INTRODUCTION

The renewed interest in molten salt coolant technology is based on 50 years history of molten salt nuclear technology development, mainly in Oak Ridge National Laboratory (ORNL). In Indian context MSBR is found to be one of the options for sustainable nuclear energy generation, especially in the third stage of the nuclear programme. The system can be operated at high temperature which makes high efficiency power conversion and efficient hydrogen generation through thermo-chemical reactions possible. At present development is in progress in BARC on two molten salt reactor concepts, one is pool type and the other is loop type. Here the design of pool type concept is described. The core is designed to operate in the fast spectrum region so the conversion of U-233 breeding is possible from thorium. Preliminary thermal hydraulic analysis is carried out with LiF-ThF₄-UF₄ as the primary coolant and fuel. The blanket material is LiF-ThF₄. FLiNaK is used as the secondary coolant for the calculations. Both forced circulation and natural circulation options are evaluated.

The schematic of the concepts is shown in Fig 1. The core of the conceptual design consists of the inventory of the salt and the reflector, made of high temperature alloy placed at top and bottom of the core. The core is surrounded by an annular fertile blanket, through which the fertile salt LiF-ThF₄ is circulated. After getting heated in the core the fuel salt is passed through a riser to the primary heat exchanger. The fertile blanket is connected to a header from where the salt will be taken out of the core through the piping for reprocessing. In this configuration the heat exchanger is the place where the maximum pressure drop occurs. Tube-plate type heat exchanger is chosen for this application after a brief literature survey. The fuel salt after rejecting heat in the primary heat exchanger flows down to the core. The down comer is an annular passage surrounding the fertile blanket. The secondary salt is FLiNaK which is circulated by forced flow in a loop. The salt flows through the tube side of the primary heat exchanger to cool the fuel salt which flows in the plate side of the heat exchanger. The temperature dependent thermo physical properties of the salt are taken from Rouch et al. [1] and Sohal et al. [2] for thermo-hydraulic analysis. The pressure drops in the heat exchangers are calculated from the correlations given in Shah and Sekulic [3]. For pressure drop calculations in the various components of PHT circuit, Idelchik [4] is referred for correlations on hydraulic resistances. The heat from the secondary coolant is transferred to the tertiary side through the secondary heat exchanger. Supercritical CO₂ is considered as the tertiary fluid which is the working fluid of Brayton Cycle for electricity generation.

The conceptual design of the reactor system is described in the paper. Thermal hydraulics analysis is carried out to find the different parameters of the system. Reactor physics feasibility analysis is also carried out and major results are described in the paper.
RESULTS AND DISCUSSIONS

Preliminary thermal hydraulics analysis is carried out to find the various parameters of the concept with both natural circulation and forced circulation options. For natural circulation option by keeping the inlet temperature 650°C the geometry of the reactor is optimised to limit the reactor outlet temperature 1000°C. The inventory of fuel salt in the PHT is found to be 74 tons. The inventory of fuel salt in the PHT is found to be 40 tons. CFD analysis is also carried out using PHOENICS code to find the velocity and temperature distribution in the PHT circuit. Figure 2 shows 2D results of the analysis. The CFD analysis is in progress to simulate different reactor transients.

Preliminary reactor physics feasibility analysis of 850 MWe pool type IMSBR with natural circulation has been carried out for a static core in hot operating condition operating in fast neutron spectrum [5]. The modelled pool type reactor includes components like IHX, riser, down comers etc. The analyses have been carried by varying several design parameters to explore breeding ratio and \(^{235}\text{U}\) inventory. The initial fissile \(^{233}\text{U}\) inventory in the present configuration is found to be 5.4 T/GWe, whereas initial BR has been found to be \(-1.1\) with 2.7% \(^{233}\text{U}\) content. The use of 0.5% (mol) of helium fuel makes the spectrum softer, which resulted in slightly high \(K_{\text{eff}}\) value and slightly less initial BR.

Figure-3 compares the neutron flux spectrum in core and blanket regions. The effects of refuelling of different volumes of fuel for corresponding removal of burned fuel have also been studied (Fig 4).

Concluding Remarks

Thermal hydraulic studies are carried out on a pool type MSBR concept to study the feasibility of natural circulation cooling as well as forced circulation cooling during normal operating conditions. It is found that the natural circulation cooling is possible with minimum temperature difference across the core of 350°C. However the design could be improved with further thermal hydraulic studies. For forced circulation cooling in the primary side it is quite feasible to design the reactor with pool type geometry. Reactor physics feasibility analysis is also carried out for static core, more rigours parametric analysis considering various reprocessing rates is under study.

References