Advancements and Challenges of CFD in Nuclear Reactor Regulation at the US-NRC

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ABSTRACT

The US Nuclear Regulatory Commission (NRC) is tasked with ensuring that the commercial use of nuclear materials in the United States is safely conducted. This includes the review and evaluation of submitted analyses that support the safety justification for specific reactor system components. Typically these analyses involve codes that have been approved for the specific application of interest and this implies that the approach has a proven history of validation and acceptance in the regulatory environment. The application of computational fluid dynamics (CFD) is becoming common practice in many industries. This includes the use of CFD by the nuclear industry for design and internal safety analyses. CFD applications used to support the licensing and regulation of nuclear power plants are less common but growing in frequency. Due to the limited number of these applications, there is typically not a proven history of acceptance for regulatory applications. This increases the work required for submission, review, and acceptance of these methods.

The ever increasing capacity of modern computers and the growing number of capable analysts ensures us that CFD applications will continue to expand into the range of tools available for nuclear reactor safety analysis. The emergence of small modular reactors and high temperature gas cooled reactors will create opportunities for CFD applications to enter into the regulatory process. The challenge for the regulator is to ensure that these tools are properly applied in order to build up the necessary evidence of validation and acceptance that is appropriate for a regulatory process. Development of best practice guidance, verification and validation methods, and CFD grade data bases are all positive developments. The regulator is still faced with significant challenges, however, in a field where CFD quality benchmark data are limited, approaches are not universal, and resource limitations and user experience impact the quality of predictions. In this challenging environment, the regulator is tasked with deciding if a given CFD simulation is good enough for the intended application.

In order for nuclear regulators to build the necessary experience and confidence in CFD methods, there is a great amount of work required to address the challenges that exist. The tasks for the nuclear community, both the regulator and the industry, include a continuation of the refinement and maintenance of best practice guidance, further development of CFD grade benchmark studies and data base standards, continued refinement of verification and validation methods, and the development of robust yet practical treatments for uncertainties and scaling. Through these efforts, it is anticipated that CFD methods will grow in acceptance for nuclear reactor safety applications.