MT25

A Helium liquefaction system using a 4 K Gifford-McMahon cryocooler

Mengyu Liu, Shaoliang Wang and Liang Li

Wuhan National High Magnetic Field Center

Huazhong University of Science and Technology, Wuhan, China

PRESENTATION ID NUMBER

Mon-Af-Po1.11-07 [170]

I Introduction

Liquid helium has bridged the gap been the physics and ultra-low temperature (below 10 K), and small-scale helium liquefier is being largely required as a flexible and convenient liquid helium supporting solution.

In this paper, a small-scale helium liquefaction system is built using a 1.5 W @ 4.2 K GM cryocooler (Sumitomo model RDK415). With a closed-cycle of natural convention loop, this liquefaction system has obtained a high efficient rate of over 19 l/day at 115 kPa.

The liquefaction system is also appropriate to be used in various cryogenic systems where liquid helium is needed, such as the cryogen-free cryostat for scientific experiments in pulsed high magnetic fields.

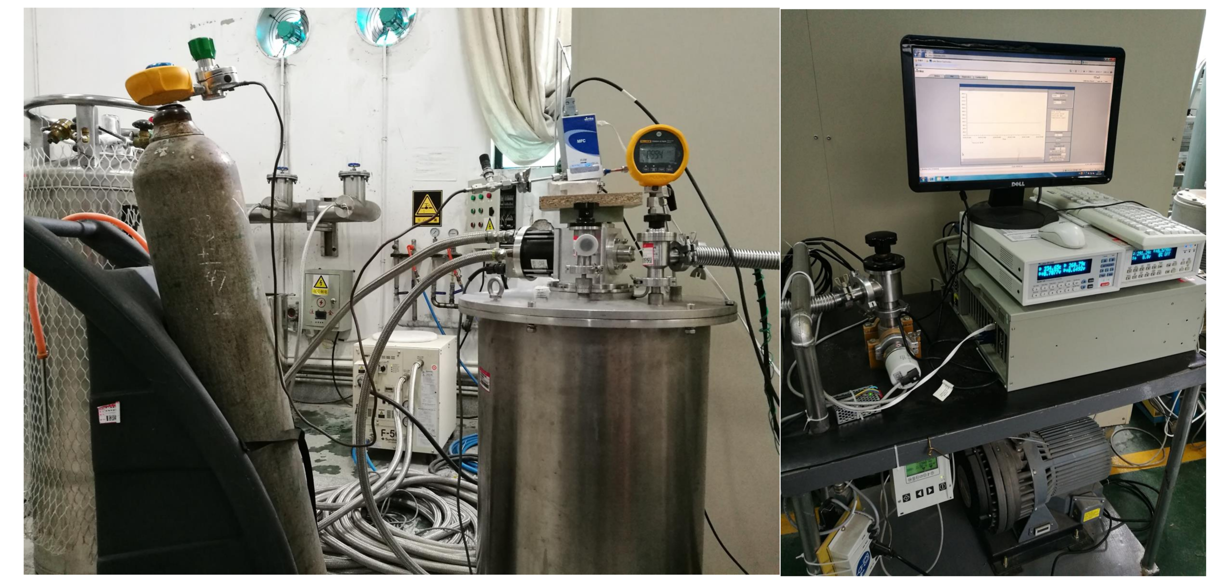

Fig. 1 Photograph of the liquefaction system

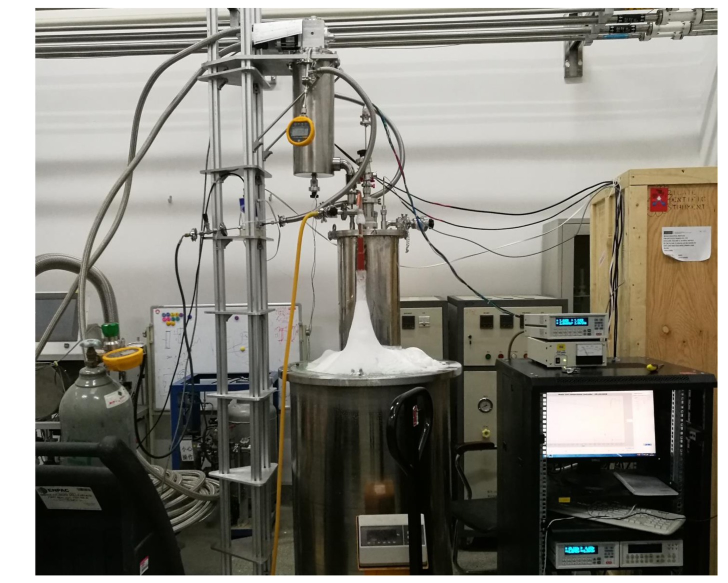

Fig. 2 Helium liquefaction module used in cryogen-free cryostat

II Experimental setup

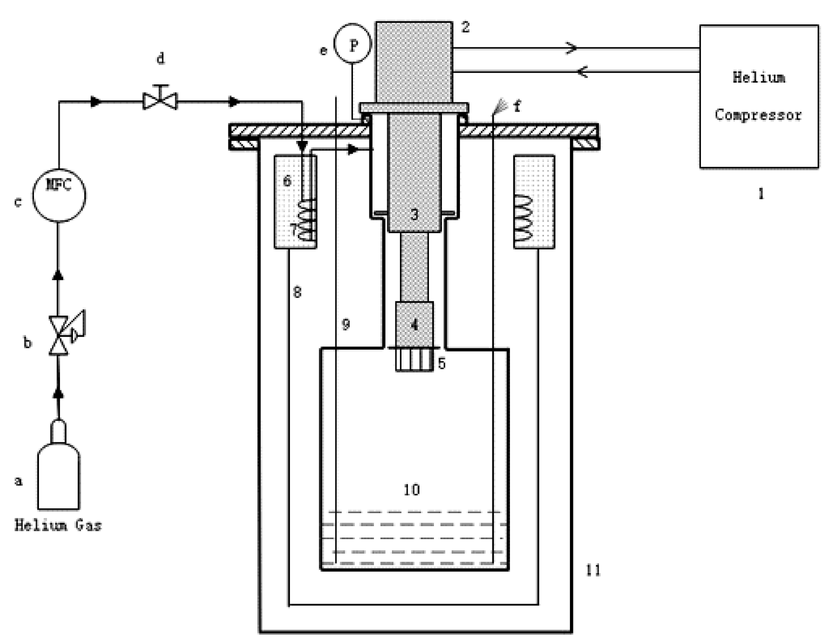

Fig. 3. Schematic of helium liquefaction system. 1: compressor; 2: GM cryocooler; 3: 1st stage cold head; 4: 2nd stage cold head; 5: con-denser; 6: liquid nitrogen cold trap; 7: heat exchanger; 8: radiation shield; 9: liquid helium transfer line; 10: liquid helium pot; 11: vacuum vessel. a: helium gas cylinder; b: pressure reducing valve; c: mass flow controller; d: needle valve; e: pressure gauge; f: liquid helium probe.

For the liquefaction system described in Fig. 3, helium gas is preliminarily cooled by passing through a LN2 cold trap. The cold trap is a circular container equipped on the top of the vacuum vessel and has a heat exchanger wrapped around its inner wall. Another function of the cold trap is to supply cold capacity for the radiation shield which is made by cooper and has aluminum foil on the surface.

Cold helium gas then supplied to the dewar and cooled by the GM cryocooler through a nature convention flow, and finally condensed on the condenser connected to the bottom of 2nd cold head. In order to make the nature convention heat exchange more effective, 6 pieces of copper plates are installed on the surface of the regenerators of the cryocooler (see details in Fig. 4).

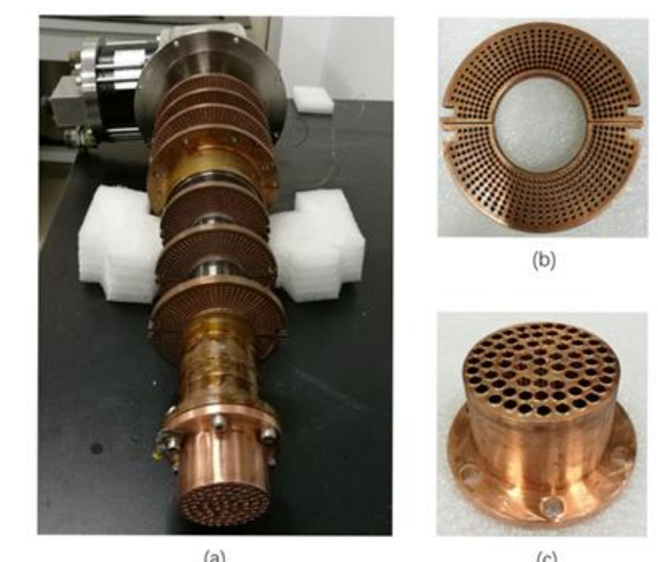

Fig. 4 Heat exchangers on GM cryocooler and the condenser

III Results and Conclusion

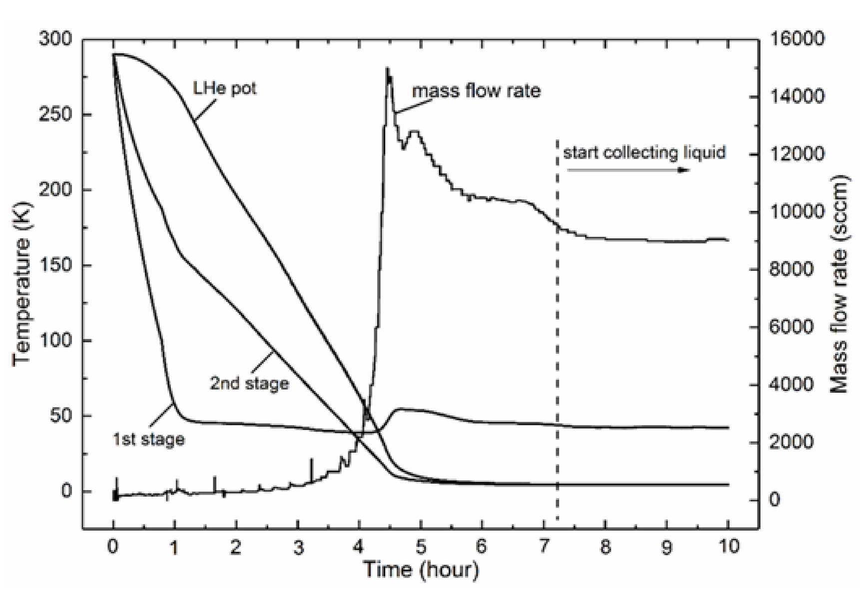

Fig. 5 Temperature variations and the mass flow rate. The working pressure in the dewar: 2 psi

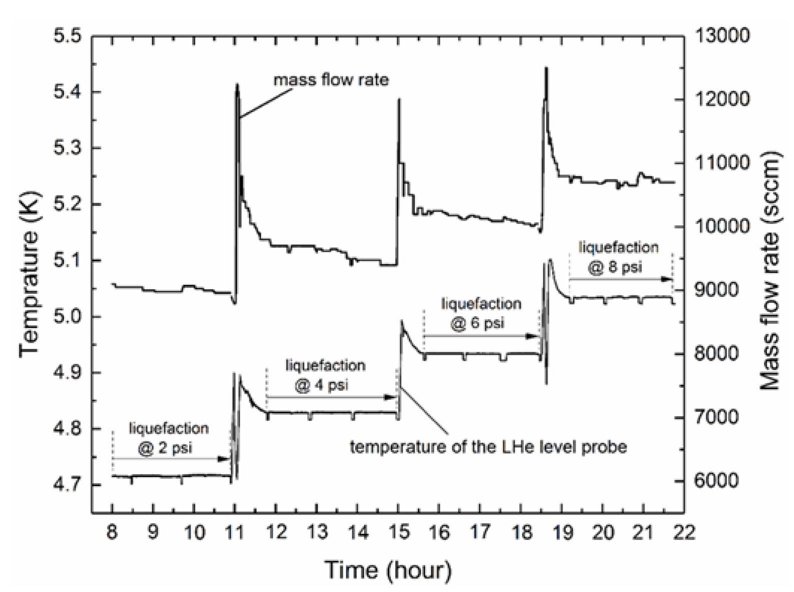

Fig. 6 Temperature of the LHe probe and mass flow rate during liquefaction

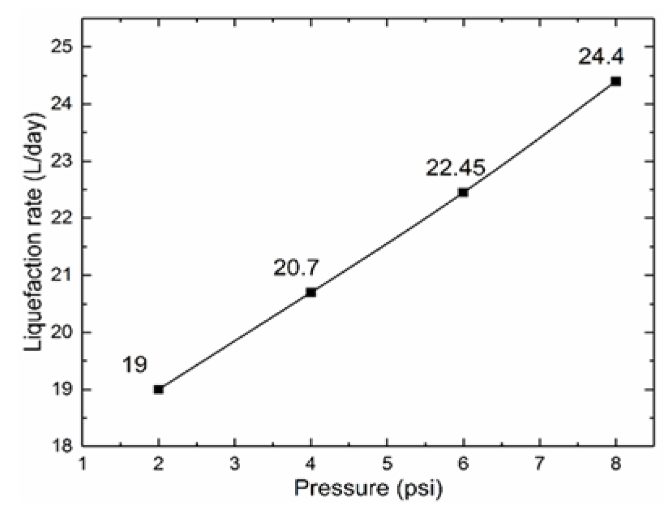

Fig. 7 Liquefaction rates under different pressures

A small-scale Helium liquefaction system using a 1.5 W @ 4.2 K GM cryocooler has been designed and tested. A liquefaction rate of 19 l/day has been obtained at a low operating pressure of 2 psi (absolute pressure near 115 kPa). The liquefaction yield would be enhanced by increasing the operation pressure. This system uses liquid nitrogen for precooling helium gas and cooling the radiation shield.

With modular design, the liquefaction system can also be equipped directly in low temperature systems to supply liquid helium, which is a good option for middle and small cryogenic laboratories to get rid of liquid helium dependence.

WHMFC

WUHAN NATIONAL HIGH MAGNETIC FIELD CENTER

Mengyu Liu
HuaZhong University of Science and Technology, WuHan, Hubei Province, 430074, China
TEL : +86 15926224258
Email: liumengyu@hust.edu.cn