

Operation of the BigRIPS cryogenic plant

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We performed two continuous operations of the BigRIPS cryogenic plant in 2019. The first operation period was from March 1 to June 24, and the second was from October 23 to December 11. The total operation time of the compressor unit was 72,222 h.

During these continuous operations, we encountered two significant incidents. One incident was the failure of the compressor unit in June. We first noticed an unusual noise that was produced by the main motor of the compressor unit. Although the noise level gradually increased daily, we maintained the continuous operation while monitoring the vibrations of the main compressor and the motor unit. However, the compressor unit suddenly stopped on June 13. Though no interlock alarm event was recorded, we consider that the reason was the over current of the main motor unit because a sudden increase of the main motor current from 29.9 A to 32.6 A was recorded in the control system. We could restart the compressor unit and maintain the continuous operation till the end of the beam time.

The main motor unit was disassembled on site to investigate the origin of the unusual vibrations. In a bearing unit on the coupling side, damage was found on a surface of its inner ring and the bearing balls (Fig. 1). We also found that the size of the housing for the damaged bearing unit was 5 μm larger than its dimension standard (+0–25 μm). The motor unit was reassembled with new bearing units, and the housing was re-manufactured with a tolerance of +0.0 μm . After the regular maintenance of the whole compressor unit, a test operation was successfully performed, and no unusual noise was produced in the second operation period.

Figure 2 shows the vibration acceleration in the vertical and horizontal directions as a function of the total operation time. Two rapid increases of the vibration acceleration at operation times of 59,000 h and 71,000 h indicate the damage of the bearing unit occurred in Dec. 2016¹⁾ and in June 2019. The vibration acceleration re-



Fig. 1. Damaged bearing unit, disassembled from the coupling side of the motor unit.

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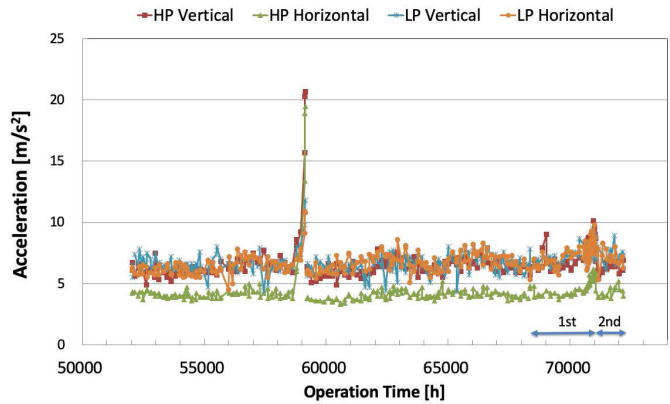


Fig. 2. Vibration acceleration of the compressor unit. Two operation periods are indicated by arrows.

mained less than 8 m/s^2 in the second operation period.

The other incident consisted of the failures of the first expansion turbine T1 in the refrigerator. The T1 turbine did not start rotation in the starting up of the refrigerator. The starting sequence of the refrigerator unit usually proceeds automatically as follows. The purge line valve opens for 30 s so that room-temperature helium gas flows into the gas-bearing cartridge of the expansion turbines T1 and T2. Subsequently the control valve CV3130 in the turbine inlet line gradually opens, and the inflow of the cold helium gas starts the rotation of T1 and T2 simultaneously. The opening of CV3130 increases up to 50% and the rotation speeds of T1 and T2 turbine increase beyond 3000 rps depending on the temperature of the inlet helium gas.

The first failure of T1 turbine occurred on June 13, when a sudden stop of the compressor caused refrigerator trip. After having the compressor unit restarted, we restarted the refrigerator operation. After the turbine trip caused by the low-temperature interlock of the inlet helium gas during the start up, T1 did not start rotation in the automatic starting sequence. We somehow started the refrigerator without the purging process and could proceed with the beam time till June 19. We stopped the refrigerator in the usual manner and visually checked T1 and T2 in the summer maintenance. Although no visual abnormality was found in the maintenance, the same failure occurred in the test operation on September 25. T1 did not work during start up.

Both turbine cartridges were sent to its manufacturer Linde and were disassembled. While T2 was not damaged, the gas bearing of T1 had problems. Scratches and particles were found on the lower axial bearing. After replacing the lower axial bearing with a new one and polishing the shaft, T1 turbine cartridge was reassembled. The repaired turbines were remounted on October 24, and the refrigerator successfully started on October 25. The origin of the scratches is under investigation.

Reference

- 1) K. Kusaka *et al.*, RIKEN Accel. Prog. Rep. **50**, 285 (2017).