NEUP Nuclear Energy University Program
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High-Temperature Electromagnetic Acoustic Transducers (EMATs) for Structural Health Monitoring

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Program: Liquid Metal-Cooled Fast Reactor Technology Development and Demonstration to Support Deployment

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ABSTRACT:
The aim of this project is to develop a prototype electromagnetic acoustic transducer (EMAT) monitoring system for structural health monitoring (SHM) and process monitoring at the Mechanisms Engineering Test Loop (METL) at Argonne National Laboratory (ANL) and similar high-temperature assets. The primary challenge is the long-term (minimum of 10 years) of near-continuous operation at 550°C with the possibility of short-term temperature excursions up to 650°C. Further, the design should be low power with the target of operating at under 12W so that it can be made to be intrinsically safe and be powered from a battery or commercial energy harvesting. The project will seek to establish core design solutions that can be used as the basis of a range of EMAT designs for different applications.

Ultrasonic measurements are used for a wide range of nondestructive evaluation (NDE) and process monitoring measurements including erosion and corrosion monitoring, crack detection and flow characterization. Ultrasonic technology is uniquely well suited to liquid metal plant as purely electromagnetic techniques will be undermined by interaction with the electrically conductive working fluid, and the non-contacting nature of EMATs means there is negligible mechanical interference with the safety critical components.

The project will focus on three main work packages. The first is to design EMATs that are resilient to the high temperatures. Inevitably, the advancements made to achieve the temperature tolerance will compromise the signal-to-noise (SNR) ratio of the EMAT; this is further compounded by the paramagnetic stainless steel test material. The second work package is to optimize the electromagnetic design and signal processing methods to enhance SNR. The final work package is focused on the demonstration and deployment of the technology; the EMAT system will be developed in the lab and demonstrated on increasingly realistic test platforms. Finally, the prototype measurement system will be deployed at the METL at ANL. The primary objective is to demonstrate long-term stability in the high-temperature industrial environment.

The project will be a collaborative effort between the University of Cincinnati (UC) and ANL. The basic science and development phase will be based at UC Center for Nondestructive Evaluation. The project will deliver a prototype EMAT measurement system that will be deployed and demonstrated at the METL facility by the ANL partners. The project team has a wealth of experience of developing metrology systems for extreme environments and liquid metal reactors.

The project will deliver a first of its kind capability for the power generation industry. The project will have a transformative impact in enabling a range of *in situ* SHM and process control measurements across the nuclear power generation industry.