

7ICMSNSE-Plenary2-3

Perspectives on the Development of Next Generation Reactor Systems Safety Analysis Codes

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Presentation Summary

Existing reactor system analysis codes, such as RELAP5-3D and TRAC, have gained worldwide success in supporting reactor safety analyses, as well as design and licensing of new reactors. These codes are important assets to the nuclear engineering research community, as well as to the nuclear industry. However, most of these codes were originally developed during the 1970s', and it becomes necessary to develop next-generation reactor system analysis codes for several reasons. Firstly, as new reactor designs emerge, there are new challenges emerging in numerical simulations of reactor systems such as long lasting transients and multi-physics phenomena. These new requirements are beyond the range of applicability of the existing system analysis codes. Advanced modeling and numerical methods must be taken into consideration to improve the existing capabilities. Secondly, by developing next-generation reactor system analysis codes, the knowledge (know how) in two phase flow modeling and the highly complex constitutive models will be transferred to the young generation of nuclear engineers. And thirdly, all computer codes have limited shelf life. It becomes less and less cost-effective to maintain a legacy code, due to the fast change of computer hardware and software environment.

There are several critical perspectives in terms of developing next-generation reactor system analysis codes: 1) The success of the next-generation codes must be built upon the success of the existing codes. The knowledge of the existing codes, not just simply the manuals and codes, but knowing why and how, must be transferred to the next-generation codes. The next-generation codes should encompass the capability of the existing codes. The shortcomings of existing codes should be identified, understood, and properly categorized, for example into model deficiencies or numerical method deficiencies. 2) State-of-the-art models and numerical methods must be considered to tackle the deficiencies in the existing codes. 3) Software design of the next-generation codes needs to take into consideration of having the flexibility

to add new models if necessary, as well as to allow for embedded uncertainty quantification, and capability of multi-physics coupling with other codes. 4) The next generation codes need proper verification and validation (V & V) before they can be used to plant applications. New approaches need to be developed to verify and validate complex multi-physics models with multiple time and length scales and advanced modeling techniques. 5) The next generation system analysis codes should be designed to be integrated into probabilistic evaluation to enable a risk-informed safety margin characterization (RISMC) process in order to optimize plant safety and performance by incorporating plant impacts, aging, and degradation processes into the safety analysis.