ADVANCED LIQUID FUEL MOLTEN SALT REACTOR CORE SIMULATION USING GEN-FOAM

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ABSTRACT

In this study, a hybrid two-dimensional (2D) / three-dimensional (3D) Liquid Fuel Molten Salt Reactor (LFMSR) core is modelled using the Multi-physics C++ code GeN-Foam (General Nuclear Foam). GeN-Foam has three main sub-solvers - for neutron kinetics, thermal hydraulics, and thermal mechanics. A steady state analysis of a simplified 2D LFMSR model has been performed assuming rotational symmetry to cross validate the code with the commercial ANSYS Computational Fluid Dynamics (CFD) code Fluent. The calculations showed a very good agreement between the two codes allowing moving onto a 3D model simulation. A coupled 3D neutron kinetic and CFD steady state analysis of the 3D LFMSR core has been performed modeling one quarter of the core using the core symmetry to reduce the computational time. The GeN-Foam neutron kinetics sub-solver has been designed to consider also the drifting of the delayed neutrons precursors in LFMSR, a capability not yet implemented in the most of current neutron kinetics codes. The mixed Uranium and Plutonium chloride fuel has been selected in this preliminary study. The calculation results meet the expectations showing that GeN-Foam has all the features necessary for LFMSR design modeling and simulation. The delayed neutrons precursors behavior is as expected - the longer-lived isotopes accumulate near the outlet while the short-lived ones lay at the generation location. The calculated maximum temperature is close to the expected one and the velocity profile is consistent with a low viscosity, high density fluid velocity profile.

KEYWORDS
GeN-Foam, CFD, multi-physics, LFMSR

1. INTRODUCTION

Liquid fuel molten salt reactor (LFMSR) is the only liquid fuel reactor among the six Generation IV nuclear reactor concepts. The LFMSR uses liquid molten salt as both coolant and fuel solvent; hence, the conventionally used methods to analyze the reactor characteristics cannot be applied to study the LFMSR. Dedicated tools need to be developed where the Computational Fluid Dynamics (CFD) calculations are coupled with a neutron kinetics solver. Liquid fueled reactors have significant safety and economic advantages over solid fueled designs. From safety point of view, there are no risks of fuel melting as the fuel is already in molten state, it is operable at atmospheric pressure, with no possibilities of hydrogen accident scenarios, and the overall cycle efficiency is in the order of 44% compared to the conventional