Thermohydraulic modelling of a transfer line for continuous flow cryostats Dittmar\textsuperscript{1}, Weisemann\textsuperscript{1}, Haberstroh\textsuperscript{1}, Hesse\textsuperscript{1}, Krzyzowski\textsuperscript{2}

**INTRODUCTION**

Transfer lines are an essential link between the mobile LHe dewar and the continuous flow cryostat. A certain fraction of LHe evaporates and the continuous flow cryostat. A certain fraction of LHe evaporates and condenses inside the transfer line due to pressure drop and heat leak. These losses reduce the experimental time and increase the LHe consumption. A dedicated thermohydraulic model has been developed, to support the design of an improved transfer line with reduced losses for continuous flow cryostats.

**EXPERIMENTAL SETUP**

The experimental setup is similar to a standard setup with a continuous flow cryostat. The transfer line has a riser length of 1.06 m, a horizontal length of 0.85 m, and a vertical one of 0.4 m. It was equipped with three pressure sensors, connected by capillaries. Their typical uncertainty is 0.5 % FS. The mass flow meter has an accuracy of 2 %.

**PRESSURE DROP CORRELATIONS**

The total pressure drop is composed of the frictional pressure drop, the gravitational pressure drop, and the pressure drop caused by acceleration. Nevertheless, the frictional pressure drop predominates the total value.

\[ \Delta p_{\text{fr}} = \frac{\rho_1 u_1^2}{2} \]

Since the transfer line’s inner diameter is 1.6 mm, it had to be proven if the homogeneous model (HM) or dedicated mini-channel correlations are more accurate.

Table 1: Two-phase multipliers of considered models.

<table>
<thead>
<tr>
<th>Model</th>
<th>Two-phase multiplier</th>
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<tr>
<td>HM</td>
<td>( \phi_{\text{HM}} = \left( 1 + x \frac{P_2 - P_1}{P_2} \right)^{-0.25} )</td>
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<tr>
<td>Subbotin et al.</td>
<td>[ \phi_{\text{SB}} = \left[ \sqrt{\frac{\lambda_{\text{c}} H_{\text{c}}}{\rho_2 C_{\text{P}}}} \right] \left( \frac{P_2}{\rho} \right)^{0.5} \left( \frac{1}{C_{\text{P}}} \right) ]</td>
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<tr>
<td>Kim and Mudawar [3]</td>
<td>( \phi_{\text{KM}} = 0.39 \cdot \frac{\lambda_{\text{c}} H_{\text{c}}}{\rho_2 C_{\text{P}}} \left( \frac{P_2}{\rho} \right)^{0.5} \left( 1 + 0.6 \cdot \frac{\lambda_{\text{c}} H_{\text{c}}}{\rho_2 C_{\text{P}}} \right) )</td>
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**RESULTS AND DISCUSSION**

The calculation results show that the approach by Subbotin et al. gives the best agreement with the experimental data. All models show higher deviations in pull mode which may be caused by an uneven distribution of the heat flux along the transfer line. The heat flux is calculated to be 0.9 W which is 45 % less than the measured value. During pull mode (low G) the critical heat flux (CHF) might be exceeded.

**CONCLUSION**

A thermodynamic model dedicated to transfer lines for continuous flow cryostats was developed having a mean accuracy of 14 %. On basis of the existing model several parameters like the insulation and the hydraulic design will be modified virtually to find a transfer line design with reduced transfer losses.

**REFERENCES**

[1] Subbotin et al. 1987, Cryogenics 27, pp 291-301