A DRACS concept design and development of thermal-balance analysis code for small modular natural circulation lead coolant fast reactor

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Abstract: The authors investigate a nature circulation decay heat removal with thermo-switch coolers. A heat pipe heat exchanger (HPHE) is proposed and applied to SSTAR[1], lead cooled fast reactor.

Introduction: A Direct Reactor Auxiliary Cooling System (DRACS) is a passive decay heat removal system, completely relying on natural convection of the coolants and air. Ongoing DRACS operation may cost heat losses during normal operation condition. To solve the issue, a passive on-and-off system is proposed and the thermal hydraulic performance are investigated.

DRACS Design and Computational Model: A decay heat removal system requires enough heat remove capacity, reliability, efficiency and economy. High temperature, Alkali metal HPHE with thermo-switch and unidirectional heat transport ability could be one of candidates. The DRACS with the HPHE is automatically switched off if coolant temperature becomes lower than its working temperature and switched on if it is higher.

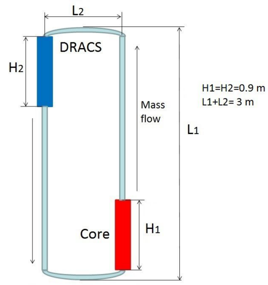

Fig.1 Naturel Circulation loop

A natural circulation loop based on SSTAR system has been modeled(Fig 1), to investigate DRACS passive switch on/off process after core shut down. System initial with mass flow as 0.001 kg/s, Isothermal temperature for coolant as 650K, threshold temperature Ts is 820K. System adiabatically, the only heat sink is the DRACS.

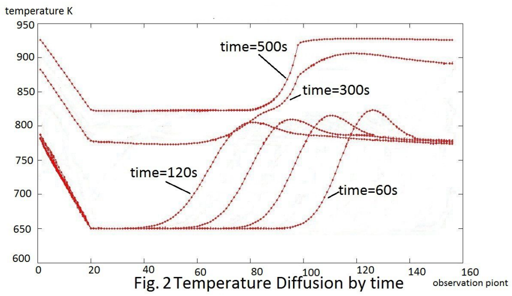

Fig. 2 Temperature Diffusion by time

Result: System temperatures keep increasing until DRACS inlet temperature becomes higher than Ts at 300second(Fig 2). With DRACS operation, the system temperature stopped rising at 500 second.The mass flow oscillation can be observed during temperature rising. The mass flow kept to reduce because decay power reduced by time, and proportional with buoyancy(Fig 3). The DRACS could limit coolant temperature after core shut down, avoiding heat losses under normal operation. The DRACS will not be switched off until the coolant temperature becomes lower than Ts. Thus additional coolers are necessary, which has not been considered in this model. Once coolant temperature is below Ts, the DRACS will passively switch off. If no another heat sink is available, the coolant temperature will increase. Once the temperature is above Ts, DRACS will switch on again and this process will be repeated.

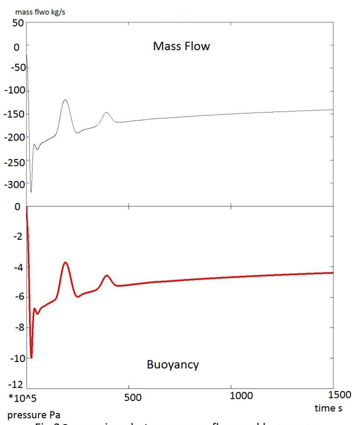

Fig.3Comparison between mass flow and buoyancy

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