies which could generate the abrupt change of properties seems justified. Depending on aims for which the given product is intended for, the expectations of effects obtained from its usage are different. One of them is increasing the mechanical properties of products. This means such material changes which will ensure either a linear or abrupt change of their service life time. The mechanical properties have the most important influence on the products destruction including structural elements of machines and devices. In case when mechanical properties of material are not enough is necessarily of substituting them by the new ones and in consequence the raw materials and energy consumption increases and often a negative influence on the environment occurs. Currently, using available materials obtained a certain level of development, but further progress in this field requires new materials and production technology. Materials with abrupt change of properties creates new opportunities for the growth of civilization through more effective use of available energy sources on the ground, research and space exploration, which may lead to a change in the type of technological civilization.

The aim of the project will be elaboration of fabrication process of new material, ie. aluminum based composite reinforced with TiC nanoparticles. This composite will be fabricated by in situ synthesis of TiC nanoparticles directly in molten alloy. Implementation of the project predict to elaborate thermodynamic and kinetic parameters of in situ processes which ensure homogeneous distribution of nanoparticle in whole volume of cast. Control of particle size will be realized by addition of moderator, which will be change of conditions of nucleation and growth of TiC particles. Also the functionalization of surface of the powder particles will be performed in order to prevent a heterogeneous distribution particle in matrix. An important element of the study will be microstructure analysis of obtained composites, especially as regards of interphase boundaries and crystallographic relationships between nanoparticles, functionalized surface of particle and matrix. Also mathematical model allowing quantified description of the placement of nanoparticles in the composite, combining the particles deployment of composite with the mechanical properties at the macro and micro level will be developed.

It is expected that the implementation of basic research in this project will solve the basic issues of the mechanism for obtaining in-situ nanoparticles in liquid alloy, functionalize their surfaces, kind of interphase boundaries matrix - the nanoparticle in the system under study, a mathematical model that allows quantified description of the distribution of nanoparticles and its relationship with mechanical properties.

Currently, human civilization is classified as a Type 0 in the scale of the development of technological civilization. Implementation of research, especially basic makes it possible to detect new phenomena, new elements of matter, as well as the development of new materials and technologies for their production. All this is aimed at further development of our human civilization and should be expected, it is possible to achieve relatively fast in its development of Type 1.