Doctoral Committee of the National Center for Nuclear Research

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A Review of the doctoral thesis of MSc Mina Torabi with the title: Probabilistic Safety Assessment for High Temperature Gas-cooled Reactors

Doctoral Committee of the National Center for Nuclear Research has appointed me a reviewer of the doctoral thesis of MSc Mina Torabi.

Title is meaningful and it corresponds to the contents of the abstract and the contents of the doctoral thesis. Doctoral thesis consists of four chapters and a list of 91 references, which are related to the thesis contents.

The first chapter with the title “Introduction” gives the background and context of the thesis. It gives the scientific objectives. The primary objective of thesis is to improve standard approach of probabilistic safety assessment for the high temperature gas cooled reactor, which is one of new designs of nuclear reactors. The focus is placed to an initiating event of depressurized loss of forced coolant accident, taking into account the characteristics of safety-related systems of high temperature gas cooled reactors. The objective is the application of life-cycle reliability simulations by taking into account realistic operational conditions of safety systems of high temperature gas cooled reactor. The objective of this thesis is to address a novel probabilistic safety assessment method that considers the unique features of the high temperature gas cooled reactors considering ageing of the equipment, which is normally not directly included in probabilistic safety assessment.

The second chapter with the title “Exploring probabilistic safety assessment approaches in nuclear power plants” gives the state of the art of probabilistic safety assessment for nuclear power plants. Failure mode and effects analysis is presented and its applications are reviewed. The nuclear field and the air and space industry are both considered. Standard probabilistic safety assessment is presented. Probabilistic safety assessment strategies for high temperature gas cooled reactors are reviewed and evaluated.

The third chapter with the title “An innovative probabilistic safety assessment approach for high temperature gas cooled reactors” represents the key chapter of the thesis. The features of the high temperature gas cooled reactor are presented. The most important systems of the power plant with this reactor are described with emphasis on their relation to safety.

Extended failure mode and effects analysis is developed and extended with inclusion of risk. Risk priority number is a quantitative addition to the failure mode and effects analysis, which is a classical qualitative method.

Event tree method for modelling and evaluation of interaction between safety systems is presented and its mathematical background is given. Example is shown based on the selected initiating event.

Fault tree method for modelling and evaluation of safety systems is presented and its mathematical background is given. Example is shown based on the selected system model.

Reliability block diagram for reliability evaluation of systems is presented and its mathematical background is given. Example is shown based on the selected system model.

Electrical facility and vessel cooling system served as system representations for application of the presented methods, for case studies.

System models are developed and the results are obtained. Software Saphire, which is well known software for probabilistic safety assessment was used for modelling and evaluations. Reliability analysis of high temperature gas cooled reactor electrical system is developed and evaluated. Novelty is presented in sense of replacing constant failure rates with ageing considered failure rates, which change through time and ageing. New mathematical model is developed and is presented mathematically and evaluation is performed. The results are given and are compared with classical evaluation.

The fourth chapter with the title “Summary and overall conclusions” gives the take away message of the thesis. A novel approach based on life-cycle simulations of system reliability is developed within the thesis. The real example study based on a depressurized loss of forced coolant accident is applied using the developed method. The results show that the improved probabilistic safety assessment is a comprehensive and valuable tool for the design and safety evaluations of the high temperature gas cooled reactors. The new method reflects the unique characteristics and operational conditions of high temperature gas cooled reactors and provides a more realistic assessment of potential risks and important insights for its safe operation.

This thesis in the field of nuclear safety is an acceptable scientific achievement, which in quality and quantity satisfies the requirements for finishing a doctoral study with a doctoral thesis. This thesis is written in an acceptable manner, so I recommend the Doctoral Committee of the National Center for Nuclear Research to allow presentation and defence of the thesis and thus the work performed.

Sincerely yours,

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