Operation of the BigRIPS cryogenic plant

K. Kusaka,[*1] M. Ohtake,[*1] Y. Yanagisawa,[*1] M. Yoshimoto,[*1] S. Michimasa,[*1] N. Fukuda,[*1] H. Takeda,[*1] H. Suzuki,[*1] Y. Shimizu,[*1] Y. Togano,[*1] S. M. Ohshima,[*2] A. Mikami,[*2] H. Hazama,[*2] H. Shiraki,[*2] H. Hirai,[*2] K. Kimura,[*2] M. Nagano,[*2] H. Shiba,[*2] S. Okada,[*2] and M. Nakayama[*2]

As reported in Refs. 1) and 2), the first expansion turbine T1 in the refrigerator (cold box) of the BigRIPS cryogenic plant experienced two failures, and the turbine wheels were replaced with new ones and re-assembled with new axial bearings in 2022. The second expansion turbine T2 was also partially repaired for preventive measure in 2023. Because scratches were observed on the T2 compressor wheel in the regular inspections, we shipped the T2 cartridge to its manufacturer Linde in October 2023 (Fig. 1). They disassembled the cartridge and inspected the turbine wheels using a dye penetrant test. Although no crucial damage was detected by the test, the compressor wheel seat was out of tolerance and wear marks were observed on the upper axial bearing. The compressor wheel and upper axial bearing were replaced with new ones, the T2 cartridge was re-assembled, and the cooling water channels were cleaned. The T2 cartridge was returned to RIKEN and re-installed on the cold box in early February 2024. We then tested the cold box unit before the continuous operation of the entire BigRIPS cryogenic plant.

The test operation began on February 15 in 2024 and completed on February 16. Only the cold box was cooled in the test operation, thus the cooling capacity of the cold box was observed using the heater power output in the phase separator. We observed that the rotation speed of the T1 turbine reached to its design value of 4600 rps once in the precooling state, and it decreased in the range from 4320 to 4360 rps in the steady state. In contrast, the rotation speed of the T2 turbine remained around the design value of 3000 rps. The heater output in the phase separator was evaluated to be 397 W with a pressure of 1.28 MPaG at the entrance of the T1 turbine. In the test operation performed in 2008 the rotation speed of the T1 turbine and the heater output in the phase separator were 4596 rps and 465 W, respectively, with the same operating pressure of the T1 entrance. The degradation of the cooling capacity is about 15%, and the origin of these differences are currently under investigation.

We performed two continuous operations of the BigRIPS cryogenic plant in 2024. The first operation period was from February 29 to July 10 and the second was from September 28 to December 25. Between these dates, we performed periodic maintenance. During maintenance last year, a small gas leak was observed in the valve unit. Therefore, the corresponding seven control valves were disassembled and inspected (Fig. 2). All seven control valves had sliding scratches on the valve plugs, which were restored after polishing with sandpaper and verified to be leak-free.

Fig. 1. T2 compressor wheel with scratches.

Fig. 2. Control valve unit in the RIBF compressor room.

At the beginning of the first operation period, we experienced the quench of the P2 coil in the STQ1 cryostat for the first time in four years. When the P2 coil was ramped up from 605 A to 610 A, it quenched at the excitation current of 605 A. Although the quenched current of 605 A was the smallest value ever, the circuit breaker installed in the STQ1 power supply operated as designed, and the excitation current attenuated in 5 s by the protection register. This quench resulted in the loss of approximately 160 m^3 of helium gas. The STQ1 magnets were then operated to avoid the excitation current of the P2 coil exceeding 600 A, and beam service was performed.

Other incidents that interrupted beam service were

*1 RIKEN Nishina Center
*2 Nippon Air Conditioning Services Co., Ltd.

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hangs-up of the CPU modules in the cryostat control system. The CPU unit of the "legacy" VME system that monitors the status of the STQ's cryostat hung up twice on April 15 and June 15, resulting in a total beam service interruption of about 16 hours. We then introduced redundancy of important signals such that cryogenic operators can monitor the status of STQ cryostats through the control system of the cryogenic plant even if the CPU unit of the VME system hangs up.

References

1) K. Kusaka *et al.*, RIKEN Accel. Prog. Rep. **53**, 222 (2020).
2) K. Kusaka *et al.*, RIKEN Accel. Prog. Rep. **56**, 209 (2023).