Test of a Submersible Liquid Helium Transfer Pump [C1Po1A-08]

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Introduction

- Transfer by pressurization is inefficient and slow
- A transfer pump was developed and tested
- This poster shows the test setup and first results

Advantages of the pump

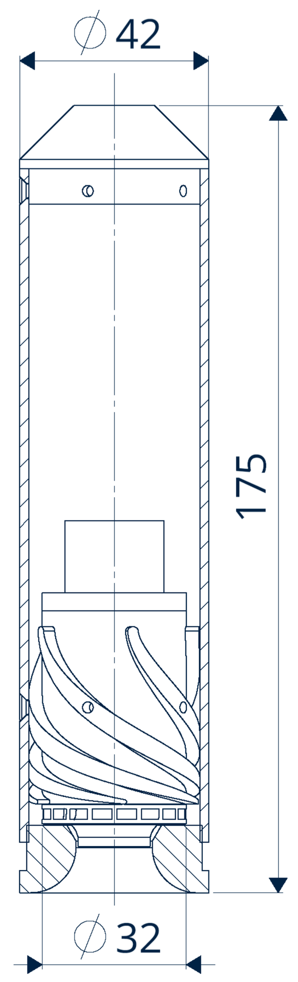
- Transfer losses by pressurization are up to 30% of transferred volume
- With a pump, this value can be decreased below 2% [1]

This presents the highest possible efficiency increase, more than optimization of compressor, turbines, HXs, etc.

- Considerably higher filling rates can be achieved

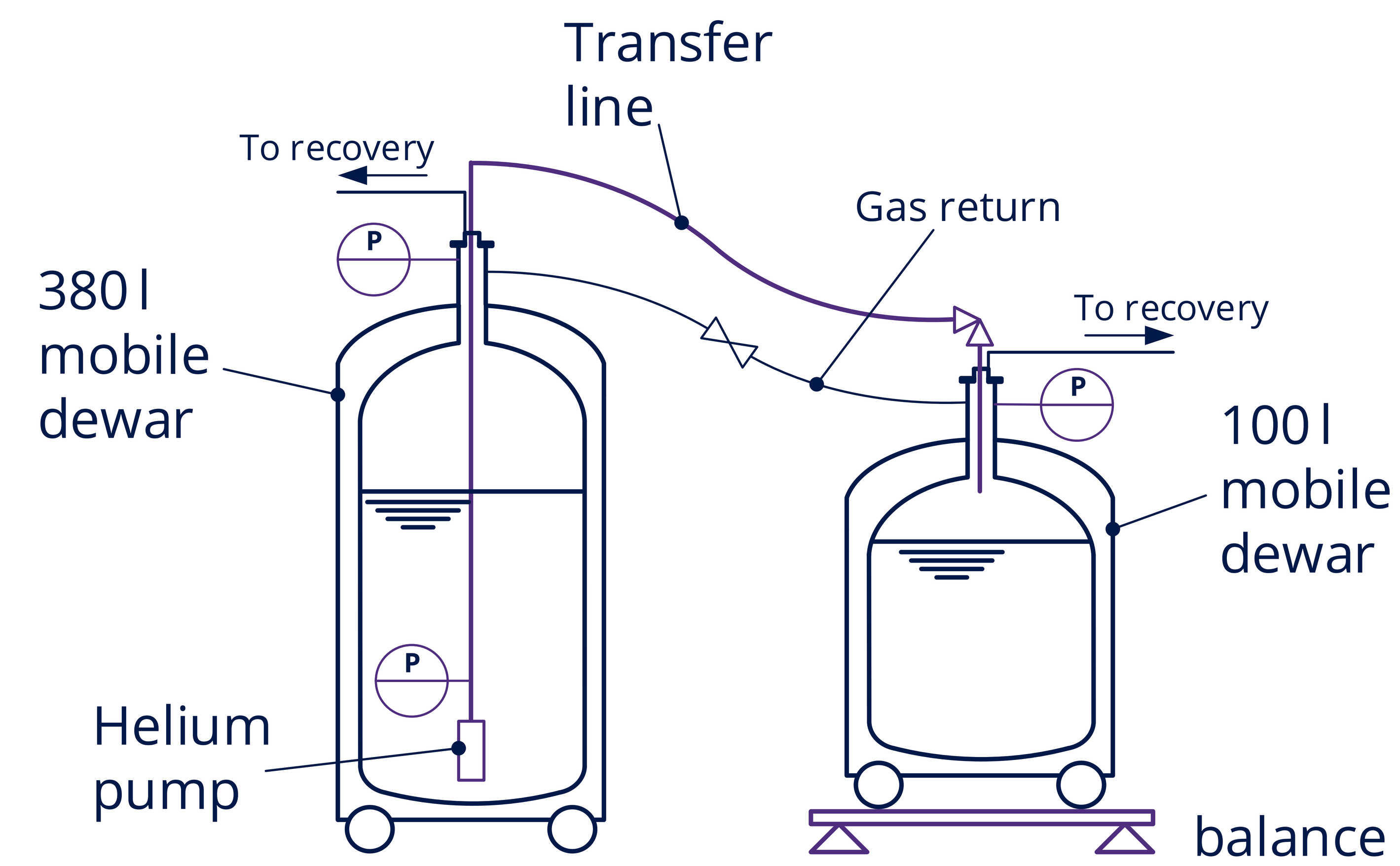
Pump design

- Submersible design, short shaft, no rotating seal
- Centrifugal impeller, axial stator
- Design for 40 g/s and 350 mbar
- Design speed 16000 rpm
- Shrouded impeller was additively manufactured
- Adjustment of axial clearance by threaded intake trumpet



Electric motor

- Pump is driven by a maxon EC-4pole22 brushless DC-motor
- Special dry running bearings for operation without lubricants
- Originally designed for extended operation down to 77 K
- Sensorless operation without any electronics in the cold environment

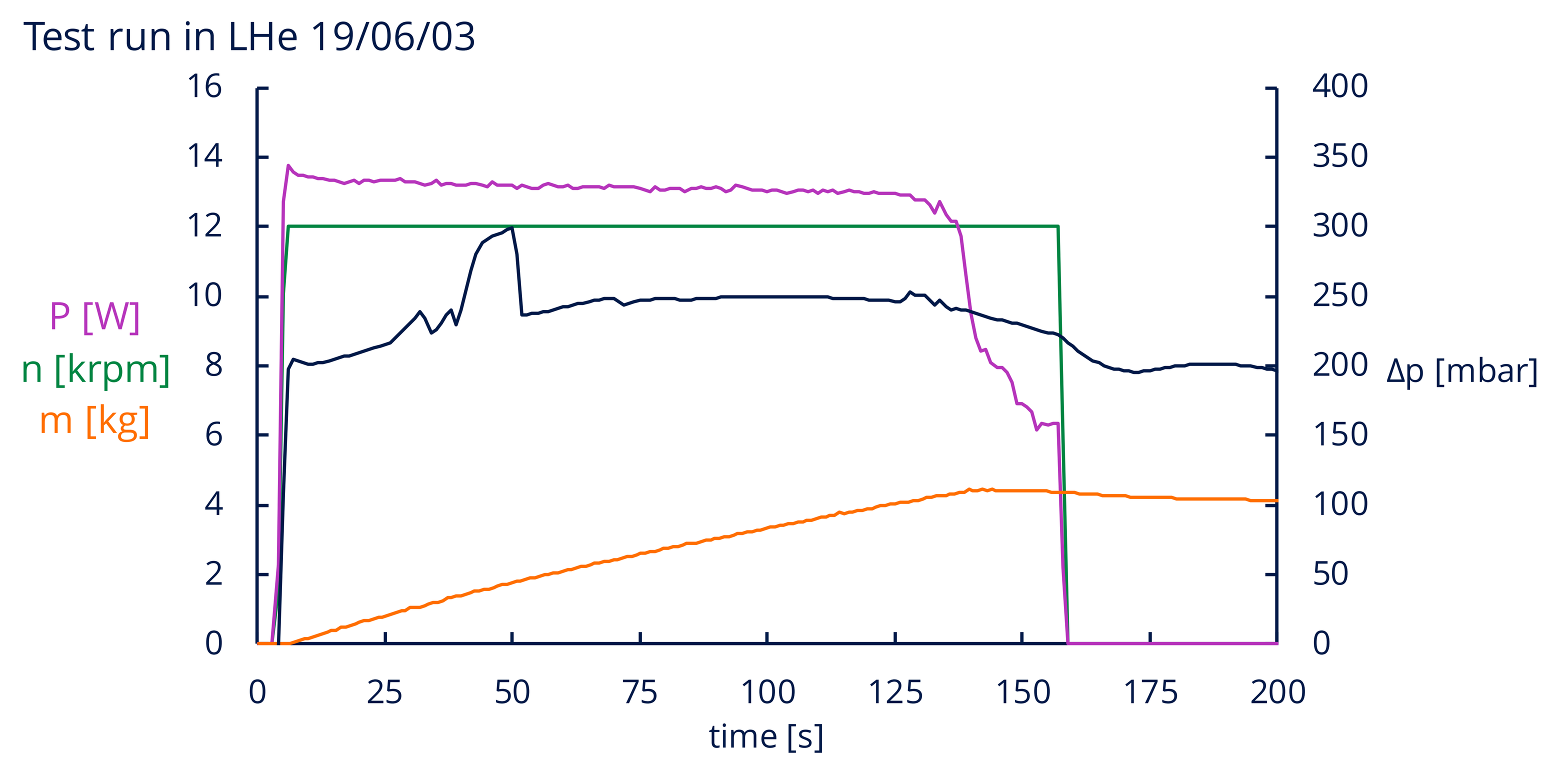


Test set-up

To assess performance data, a transfer set-up between two mobile dewars was established.
The pump is mounted at the lower end of the riser of a purpose-built single-flow transfer line with ID 16 mm (of flexible part).
Both dewars are connected to the recovery system on individual inlets.
A gas return ensures that the pressure of the starting dewar remains above atmospheric, while a valve prevents runaway of the pressure in the system.
Dewar pressures are measured at the top flanges with transducers with a total error of ±4 mbar. Static pressure at pump outlet was measured via a capillary with a warm transducer with a total error of ±8 mbar.
The transferred mass is recorded with a digital balance with a total error of ±15 g
The temperature of the cold gas leaving the receiving dewar was estimated to 8 K. This unknown parameter gives the highest uncertainty in the measurement.

Lifetime test

The motor was run in LN_2 continuously for 14 days to verify the lifetime of the bearings under no-load conditions. No signs of degradation were found. This timespan equals transfer of 400,000 l of LHe, or several years of filling operations.



Results

Flow rates of 40 g/s against a pressure of 200 mbar were achieved. For this, the electric power of 13 W was required. Consequently, less than 2% of the transferred helium were evaporated by the electric power input.

The backpressure is driven by the pressure drop of the warm gas in the recovery system.

Outlook

- Procurement of a double-flow transfer line is ongoing, allowing to take measurements at low backpressures
- Optimization of the double-flow transfer lines will allow filling operation with minimal losses
- Emphasis is given on reducing the thermal mass of the transfer line
- Large cross-sections allow to redesign the pump for lower speeds

Literature

[1] Berndt H, Doll and Wiedemann W: *Two Years' Experience in Liquid Helium Transfer with a Maintenance Free Centrifugal Pump* Advances in Cryogenic Engineering Vol 35 1039-43