Validation of Robustness in TCR Design Strategies

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ABSTRACT:

The Transformational Challenge Reactor (TCR) program aims to bring 21st century manufacturing, control system and software technology to nuclear safety grade components with the hope of changing the economic paradigm of nuclear energy. Currently, the basis for TCR design is a gas cooled reactor with multiple solid materials types in a unique arrangement. The current timeline to demonstrate the TCR project is 60 months. The current TCR primarily utilizes MCNP, RELAP/TRACE and recently BISON. The objective of the proposed work is to: 1) Provide confirmatory analysis of TCR for the expected performance of the design within the first year of the project 2) Develop performance metrics for sensor signal for autonomous operation 3) Inform robustness requirements of the artificial intelligence (AI) software for operational decision making. We will meet the outlined objective by performing sensitivity analysis (SA) and uncertainty quantification (UQ) of TCR design parameters and the relevant physical phenomena. We will utilize reliable and high fidelity techniques for such heterogeneous application. Specifically, open-source time dependent Monte-Carlo (MC) code OpenMC, NQA1 qualified commercial codes STARCCM+ and ABAQUS for thermal-hydraulics and structural mechanics, respectively. The SA/UQ analysis will provide key insights to allow for development of performance metrics of robustness for the envisioned sensors, by processing signals such as neutron flux, temperature and strains. The data generated as part of SA/UQ can also inform the needed robustness for AI by enveloping the attainable level of decision making by the software. Furthermore, the quantification of the uncertainties in TCR will help guide the sensor design and its performance goals. The key for successful completion of the stated objectives lies within the multidisciplinary proposing team. The team has decade of successful collaboration among them on development and utilization of high fidelity tools for reactor applications. The team is made up of a fuel and reactor design expert, Computational Fluid Dynamics (CFD) Expert and Neutronics expert and a member of the TCR analyst team to provide the necessary baseline information and keep the team well-connected with TCR progress.