Syntactic, multiscale computational models of high-performance for materials with limited ductility

Majority of European manufacturing sectors are largely based on the application of advanced metallic materials, including multiphase steels, titanium alloys or magnesium alloys, which are used by automotive, aerospace and energy industry. ***These materials are characterized by limited ductility and complex mechanism of deformation***. The theoretical description of phenomena occurring during deformation of multiphase materials is available in the scientific literature. However, there is no information on the mathematical models that can be used in numerical modelling of multiphase material behaviour during deformation with regard to the identification of the parameters of these models on the basis of laboratory test results and the results of numerical modelling of these tests. Hence the objectives of the project are presented below.

The main objective of the research is to develop and implement a high-performance application to identify effectively the parameters of syntactic material models. In addition, an application will include a module of sensitivity analysis to support the model reduction to make it useful in practical applications. In the project the developed numerical package will be applied to multiscale models for advanced materials characterized by limited ductility. Numerical modelling of such materials should be carried out with respect to microstructural phenomena. Thus, the next objective of the project is to develop mathematical models and algorithms of these phenomena for direct implementation. Developed numerical library of multiscale material models will be included to application for metal forming in macro scale and it will allow to precise and 3D analysis of deformation process.

In the project, a ***database of the multiscale models*** of various computational complexity for the selected materials and the syntax for constructing models correct in terms of physics phenomena occurring during deformation will be developed. The database will allow to select a model with respect to the purpose of the research: less complexity models intended for modelling of industrial processes, complex models of long calculation times for academic research to understand the mechanisms and phenomena during deformation. The developed in the project multiscale models will be identified and validated for the selected materials on the basis of the applied research methods.

The method dedicated to identification of the parameters of multiscale models will be developed and implemented in the project. The main output of the project will be the numerical package for inverse calculations of mulitscale model parameters. The tool will be used to identify both the multiscale model parameters for the selected in the project materials, new materials which behaviour can be described with the developed multiscale models, and new multiscale models.

The proposed solution will allow for more detailed analysis of the phenomena during deformation, in particular when laboratory tests cannot be performed or the test costs are very high. Reduction of the number of laboratory tests positive impact on the environment. Detailed analysis of the investigated materials contribute to more effective use of these materials in the planning of new technologies, positively influencing the development of civilization and economic society.

Thus, ***the innovative aspect of the project*** is the incorporation of the different deformation mechanisms into the inverse analysis (identification procedure) of the laboratory tests and combining it with volume fraction, morphology and properties of different structural constituents.

The project will also contribute to innovation, will strengthen intelligent manufacturing and will contribute to enhanced safety of people and environment. Development of proposed numerical package will help to gain further knowledge in understanding of materials characterized by complex deformation mechanisms. This in turn will be an important step forward for the certification of new, enhanced materials that will revolutionize the automotive, aerospace and energy industry.