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Project: Experimental Study of Liquid Sodium Heat Transfer at Low Pe (in SFR fuel assemblies, intermediate heat exchangers, and PCHEs)
Advisor: Mark Anderson
Sponsor: UNLP Fellowship, DOE-NE NEUP, TerraPower

SCL

THL Thermal Hydraulics Laboratory

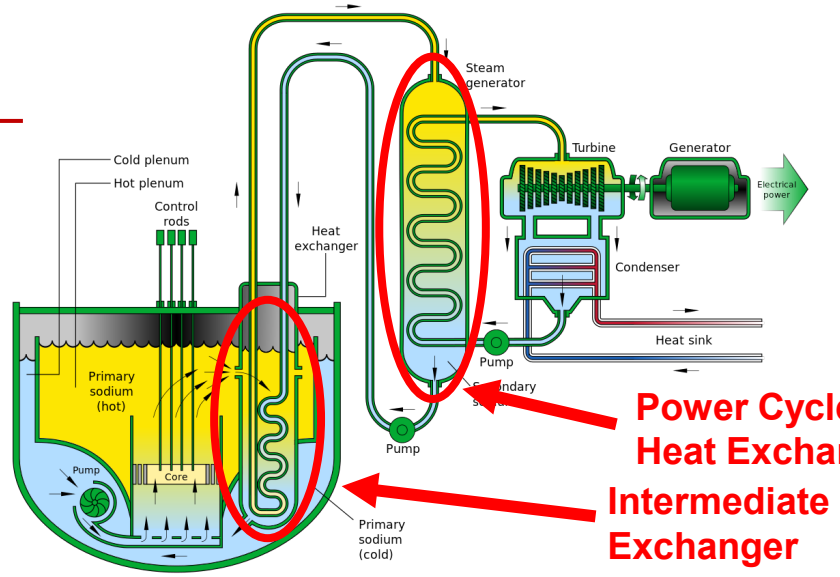
UNLP University Nuclear Leadership Program

NEUP Nuclear Energy University Program
U.S. Department of Energy

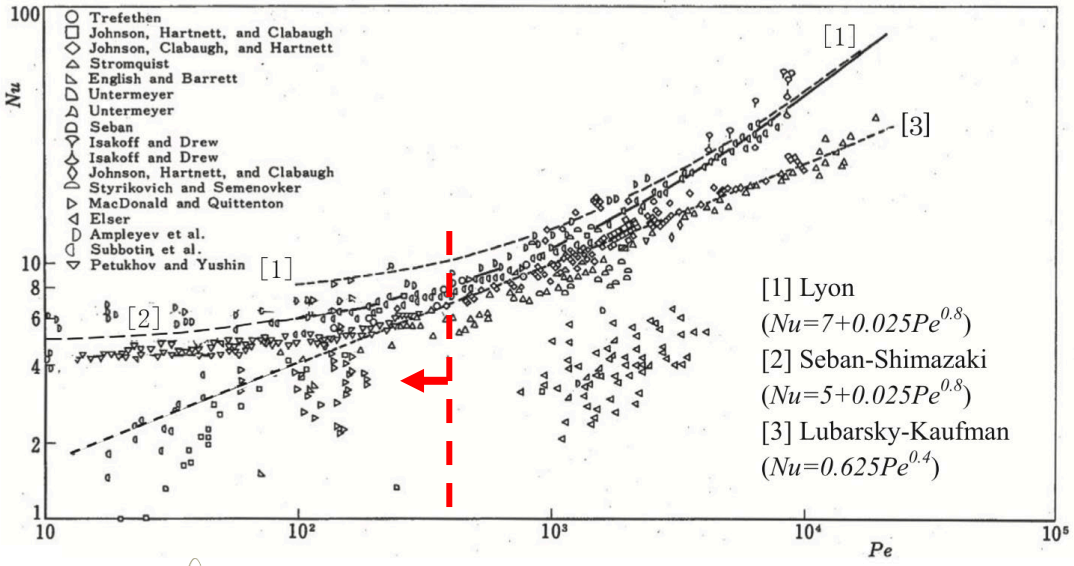
TerraPower
A Nuclear Innovation Company

Background

- Sodium fast reactors (SFR) use **liquid sodium as a heat transfer fluid**
  - High thermal conductivity, high operating temperature (efficient), and allows for fast neutron spectrum and breeding/burning nuclear fuel (recycle spent fuel)
  - Low Prandtl number fluid: heat transfer is studied using experimental correlations
- Pool type SFRs utilize two **heat exchangers** to transfer heat from the core to the working fluid/power cycle →
- These heat exchangers receive **sodium flows at low Peclet numbers**
- Current liquid metal heat transfer correlations for low Pe conditions are lacking (large spread in data) →
  - Designers in the nuclear industry still have some lingering questions about heat transfer to sodium flows here
- Compact printed-circuit heat exchangers (PCHEs) represent a promising candidate for the power cycle heat exchangers of SFR power plants, particularly when coupled with a supercritical CO_2 Brayton cycle
- Building reliable models backed up by experimental data for sodium flows through bundles of wire-wrapped fuel elements in SFR cores for aid in the design and licensing of new SFRs is an important goal



"Sodium-Cooled Fast Reactor (SFR)," *GIF Portal*. https://www.gen-4.org/gif/jcms/c_42152/sodium-cooled-fast-reactor-sfr (accessed Apr. 23, 2022).



Project Goals

- Collect accurate high resolution **sodium** heat transfer data in several relevant geometries using an experimental liquid sodium flow loop:

1) An upward sodium flow through a **vertical annular duct test section** with a heater rod at its center, instrumented with optical fiber temperature sensors for measuring axial and radial temperature profiles
   a. Containing a bare heater rod
   b. Containing a heater rod with a helical wire wrap
2) A downward sodium flow through a **diffusion-bonded printed-circuit heat exchanger** with high pressure nitrogen gas as the cold fluid, instrumented with thermocouples and optical fiber temperatures sensors to provide internal wall temperature data in the heat exchanger
   a. With elliptical sodium side channels
   b. With semielliptical sodium side channels

- Construct heat transfer correlations appropriate for comparison with existing data and a variety of computational models
- Provide further validation for optical fiber temperature sensors in high temperature liquid metal applications in the nuclear industry