PHYTRA4 – The Fourth International Conference on Physics and Technology of Reactors and Applications.
Marrakech, Morocco, September 17-19, 2018, on CD-ROM, GMTR, Rabat, Morocco (2018)

MODELLING AND SIMULATION OF A LIQUID FUEL MOLTEN SALT REACTOR CORE USING GEN-FOAM

Sandesh Bhaskar, Muhammad Altahhan, Devshibhai Ziyad, Paolo Balestra, Jason Hou, Maria Avramova
Department of Nuclear Engineering, North Carolina State University
Raleigh, NC 27695, U.S.A
sbhaska2@ncsu.edu; mraltahh@ncsu.sdu; dsziyad@ncsu.edu;
pbalest@ncsu.edu; jason.hou@ncsu.edu; mnavramo@ncsu.edu

ABSTRACT

In this study, a Liquid Fuel Molten Salt Reactor (LFMSR) design was proposed and modelled using the Multi-physics C++ code GeN-Foam. GeN-Foam has three main sub-solvers that solve for Neutronics, thermal hydraulics, and thermal mechanics. A coupled steady-state analysis of the LFMSR core fueled with fresh fuel with the chemical form of $1 \cdot PuCl_3$ $8 \cdot UCl_3$ $10 \cdot NaCl$ was performed using a quarter core presentation. The neutronics sub-solver implemented in GeN-Foam is capable of simulating the drifting of the delayed neutrons precursors in LFMSR, which is not taken into account in most of the current neutron kinetics codes. The preliminary results show that delayed neutrons precursors behavior is as expected with the longer-lived isotopes accumulated closer to the outlet while the short-lived ones are closer to the point of production which depends on the neutron flux. In addition, the calculated maximum temperature difference is similar to the one predicted according to the power energy relation.

Key Words: GeN-Foam, CFD, multi-physics, LFMSR

1. INTRODUCTION

Liquid fueled reactors have significant safety and economic advantages over solid fueled designs. From safety point of view, it is operable at atmospheric pressure, no risks of fuel melting as the fuel is already in molten state, lesser possibilities of hydrogen accident scenarios and the overall cycle efficiency is in the order of 44% compared to the conventional reactors which stands at 33%. Economically, fuel pellets and rods need not be manufactured in the case of LFMSR, online refueling while the reactor is in operation ensures that the reactor does not have to be shut down making it different from the conventional reactors [1].

On the other hand, LFMSR are characterized by fuel flowing out of the core into the primary circuit in which there is no sustaining neutron flux and hence some of the delayed neutrons that are used in controlling the reactor operation are emitted outside of the core. This will make the total delayed neutron fraction (β_{tot}) lower which will affect the reactivity insertions. Another significant issue from the material point of view is that pipes, valves and pumps are prone to corrosion. Also, the modeling and simulation tools currently available are not capable of fully describing the kinetics of these systems in an efficient manner. Although many validated neutronics and thermal hydraulic packages do exist, they cannot provide analysis with the time