Steel is probably the most known metal with obvious applications in every day life. It is used to construct small elements such as screws or knives, through elements of car body, elements of airplanes and finishing on huge elements of skyscraper. There is no need to convince anybody that steel is important. However not all steels are the same. For different applications different properties of used metal may be important.

Among construction materials, the search for those with high strength-to-density ratio and good ductility is still an objective of the research in many laboratories in the world. It was observed that multiphase materials, which have the features of composites, are very promising and are characterized by high values of the mentioned parameters. Recent research shows that it is still possible to significantly improve desired features by proper choice of chemical parameters and proper processing in factory. Among other things, to reach these improvements, a complex thermomechanical cycles are needed when steel is manufactured. Numerical modelling is an important support for the design of these cycles. The aim of the proposed project is to create a methodology that will enable effective prediction of microstructural features and properties in the multiphase materials resulting from the production. Simply, results of simulation lead to optimal metal processing and that way overall properties of steel are significantly improved. Reaching the aims of the project require solution of evolution equation with stochastic variables. Although the methodology we aim to develop in the project is general, the case studies for multiphase steels also will be performed.

In the first step, some statistical descriptors of the microstructure features will be analysed and those responsible for desired properties of products will be selected. Then an analysis of the obtained evolution equations will be conducted, with possible simplifications in the first step. We hope that exact, mathematically strict solutions for these simplest equations can be calculated. Where possible, an attempt to determine mathematically strict conditions, which ensure existence and uniqueness of the solution, will be made. This knowledge will be later used as a benchmark in numerical simulations. Simply, not always computer simulation reflects real solution of the equations, because errors of computation can quickly accumulate leading to a completely different picture. Knowledge about analytic solutions will be helpful in avoiding such pitfalls and choice of most suitable numerical methods.

The main objective of our research is design of computationally effective methodology for finding accurate solution of these equations. Theoretical aspects of material design based on numerical simulations with stochastic parameters will then be applied to find reliable and technologically justified solutions. This final shaping step includes sensitivity analysis for evaluation possible model reduction methods and inverse analysis for identification of the models.

A numerical tool (and methodology for its creation) based on the stochastic analysis of the manufacturing process will be the main output of the project. It is expected that this tool will be a useful support of research on development of new multiphase steels.