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Telescopic Control Rod for Significant Reduction in HTR Height and therefore Cost

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Program: Reactor Concepts

ABSTRACT:

High Temperature Reactors (HTRs) have tall cores. Reactivity is managed through control rods, which typically contain annular absorbers and absorb most incident neutrons. The control rods are housed within the reactor vessel, which is contained within a silo embedded in the ground. Incremental increases to the silo depth are high cost. We propose a compact design for a small modular high temperature reactor (HTR) control rod that extends telescopically. The technology is applicable to both pebble bed and prismatic HTRs and both are given equal consideration in this project. It consists of ~5 concentric annuli that nest together above the core when withdrawn. This compact component substantially reduces the length of the above vessel control rod housing compartments thus depth of the silo and hence is of potentially major cost benefit. **The primary objective of this project is to develop the telescopic control rod to the point of being technically feasible and licensable,** through a multidisciplinary design study encompassing theoretical and experimental work. To achieve this, specific objectives are as follows:

(1) Develop a mechanical design where potential failure mechanisms are identified and designed out, accounting for thermal and irradiation behavior. Reactor physics considerations include adequate shutdown margin and ensuring positive differential control rod worth at all intermediate insertions.
(2) Demonstrate experimentally the extension and contraction mechanism of a prototype control rod in a hot He environment, through in-situ evaluations of the sliding velocity and coefficient of friction. If funded from the US/UK collaborative mechanism, University of Manchester & Jacobs will provide complementary oxidation and wear testing and characterization.
(3) Perform a cost-benefit analysis to determine or otherwise the economic case for the concept.
(4) In partnering with Framatome and X-Energy, demonstrate the concept to sufficient maturity to be a credible design option for prismatic and pebble bed HTR vendors, with the goal of incorporating it in SC-HTGR and Xe-100.

The shorter control rods may make it practical to extend the RPV to house the control rods within the vessel. The concept may hence provide a pathway to integral HTR technology, with significant reduction in vessel penetrations with safety benefits through simplifying RPV code compliance. While this is a design variant, and not the main thrust of the proposal, a supplemental objective is therefore to:

(5) Evaluate the feasibility and relative merits of integral telescopic control rods in an HTR.