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C3Or1A-02: Thermo-Fluid Analyses and Experiments for UCN Cryogenic System

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Cold neutrons are down-scattered by isopure superfluid 4He (IPHe-II) with around 0.8 K to become ultra-cold neutrons (UCN). The UCN lifetime strongly depends on the temperature of the IPHe-II. During the beam operation, temperature of the IPHe-II gradually increasing from 0.8 K due to the dynamic heat load. The TUCAN collaboration is now developing the new cryogenic system. There are mainly two important requirements. One is to lower IPHe-II temperature to below 1 K. The other is to suppress the temperature increase to within 0.2 K or less during the operation. In order to satisfy such requirements, not only 4He but also 3He has to be circulated through the system to fill saturated 3He of 0.8 K in the final heat exchanger for cooling down of IPHe-II to 0.8 K. There are six heat exchangers which are mainly categorized in two groups, "counter flow type"and "pool cooling type", respectively. In order to design these heat exchangers properly, thermo-fluid simulations are carried out by considering forced convection heat transfer for the single and two phase flow, nucleate boiling heat transfer of liquid 3He and 4He, critical heat flux of He II, film boiling heat transfer of He II and Kapitza conductance. It is also quite important to predict the pressure drop through vacuum line for the circulated 3He. The vacuum line should have large conductance while suppressing radiation heat transfer from room temperature by inserting the baffle plates. LES are carried out to predict the pressure drop and find optimal vacuum pipe with baffles. In addition, Thermo-fluid behaviors of IPHe-II are also simulated to understand them. The cryogenic test system is developed to check the validity of these simulation results and design validates. In this presentation, the simulation schemes, test system and these results will be discussed.

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