# High temperature tribological performance of Ni alloys under helium environment for very high temperature gas cooled reactors (VHTRs)

**PI**: Andreas A. Polycarpou-Texas A&M University

**Program**: Nuclear Reactor Technologies

**Collaborators**:

Xinghang Zhang- Texas A&M University

Ali Beheshti- Lamar University

**ABSTRACT:**

Operating at high temperatures (HT) is critical for nuclear reactors as it results in substantial thermal efficiency improvement. In view of design demands, materials that can withstand HT and harsh environments are necessary for reliable and effective nuclear reactor operation. Alloy 800H and Inconel 617 are the principle candidates in high/very high temperature gas cooled reactors (HTGR/VHTRs) with outlet temperatures of 700-950°C. The literature is relatively abundant with works pertaining to mechanical behavior studies as well as oxidation/corrosion for 800H, Inconel 617 and other nickel alloys. What is missing in the literature is HT tribological performance of 800H-800H, Alloy 617-800H and Alloy 617-617 interfaces, especially in the presence of Helium (He) coolant.

The scope and objectives of this research project is to systematically evaluate the tribological response of 800H and 617 alloys at relevant reactor operating temperatures and in the presence of He coolant. The outcome is to further enhance HT durability and environmental compatibility of tribological components operating in VHTGR. This project focuses on a comprehensive experimental plan to investigate and compare the friction, surface damage (wear, fretting, self-welding, corrosion/oxidation) and contact response of tribo-pairs consisting of alloys 800H and 617 in simulated HTGR/VHTR He and in atmospheric conditions (under normal and HT). The major tasks are HT aging with and without He environment (sample preparation), macro tribology experiments (unidirectional and oscillation/ fretting), micro/nano-mechanical testing (HT indentation and scratch), detailed material characterization before and after tribological experiments (SEM, EDX, EBSD, TEM and STEM), analytical/numerical modeling, considering parameters involved in HTGR/VHTR conditions and eventually a comprehensive analysis of the obtained data seeking mitigation alternatives and optimum and safe design/operating conditions.

The major deliverables are obtaining basic/fundamental knowledge of failure mechanisms and tribological response in these materials as well as predictive models. Specifically, knowledge of friction coefficient behavior (static and dynamic), wear, fretting, oxidation and self-welding leading to interface failures, as a function of aging time, dwell time, temperature, speed, load, gas composition, and surface roughness will be established for each material pair in the presence of air, helium and helium with impurities. In addition, this research will result in finding and suggesting alternative solutions to mitigate tribological problems with these Ni alloys under HTGR/VHTR conditions through investigating different practical approaches such as optimizing the design as well as operating conditions, and also surface modifications (surface topography alternation/treatments and HT super hard coatings).

The potential impact of the project is to enable improved and safer design of HTGR/VHTR towards licensing in Nuclear Regulatory Commission (NRC), especially with the forthcoming addition of Alloy 617 to the ASME Code for HTGR/VHTR. Furthermore, this project will result in a clear and inclusive understanding of the tribological performance of Ni based alloys in high temperature (HT) gas cooled reactors HTGR/VHTR operational environment as well as an enhancement in HT durability/environmental compatibility of tribo-pairs in HTGRs with He coolant.