ENTHALPY RECOVERY SYSTEM FOR ITER CRYOPUMPS*

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The primary pumping system of ITER consists of sixteen cryopumps. The cryopanels in these pumps are cooled using supercritical helium (SCHe), nominally at 4.5 K. During plasma operations twelve cryopumps are in pumping mode and four are in various stages of regeneration. The pumping time of each cryopump is limited to 900 s to maintain hydrogen inventories at acceptable levels. After 900 s of pumping, regeneration is required. During the regeneration phase, a pump is warmed up to ~ 80 K to desorb the gases accumulated on the 4.5 K cryopanel. Following desorption, the cryopump is evacuated with a mechanical pumping system for a period of 75 s to remove desorbed gases. The final phase of the regeneration sequence, lasting 75 s, is to re-cool the cryopanel to 4.5 K. If, during warm up and cool down of the cryopanels, the cold cryogen can not be recovered, the consumption of SCHe will be over 6000l/h. This consumption can be reduced by about 50% by an arrangement that will allow the enthalpy of a cold panel to be recovered during warm up and transfer of this enthalpy to a panel undergoing cool down. The efficiency of this energy recovery will depend on the temperature profiles of the exhaust gases from both the warming and cooling panels. The purpose of this task was to develop an analysis tool to 1) Insure that the warm up and cool down can be carried out in 75 s and 2) to evaluate reduced consumption of SCHe enthalpy recovery.

A computer model of the ITER cryopump was developed. The model represents the important geometrical features of the pump and solves the energy equations for the solid and the fluid, the continuity equation, and the equation of state. All thermophysical properties are variable with temperature. The twenty cryopanels of each pump can be connected in series or parallel flow arrangement. A similar model has been previously used to design the DIII–D cryopump and shows good agreement between analysis and experiment.

The analysis results show that each cryopump can be cooled from 80 K to 4.5 K in 75 s by using a SCHe flow of 125 g/s at 4 K when all cryopanels are connected in series. A similar arrangement enables the warm up from 4.5 to 80 K with a flow rate of 125 g/s at 90 K. The analysis further shows that during the warm up, 80% of SCHe inside the cryopump can be recovered by using a reduced flow rate of 5 g/s for several seconds. The analysis shows that SCHe requirements can be reduced by 30 to 40%, resulting in operating cost savings of several million dollars per year.

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