TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Mechanical Science and Engineering Institute of Power Engineering, Bitzer Chair of Refrigeration, Cryogenics and Compressor Technology C2PoC-04

Operating parameters of LHe transfer lines used with continuous flow cryostats at low sample temperatures

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MOTIVATION

Although continuous flow cryostats are widely used, only little data exists concerning the performance of the required transfer line. Therefore, experimental data of a single-channel flexible transfer line was gathered, also to identify the potential for improvements.

EXPERIMENTAL SETUP

The experimental setup features a continuous flow cryostat for low temperature microscopy equipped with temperature and pressure sensors. Furthermore, it was equipped with additional radiation shields to minimise its specific heat load. An experimental transfer line with built-in sensors was examined as well as a reference line. Both transfer lines feature a riser length of 1060 mm, a flexible length of 700 mm and a cryostat side length of 410 mm. The applied MLI is characterised by a layer density of 250 layers/cm. The maximum deviations of the sensors are ± 0.5 kPa for the pressure transmitters, ± 0.25 K for the silicon diode temperature sensors, and ± 0.004 g/s for the mass flow measurement at room temperature.

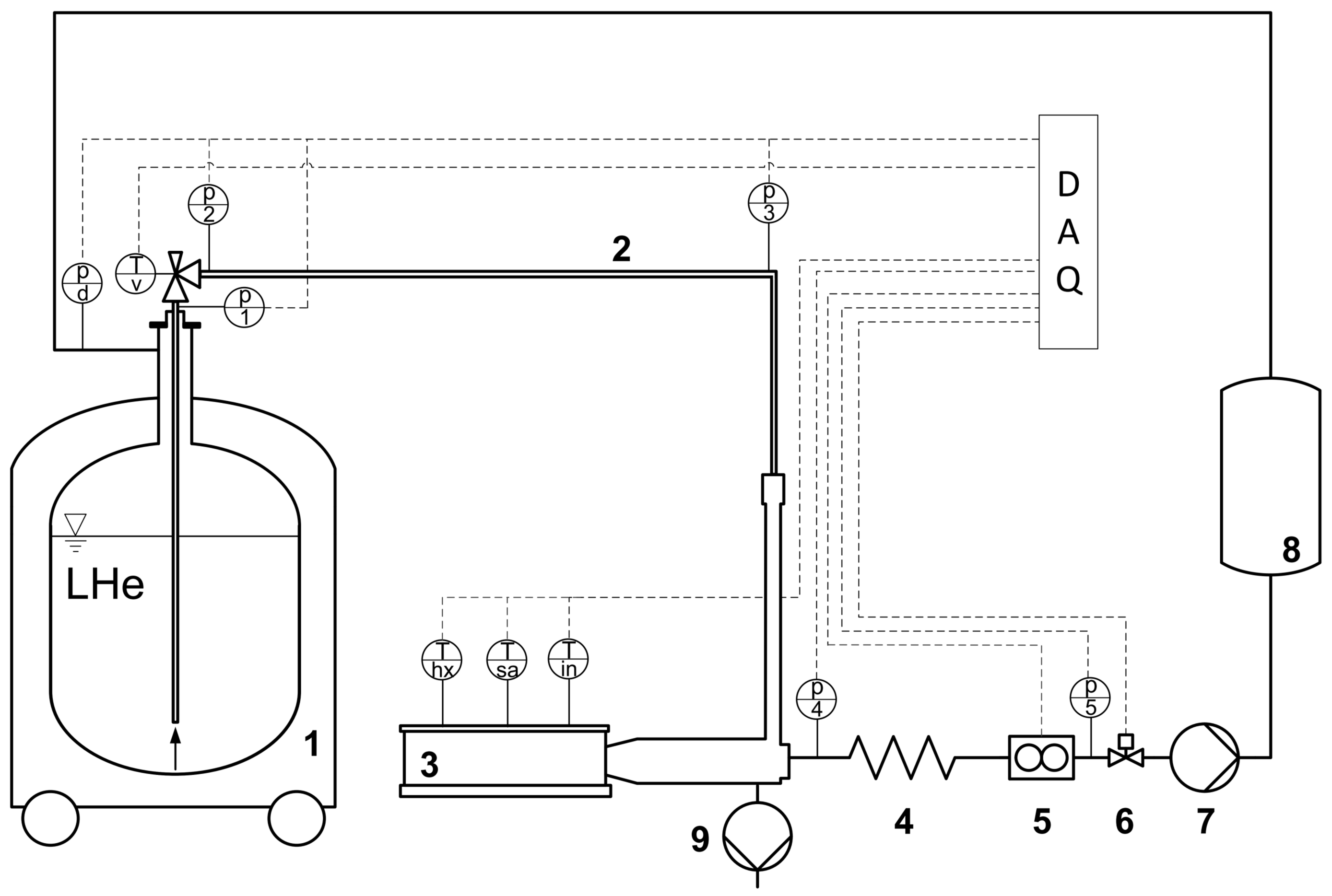

Figure 1: Test setup; 1: mobile dewar, 2: transfer line, 3: flow cryostat, 4: gas heater, 5: mass flow meter, 6: solenoid valve, 7: feed pump, 8: gas storage, 9: vacuum pump.

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RESULTS

COOL-DOWN BEHAVIOUR

Steady operation was obtained after roughly 50 min. Due to the rapid drop of the temperature around 39 min the mass flow rate increases drastically which requires a mass flow adjustment by the needle valve. During steady state the inner body valve has a temperature of 12 K.

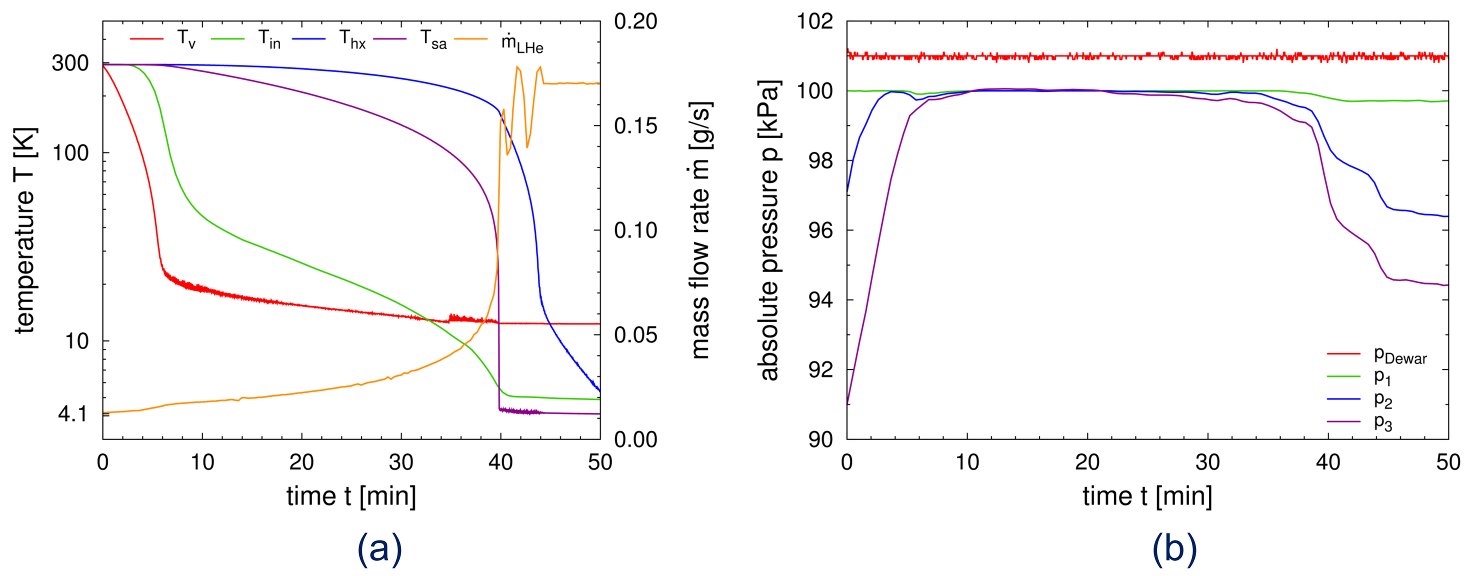

Figure 2: (a) Temperature profile during cool-down; (b) Related pressure course.

HEAT LEAK

The heat leak and outlet quality are determined by means of an electrical heater at the cryostat inlet: $h_{out} = h_g - \frac{P_{el}}{\dot{m}}$.

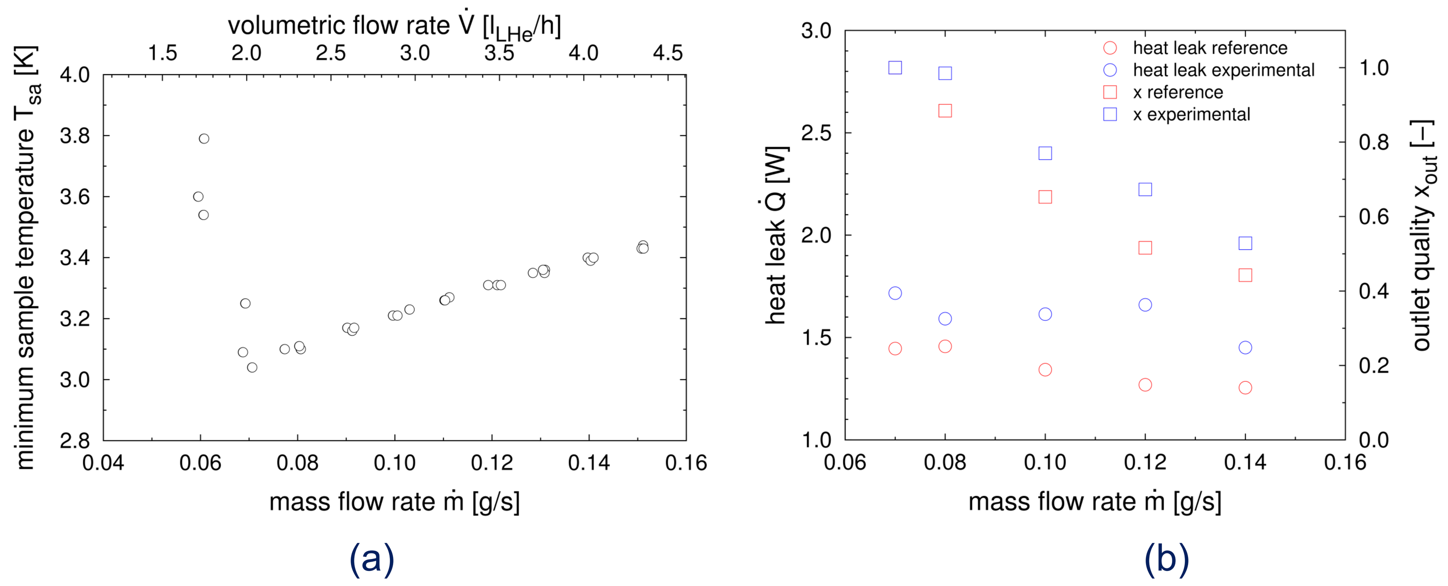

Figure 3: (a) Minimum sample temperature as a function of the mass flow rate (reference line); (b) Heat leak and outlet quality of both transfer lines.

The reference line has a heat leak of 1.36 ± 0.09 W. The outlet quality is 0.44 at 0.14 g/s and 1 at 0.07 g/s. Due to the instrumentation the heat leak of the experimental transfer line increases to 1.65 ± 0.08 W. At 0.14 g/s the outlet quality is 0.55. The dew line is reached at 0.08 g/s.

PRESSURE DROP

The largest portion of the overall pressure drop is caused by the needle valve at very low temperature operation.

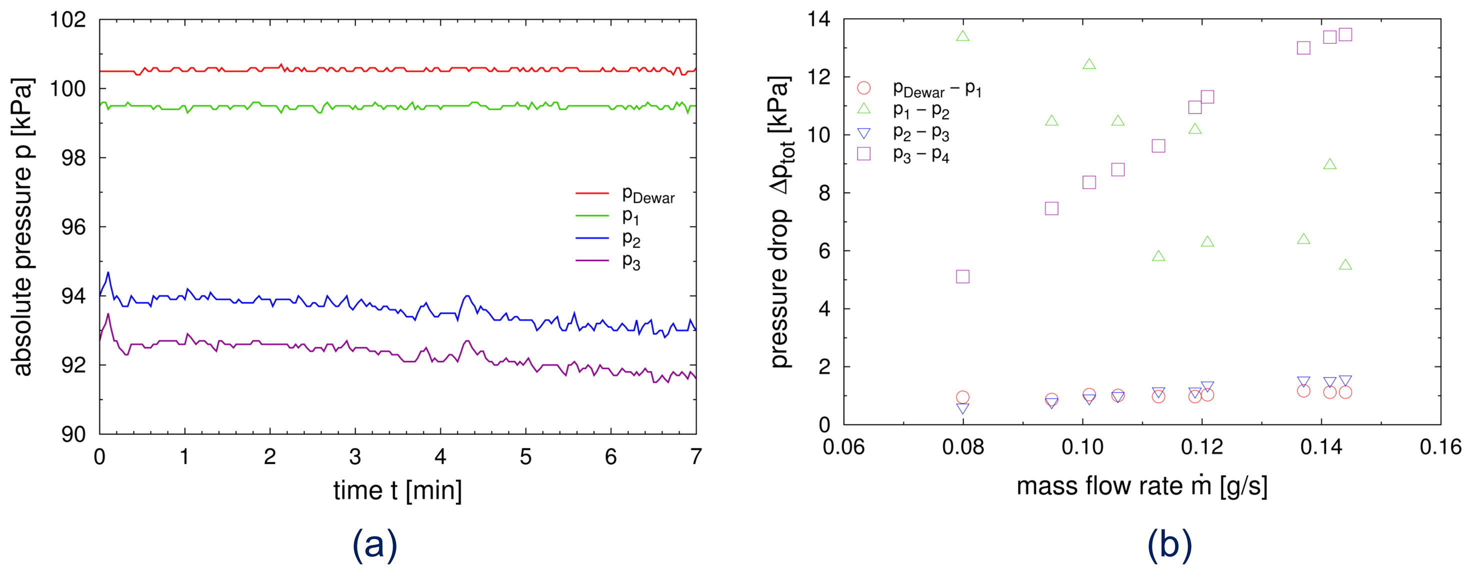

Figure 4: (a) Local pressure for operation at 4 K; (b) Pressure drop for operation at 4 K.

HELIUM PURITY

During operation below 4.2 K a reproducable clogging of the needle valve was observed. It is believed that this behaviour is caused by the precipitation of H_2 dissolved in LHe at a concentration of 0.1 ppb.

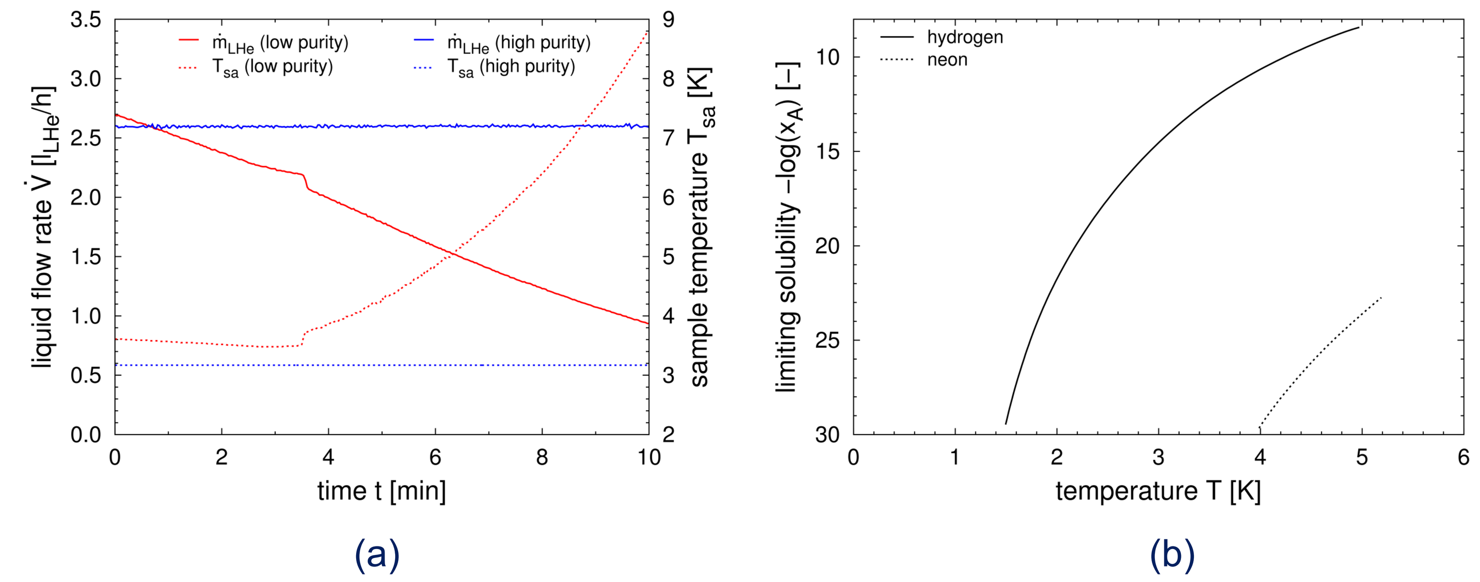

Figure 5: (a) Influence of the helium purity on steady state operation; (b) Limiting solubility of hydrogen and neon according to [1].

CONCLUSION

A state of the art transfer line for flow cryostats was examined to analyse the current state of development. Variations of the insulation design and a distribution of the pressure drop over the complete transfer line length will improve its performance most probably.

REFERENCES
[1] Jewell C and McClintock P 1979 *Cryogenics* **19** 682-83

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