Operation of the BigRIPS cryogenic plant

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In 2016, we have operated the BigRIPS cryogenic plant according to the RIBF beam time schedule. We started continuous operation in March, and, after about 100 days of steady state operation, the main compressor was stopped in July. After the summer maintenance,[1)] we restarted the cryogenic plant in September and stopped the compressor in December. The total operation time of the compressor unit was 59,276 h.

During these continuous operations, we faced three significant incidents. One incident was the sudden stop of the compressor unit on Oct. 12 that was caused by a power outage. This large power outage in the Tokyo metropolitan area was caused by a power transmission cable of the Tokyo Electric Power Co. (TEPCO) that caught on fire. Although the power of all the cryogenic plants and most of the water cooling system in the RIBF facility is supplied by the independent RIBF co-generation system (CGS), a momentary voltage drop arose from the power switching system interlock between the TEPCO- and the CGS-power lines. The momentary voltage drop stopped some cooling water pumps and our compressor unit stopped at the same time. The reason for the failure of the mechanical components caused by the momentary voltage drop is under investigation.

Another incident consisted of the sudden stops of the expansion turbines in the refrigerator, which were false interlock stops caused by the failure of the temperature transducer for the helium gas at the exit of the second turbine, T2. We replaced the temperature transducer and continued the operation. The temperature at the T2 exit is one of the most important parameters for the refrigerator system and is usually set to 11.6 K for optimum cooling capacity. However, we had to change the T2 temperature parameter to 10.5 K for optimum cooling capacity during the ^{48}Ca beam time. At this parameter setting, we operated the cryogenic system with a beam heat load fluctuation of more than 100 W. We calibrate the T2 temperature transducer and test the cooling capacity using the stand alone operation of the TCF200 cold-box in 2017.

The third incident was an unusual noise that was produced by the main motor of the compressor unit. We first noticed the noise in mid-November and the noise level gradually increased daily, even though we had greased the motor unit. Since 2015, we have regularly measured the vibrations of the main compressor unit using an OH-580A hand-held vibration tester.[4)] The vibration acceleration in the vertical and horizontal directions as a function of the total operation time is shown in Fig. 1. Measurements were performed both at the high-pressure and low-pressure sides of the compressor. It is clear that the vibration acceleration increased drastically after hour 58,630 of operation, which corresponds to Nov. 14. On Dec. 5, the acceleration exceeded more than 20 m/s^2 and the noise level became dangerously large, so we decided to cancel the beam time and stop the compressor unit on Dec. 6. After a 6-h recovery operation after the expansion turbines were stopped, the compressor was safely stopped. Using a temporary recovery line, evaporated helium gas from the STQ cryostats was successfully transferred to the RIKEN liquid-helium supply and recovery system.

The main motor unit was disassembled on site to investigate the origin of the unusual vibrations. In a baring unit on the anti-coupling side, damage was found on a surface of its inner ring (Fig. 2). The motor unit was reassembled with a new bearing unit. After careful mechanical and electrical checks of the whole compressor unit, the test operation was successfully performed and the vibration acceleration was measured to be less than 8 m/s^2. The origin of the bearing damage is under investigation.

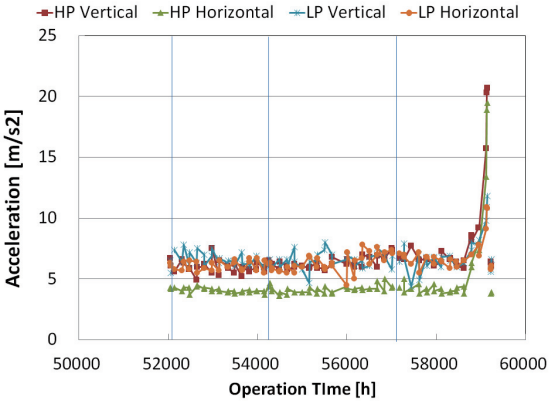

Fig. 1. Vibration acceleration of the compressor unit.

Fig. 2. Damaged bearing unit, disassembled from the anti-coupling side of the motor unit.

References

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2) http://www.testo.jp.

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