DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

Development of the novel heterogeneous materials leads to obtaining materials with unique properties, sometimes opposite of that characteristic for materials used as phases of the composite. Prediction of material effective properties by performing numerical simulations is very important issue. In this way an impact of morphology and properties of the individual phases on effective material properties can be determined. Computational analysis can lead to better understanding of the material behavior and also it can be powerful tool in designing a new materials. From the other hand, besides estimation of effective properties, determining local material behavior at micro level is also very important. For example knowledge of micro stresses and strains fields allows to predict a failure of the material. Modern composite materials often contain phases with complex, nonhomogeneous spatial orientation. Assuming nonlinear material behavior and complex orientation of phases is very complex issue from the computational point of view. During realization of the project hybrid Mori-Tanaka/Finite element (M-T/FE) homogenization method will be developed. This method combines advantages of classical micromechanical approach with versatility of finite element based computations. The homogenization procedure involves replacing the heterogeneous material with an equivalent homogeneous material by analysis of representative volume element that is a statistical representation of material properties. Proposed hybrid M-T/FE method is generally less computational expensive than classical finite element method based homogenization. Generally proposed method is suitable for wide range of constitutive models however this project will be focused on analysis of two phase material containing elastic-plastic matrix material and elastic inclusion material. Moreover M-T/FE method will be extended to analysis of different, other than ellipsoidal inclusion’s shapes and inclusions distributed in non-homogenous way in accordance with orientation distribution function by involving two-step homogenization approach. Concluding, hybrid M-T/FE method with proposed modifications and improvements can be more efficient than classical finite element based homogenization and more versatile and general than mean field approaches. Another field of the research will be devoted to multiscale identification of material parameters. During an analysis of this problem data connected with two different scales will be taken into account. The proposed approaches in the first stage of the research are based on assumption that material parameters of each individual phase are known. The problem that will be considered is an inverse problem and it accounts the determination of material properties of individual material by assuming knowledge about data connected with microstructure description and data connected with the effective properties or microstrain fields. To solve this problem coupling of computational procedures from the first stage of the research with evolutionary algorithms is proposed. This approach will allow to deal with an analysis of heterogeneous materials in case when the information about the material properties of constitutes are not complete. The next research task of the project is an experimental analysis of the strain fields at the microstructure level by using digital image correlation method is proposed. The digital image correlation is an optical method that uses an image correlation algorithm, based on coordinate transformation from one camera image to another for full-field displacements and strains evaluation. This task is connected with designing a special testing unit that involves microscope, cameras, mounting unit and personal computer. During this project already existing laboratory unit dedicated to microscopic observations will my modified. After implementing the testing unit experimental research of selected materials will be carried on. Planned experiments in this field has got an original character and it will lead to better understanding of material behavior at microstructure level. The results obtained by developed computational methods will be validated experimentally i.a. by classical material strength tests (uniaxial tensile and compression tests). In addition a microtomography examination of selected material will be realized for obtaining a detailed description of the material microstructure. It will allow to set up an appropriate microstructure representation in the numerical analysis and make the experimental verification reliable. In conclusion proposed computational methods will be validated experimentally both in macro scale (effective properties) and in micro scale (micro strain fields) and additionally in solving of inverse problems.