JOINT INSTITUTE FOR NUCLEAR RESEARCH
Frank Laboratory of Neutron Physics

FINAL REPORT ON THE SUMMER STUDENT PROGRAM

Development of PTH sample environment system for the DN-12 diffractometer of the IBR-2M reactor

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Project "Development of PTH sample environment system for the DN-12 diffractometer of the IBR-2M reactor".
Theme "Development of Experimental Facilities for Condense Matter Investigations on the IBR-2M Reactor Beams".

Abstact: Condensed matter investigations using thermal neutron scattering in most cases involve the application of physical equipment that makes it possible to vary the sample temperature in a wide range. The spectrometers of the IBR-2M reactor are well equipped with cryostats on the basis of closed-cycle cryocoolers with a variable temperature range of 300-4 K. The properties of the horizontal cryostat with a superconducting magnet ("split" system of two coils) and a cryostat-insert for high-pressure cells is studied.

Introduction

In the Frank Laboratory of Neutron Physics various condensed matter investigations are planned at different temperatures and magnetic fields using high-pressure cells. In experiments in the diffractometer DN-12 we will use a cryostat with a superconducting magnet and a cryostat-insert (Fig. 1). It should be noted that the cryostat does not require the use of liquid helium. With their help, it is possible to cool a high-pressure chamber and to conduct magnetic studies of samples depending on pressure and temperature (PTH experiments).

To understand the operation of the cryogenic system, it is important to carry out an experimental evaluation of the heat input in the shaft using a helium-4 heat exchange gas.

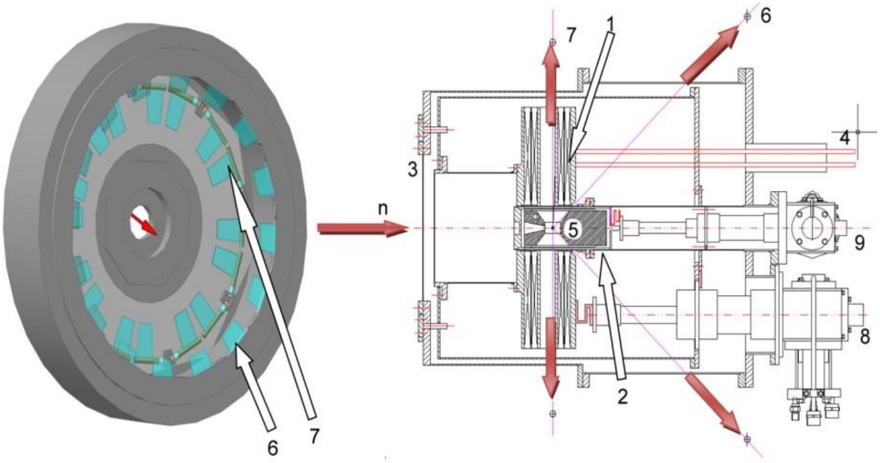

Fig. 1. Preliminary design of horizontal shaft cryostat with a superconducting magnet and cryostat-insert, and DN-12 diffractometer: 1 – superconducting magnet; 2 – cryostat-insert and shaft; 3 – entrance window for neutrons/back-scattering window; 4 – current lead (up to 300 A); 5 – high-pressure cell; 6 and 7 – detectors of scattered neutrons at angles of 45° and 90°; 8 – cryocooler RDK408D; 9 – cryocooler of cryostat-insert.

Experimental method

To assess the heat input through the shaft, a stand was made, namely a shaft cryostat with cooling by the cryocooler RDK408D (Fig. 2). The cold end of the shaft is connected to the second stage of the cryocooler by means of a thermal bridge.

Figure 2. Shaft cryostat with cryocooler RDK-408D2 in horizontal position.

The thermal bridge was made of copper and has dimensions: length 180 mm, section 50 mm2. The temperature was controlled by thermometers located at the ends of the thermal bridge. The measurements were carried out in two positions of the cryostat, in the vertical and horizontal directions. The shaft was filled with helium at a pressure of 0, 2, 10 and 20 mbar.

Tables 1 and 2 show the temperature of the ends of the thermal bridge as a function of the pressure of helium.

Pressure in system, P, mbar	Temperature (K) at the ends of the thermal bridge in the vertical position of the cryostat	
0	7.35	3.08
10	7.59	3.16
20	7.56	3.18
2	7.466	3.16

Table 1.

Pressure in system, P, mbar	Temperature (K) at the ends of the thermal bridge in the horizontal position of the cryostat	
0	7,35	3,08
10	7,832	3,22
20	8,27	3,28
2	7,501	3,22

Table 2.

Based on the data presented in Tables 1 and 2, the heat input for copper (Cu with heat conductivity $\lambda = 5 * 10^2 \frac{Вт}{м*К}$). We use the formula, which is represented as:

$$Q = \lambda \Delta T S / l$$

$$Q = \lambda (T_1 - T_0) S / l = 500(T_1 - T_0) \cdot 50 \cdot 10^{-4} / 180 \cdot 10^{-2}$$

Heat inflow in the vertical position of the cryostat (Table 3):

P, mbar	Q, mW
0	5,930
2	5,980
10	6,152
20	6,083

Table 3.

Heat input in the horizontal position of the cryostat (Table 4):

P, mbar	Q, mW
0	5,930
2	5,945
10	6,405
20	6,930

Table 4.

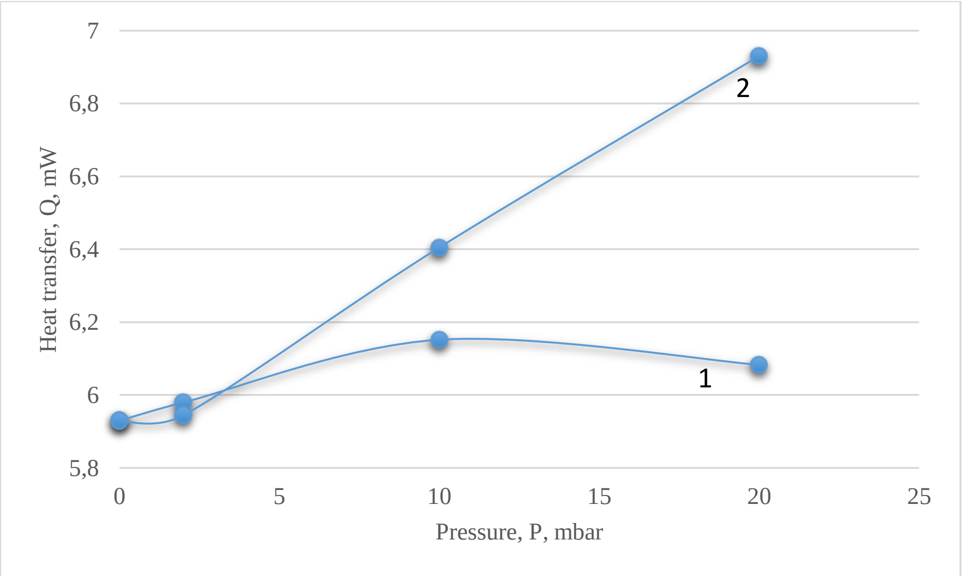

Figure 3. Dependencies of the parameters according to the data in Tables 3 and 4

CONCLUSION

The results show a slight increase in heat input when using heat exchange gas, both in vertical and horizontal orientation of the cryostat. The amount of heat inflow should not affect the operation of the cryogenic system of the magnet. This will allow the use of heat exchange gas when the sample or the high-pressure chamber is pre-cooled.

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