Enhancement of EM Pump Performance through Modeling and Testing

PI: Mark Anderson, University of Wisconsin-Madison

Program: RC-2.2 Electromechanical Pump

Collaborators: William Nollet (Fort Lewis College), Lee Gouwens, Arthur Gage (CMI-NovaCast), Michael Hvasta (Hvasta, LLC)

ABSTRACT:

Electromagnetic (EM) pumps are designed to circulate high-temperature, electrically-conductive liquid metals, such as sodium. Compared to older and larger mechanical pumps, EM pumps are intrinsically safe, reliable, and leak-resistant because they lack moving parts or seals in contact with the flowing molten metal. For these reasons, EM pump research has traditionally been a cornerstone of sodium-cooled fast reactor (SFR) development. The major issue associated with EM pumps is the lower efficiency as compared to mechanical pumps. Even the best EM pumps typically have efficiencies lower than 40%. Improving the performance of EM pumps will be an important aspect of making Gen-IV SFRs more technologically and financially viable.

Enhancing EM pump performance will require a better means of predicting, measuring, and minimizing unwanted 'longitudinal' and 'transverse' end effects, which reduce overall pump efficiency and cause non-ideal velocity gradients throughout the pump. These effects are inherent to many different EM pump designs and result from different duct geometries, coil configurations, and operating conditions. This proposal will address several of these issues through the following project objectives.

Overall Project Objectives:

1. Develop computer models for electromagnetic pumps, benchmarking initially against the preexisting Moving Magnet Pump (MMP) and Annular Linear Induction Pumps (ALIP) to be designed and constructed. This computer model will allow for modifiable pump geometry, sodium condition (temperature, wetting, etc.) and electrical input parameters for induction pumps.
2. Develop and utilize advanced diagnostic tools to measure transient magnetic fields and distributed temperatures and velocities to quantify pump end effects. These tools will be used to validate electromagnetic pump computer models as well as enhance the ability to perform real-time diagnostics of an electromagnetic pump in situ.
3. Increase overall efficiency of electromagnetic pumps using an enhanced understanding of end effect phenomena. Efficiency of ALIP will be optimized in computer model and compared against experimentally acquired pump efficiency curves.
4. Provide several students with an education in the unique aspects of sodium fast reactor technologies, including the skills required for safe handling of high temperature alkali metals, hands-on experience with state of the art hydrodynamic sensors, sodium purification systems, three phase electrical engineering etc.