Embedded Instrumentation and Controls for Extreme Environments

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ABSTRACT:

The objective of this project is to develop and demonstrate new embedded instrumentation and control (I&C) technologies and integration methods for extreme environments. Embedding I&C during the early phases of system design contrasts with the traditional, serial approach that incorporates I&C after the mechanical and electrical design. Deeply embedding I&C into major nuclear power system components can improve component efficiency, increase reliability, reduce maintenance costs, provide real-time prognostics and diagnostics, and enable otherwise unachievable component performance.

The proposed work will utilize the project team's distinctive prior experience in fluoride salt-cooled high temperature reactor design along with sensor design, advanced control theory, materials, and machine design for extreme environments to develop new high temperature sensors, characterize the sensor performance, and integrate sensors, controls, and system design into an embedded I&C test and demonstration platform. This testbed will consist of a high temperature pump system that utilizes active magnetic bearings and a switched reluctance motor to remove the need for pump seals which are a major cause of maintenance and failure. The system is tailored for high-temperature fluoride salt cooled reactor applications with operating temperatures up to 700 °C. High-temperature pumps represent a particularly suitable demonstration and development platform due to their large potential for performance and reliability improvements and their widespread use in nuclear power plants. The embedded I&C technologies developed will cross cut a large class of reactors including liquid metal reactors and high-temperature gas reactors. The extreme environment of high temperature pumps present serious design challenges for instrumentation and control. The successful embedding of I&C in this extreme environment requires a multi-disciplinary unified design effort.

Successful completion of this project will yield cross-cutting sensor and control technologies for nuclear reactors, multi-disciplinary design integration techniques, performance and fault tolerance characterization, and a high-temperature, loop-scale embedded I&C testbed and demonstration platform for future research into embedded instrumentation and control technologies for extreme environments.