C3PoE - 434 The Effect of Condensation Area and Operating Temperature on Heat transfer Capacity of a Closed Loop Thermosyphon Cooling System for HTS Machinery

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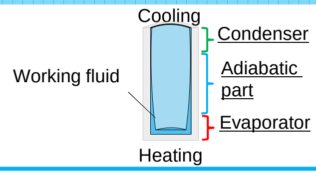
Introduction

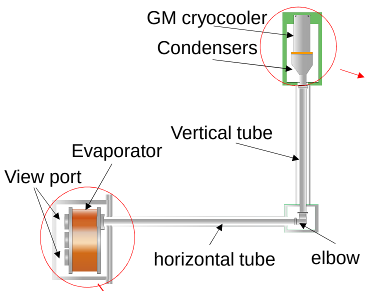
High temperature superconducting (HTS) rotating machines require sophisticated cooling system. Concerning the available HTS wire performance of field poles, it is essential to keep their temperature in the range of 28 K to 40 K. Natural convection-cooling system using thermosyphon is one cooling system capable of satisfying this temperature range. The heat transfer capacity of thermosyphon cooling system depends on the condenser, adiabatic tube and evaporator design. For optimized performance of a thermosyphon cooling system, a heat transfer capacity has to be studied. In this study, we focused on the heat transfer area of condenser part.

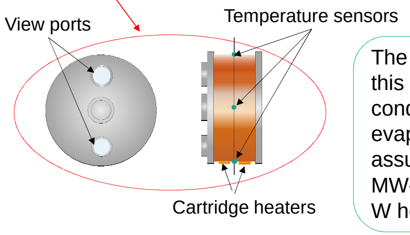
Thermosyphon

Thermosyphon is one phenomena of heat transfer. It is constructed from condenser part, adiabatic part and evaporator part. In the condenser, the working fluid condenses and flows down by gravity. In the evaporator, working fluid vaporizes and moves by buoyancy to the condenser thereby completing the cycle.



Experimental Set-up





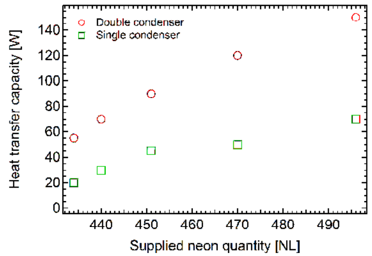
The thermosyphon cooling system in this experiment is composed of condenser, adiabatic tube and evaporator. This cooling system assumes a half-scale model of 20 MW-class HTS motor which has 400 W heat generation.

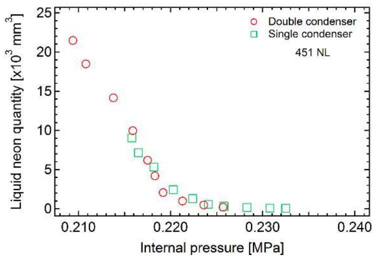
Heat load experiment

The heat load experiment was conducted with five different neon quantities as 435, 440, 451, 470, 496 NL. The heat load was applied to the bottom of the evaporator for 3 hours. The heat load was applied until boiling form is changed from nucleate boiling to film boiling. We also investigated to the effect of condenser temperature with 470 NL.

Results

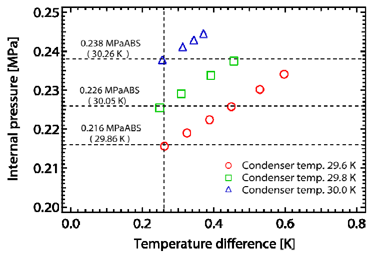
A. Results of heat load test

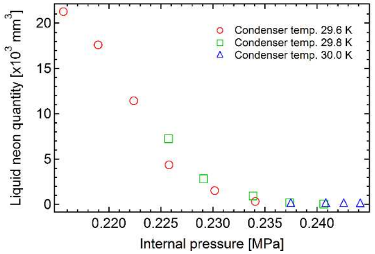




The number of condensers affects the heat transfer capacity.
At the same internal pressure, the liquid neon quantity in the evaporator is the same for both single and double condenser configurations.
Upon reducing the condenser number, the liquid neon quantity decreased and internal pressure increased.

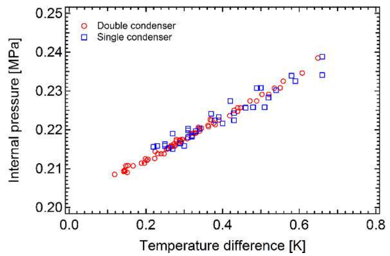
B. Effect of condenser operating temperature





The liquid neon quantity follows the same curve even if we changed the condenser operating temperature.
The internal pressure depends on ΔT, the difference between saturation temperature and condenser operating temperature.
The liquid neon quantity increases with decreasing condenser operating temperature.

C. Relationship between the internal pressure and ΔT



Both of the single and double condenser results follows the same curve. That is, even if the heat transfer area changed, the relationship between the internal pressure and temperature difference did not change. Given ΔT, the internal pressure can be predicted.

Conclusions

・We conclude the internal pressure is related to the heat transfer area of condenser.
・The heat load test was conducted using both double and single cryocooler. And we also obtained the effect of condenser operating temperature.
・We evaluated the internal pressure is related to the heat transfer area of condenser and condenser temperature.
・From the results, we can predict the internal pressure. And this results can be used for design the TS cooling system.