TEST FACILITY FOR SIS300 CRYOMODULES

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Abstract

Within the framework of cooperation with GSI (Darmstadt, Germany), IHEP develops the superconducting quadrupole and corrector magnets, which in the specific combinations will be united into the so called cryomodules having common cryostat.

The facility for testing these cryomodules in the forced flow cooling mode, where it is intended to carry out the complex of electrical, magnetic and thermophysical tests, is examined.

The facility is based on the existing helium compression and purification equipment, helium refrigerator and research cryostats. A satellite refrigerator is added to the cryogenic system, which also works as the helium mass flow rate multiplier.

INTRODUCTION

IHEP participates in the development and manufacture of superconducting quadrupole magnets and correction (SCM) for the SIS300 accelerator project FAIR [1], in the process of implementation which need to be complex electrical, magnetic and thermal tests as a separate SCM coils and cryogenic modules (CM), which represent a cryostat with a given set of 2-3 SCM coils.

Testing of SCM coils will be held in a cryostat with boiling helium cryogenic modules - to the stocks that provides a single-phase pumping helium through the superconducting coil.

Thus, established at IHEP TF for the test of SCM coil blocks and CM products will contain helium cryogenerating setting that provides the stand with liquid helium and a circulating stream of single-phase helium, current sources and a system of magnetic and current measurements.

HEAT LEAKAGE AND HEAT RELEASE IN THE ELEMENTS OF THE TEST FACILITY

Initial data for the cryogenic system of the test facility (TF) are based on the imputation of coil blocks of SCM, the experimental data on the installation KGU cryogenic plant and test stands magnets UNK, IHEP:

- Expected heat in the quadrupole - 2 watts.
- Expected maximum heat dissipation in the corrector - 1 W.
- Expected heat leakage to the cryogenic helium cryostat module (CM) - 3 W
- Heat leakage of current leads to liquid helium - 1 W at 1 kA.
- Heat leaks to the helium pipelines with nitrogen screen - 5 watts into a single pipeline.
- Expected to helium heat leakage through anticryostat magnetic measurements - 20 W
- Critical temperature for the quadrupole - 6.7 K.
- Critical temperature for the corrector - above 6.7K.
- Operating current in the measurement of magnetic field quadrupole - 6.2 kA.
- The maximum operating current in the measurement of the magnetic field corrector - 300 A.
- Temporary temperature gradient along the length of the quadrupole is not limited to, as well as a similar gradient is not limited to magnets UNK, FNAL.
- The pressure before the valve P3 (KGU) - 7 bar.
- The temperature before the valve P3 (KGU) - 4.5 K.
- Flow through the valve P3 (KGU) - 5 g / sec.
- Consumption of liquid helium for cooling the current leads - 1 liter / hour of liquid helium at 1 kA.

HELIUM CRYOGENIC SYSTEM FOR RESEARCH SCM COILS INTO THE BOILING HELIUM

As the helium cryogenic system for the test of SCM in boiling helium using an existing cryogenic system for the test of superconducting magnet blocks corrective and quadrupole magnets in the submersible mode (boiling helium). It uses existing cryogenerating helium plant KGU 500, Kp 1/1.5 cryostat, system cryogenic and "warm" helium and nitrogen pipelines, the system of magnetic measurements, current sources feeding the system and SCM measurements of current parameters.

Additional improvement of this system is not required.

HELIUM CRYOGENIC SYSTEM FOR RESEARCH CM IN FORCED FLOW COOLING MODE

Projected helium circuit for single phase flow of helium through the corrective and quadrupole CM coils is shown in Figure 1.

Cryostatting magnets CM is as follows.

After the compressor of the cryogenic plant (CP), compressed helium goes to the KGU 500. Installing the KGU 500 is used only in the liquefier mode, supplying the liquid helium satellite refrigerator SR and accumulating of liquid helium in a 800-liter vessel KGU. With the accumulation in the vessel, KGU 500 stops and satellite refrigerator receives liquid helium directly from the vessel of KGU 500.

The helium flow after satellite refrigerator at T ~ 4,5 K is cooled in a cryostat-recooler to T ~ 4,3 K and cools the coils of magnets CM. phase helium is divided into two streams after the CM. The first stream goes to the cooling current leads and in the gasholder with cryogenic plant, the second, after the CM, passing through the valve CV6, turns into a two-phase flow and in CR cools the main flow of helium. Next, a reverse flow of CR in the SR line cools the flow from the compressor CP.

Electric EH - phase flow of helium is used as if magnets CM in controlled Quench, and the measurement of heat and heat release.

Reverse flow of helium after SR goes into gasholder with cryogenic plant.

Application of satellite refrigerator as a multiplier allows the flow of helium to increase the multiplicity of circulation through the superconducting coil CM single-phase helium cooling capacity without increasing the system.

Thermodynamic analysis of this system [2,3] shows that for a satellite refrigerator with cold 100 W helium temperature level will require about 25 liters of liquid helium per hour. This means that the installation KGU 500, capacity 150 liters per hour will operate only one eight-hour shift for a period of 36 hours, which reduces the number of staff.

Satellite helium refrigerator is a cryogenic device, consisting only of the heat exchanger, located in the cryostat. It does not contain low-temperature expanders, which simplifies automation. With the same purpose in the scheme introduced remote-controlled valves CV1-CV7, safety valves SV and Quench receiver for effective evacuation of helium from the cryogenic module CM in Quench.

SYSTEM OF AUTOMATIC DATA ACQUISITION AND PROCESSING OF INFORMATION

Automated acquisition and processing of information generated by the TF will provide an automated and manual process of managing a booth with necessary information, which should also be displayed on the display control panel.

This information includes:

- Temperature of cryogenic units and helium and nitrogen fluxes;
- Pressure helium flows;
- The level of liquid helium in the cryostat CR;

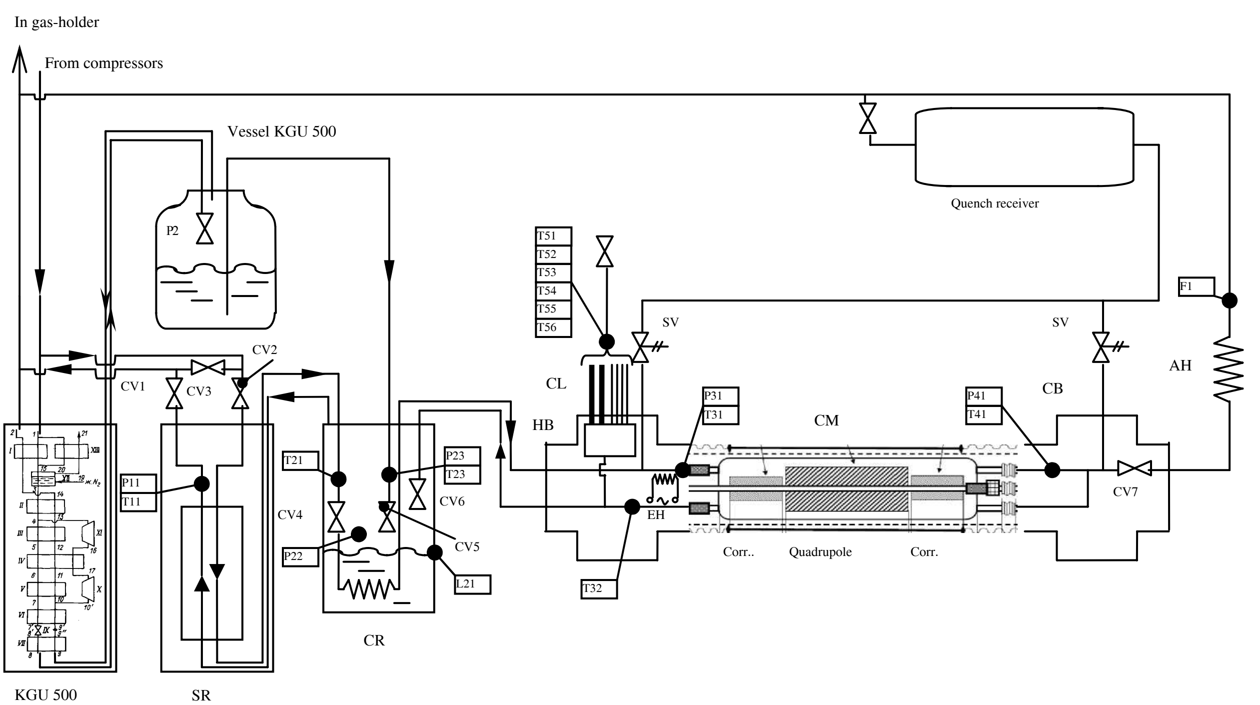

Fig.1. Test facility for research cryogenic modules in forced flow cooling mode

Symbols: HB - head box with current leads CL, CB - closing boxes, CM - cryogenic module, AH - heat exchanger to heat the helium due to atmospheric temperature, EH - an electric heater is a single-phase flow of helium, CV1-CV6 - remote-controlled valves, SR - Satellite refrigerator, CR – cryostat-recooler, SV - safety valves, T11-T56 - temperature sensors, P11-R41 - pressure sensors, F1 - flow sensor of gaseous helium.

- Position of the gas-holder;
- Position of stocks of remote-controlled valves.

Additionally, the system of collecting and processing information is to provide the operator of the TF data on vacuum insulation, the currents in the SC coils of magnets, magnetic field, the probability of the start of Quench and promptly furnish data on the pressure in the magnet and in the structural elements of the TF after Quench.

For remote control booth should be laid to move from automatic control to manual control directly from the console.

The basis of the hardware configuration of automated data acquisition and processing of information will set a three-tier organization of computing resources. This configuration includes a personal computer on the upper level, unified controllers that act as servers and computers at the front edge of mid-level and specialized hardware controllers on the ground.

VACUUM POST

Cryogenic equipment is carried out with high-vacuum insulation, working in a vacuum no worse than 10^{-5} mm Hg To ensure that the vacuum will be used positions with a backing and high-vacuum turbomolecular pumps, which can bring the vacuum in an isolated area without leaks to 10^{-6} mm Hg.

CONCLUSION

The considered scheme of the test facility will allow efficient and low cost to conduct research cryogenic modules.

Partial automation and the use of satellite refrigerator in the scheme of the test facility will use the minimum number of staff.

REFERENCES

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