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The abstract of dissertation titled:

„Best estimate plus uncertainty methodology based on computational methods of inverse uncertainty quantification"

The doctoral dissertation is devoted to the development of a new methodology of best estimate plus uncertainty calculations, which will be an improvement over the currently implemented methodologies by introducing inverse uncertainty quantification of input parameters. Best estimate plus uncertainty methodologies may be used as one of the approaches to perform deterministic safety analyses of design basis accidents in nuclear reactors. The proposed methodology is based on best practices obtained from the implementation of current methods, additionally allowing for a reduction of the user effect. Development of the methodology leads to the proposition, implementation and demonstration of two computational methods of inverse uncertainty quantification. Probability density functions of input parameters which are the results of inverse quantification were validated in the next steps of the developed methodology.

The doctoral dissertation opens with a discussion of the most important issues of deterministic safety analyses performed with best estimate plus uncertainty approach. Two currently used methods have been discussed along with a presentation of their strengths and weaknesses, which formed a basis and motivation for improvements proposition and development of a new methodology. The following chapters of the dissertation describe the methodology, consisting of six elements. All six elements were thoroughly discussed. Implementation of each element of the methodology followed. The thesis's central part consists of a description of two inverse uncertainty quantification methods. The methods were used to quantify the uncertainties of input parameters of the thermal-hydraulic code TRACE. Those input parameters characterize three phenomena observed during LBLOCA: critical flow, heat transfer in the core and quench front propagation. Inverse quantification for those parameters was performed for two separate effect tests: Marviken critical flow experiment and Flecht Seaset reflood experiment. First of the developed methods is based on Bayesian inference and the application of Monte Carlo methods for random sampling. The second method is based on machine learning algorithms. A supervised machine learning algorithm based on random forests was implemented to quantify the discrepancy between experimental data and the results of calculations performed with the TRACE computer code. The solution to the inverse uncertainty quantification problem are probability density functions of code input parameters, inferred by their influence on the output parameters of calculations and their agreement with experimental data. Probability density functions were validated in the next step of the methodology presented in the dissertation. Validation was performed for the LOFT facility, where an array of phenomena occurring during LBLOCA were studied. Finally, best estimate plus uncertainty calculations using proposed probability density functions for input parameters were performed for a Pressurized Water Reactor for a LBLOCA scenario. The dissertation ends with a closing discussion, conclusions on the effectiveness and utility of the proposed methodology, and user effect reduction achievement by the introduction of inverse uncertainty quantification methods. Further research on both the methodology and computational methods is also proposed.

Keywords: nuclear power, nuclear safety, best estimate plus uncertainty, inverse uncertainty quantification, TRACE, Markov Chain Monte Carlo, machine learning

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Signature