Introduction
Application of HTS bulk or conductor materials to machinery such as motors and generators can make them lighter, compact and more efficient. An HTS motor or generator differs from a conventional one in that it would have an HTS field coil or bulk that is cooled by a cryogenic cooling system. When employed to cool HTS motors and generators, thermosyphon (TS) cooling exhibits high heat transfer rate and near-isothermal operation. It also has simple structure. In this work, an experimental study of neon TS was conducted. Temperature distribution in a TS is important in characterising its performance. So a thermal model was developed to estimate the temperature distribution of the thermosyphon components, especially the evaporator.

Thermosyphon Operating Principle

- Condenser
- Adiabatic tube
- Evaporator
- Gravity

Experimental Set-Up
The neon thermosyphon has a maximum cooling power of 200W. It comprises of a cylindrical evaporator operating at 30K and two condensers, each mounted on a cold head of a Cryomech G-M cryocooler. Cold heads were regulated at 29.7K. The cold mass is wrapped in a 20-layer MLI and housed in an evacuated cryostat. By applying heat load to the evaporator at varying filling ratios, the behaviour of the TS was studied.

Instrumentation
Evaporator is fitted with viewports for viewing neon liquid and "wetted area". Temperature sensors T1-T6 measure temperature at shown locations. T7 measures the neon-evaporator interface temperature. Total heat invasion Qexp was computed in real time.

Thermal Analysis

- Q1: Convection
- Q2: Radiation through MLI
- Q3: Radiation to cold mass
- Q4: Convection through MLI
- Q5: Supports conduction

Development of Simulation Model

Defined Boundary Conditions
- Temperature
- Heat flux
- Convection
- Radiation

Determination of Effective Emissivity
The thermal effect of MLI was accounted for by defining its effective emissivity εeff, which was determined by tweaking εeff until measured and estimated heat invasion. Heat transfer rate through the MLI is modelled by:

\[ Q = \sigma A_s \varepsilon_{eff} (T_s^4 - T_{3surf}^4) \] [W]

- Assume MLI effective emissivity \( \varepsilon_s = 0.015 \)
- Estimate temperature & heat invasion(\( Q_{est} \))

Model

- New \( \varepsilon_{eff} \)
- Yes: Final \( \varepsilon_{eff} = 0.03 \)
- No: Thermosyphon temperature estimation

Results and Discussion

Estimated vs Measured Temperature
Estimation error at various neon filling ratios & heat loads. (NL= Normal Litres). Error = measured temperature - estimated temperature.

- Estimated temperature varies within 0.5K to 3K of measured data. Temperature is underestimated at all points.

- Despite a constant effective emissivity, the model closely estimated experimental heat invasion. Maximum error is 0.8W.

- Thermosyphon heat invasion enumeration:
  - Through MLI to the cold mass: 48%, Conduction via supports: 52%

Conclusion
Experimental and simulated temperature distributions at various filling ratios and heat loads of a closed two-phase thermosyphon were compared. Effective emissivity approach allows for reasonable estimation of thermal parameters. The modelling approach is acceptable for validating temperature data and fairly useful for HTS cooling system design.