Operation of BigRIPS cryogenic plant

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Following the accident that occurred on December 3, 2021,[1] the main motor of the BigRIPS compressor unit was shipped to the manufacturer's factory and disassembled. Damages were found in the bearing units on both the coupling and anticoupling sides. In particular the bearing unit on the coupling side was heavily damaged such that the ribbon retainer was destroyed and the surfaces of the bearing balls and rings were ruined (Fig. 1). We also found that the size of the housing for the damaged bearing unit was 20 μm larger than its standard dimension (+0 to 25 μm). After cleaning the rotor and stator, the motor unit was reassembled using new bearing units and the re-manufactured bracket housing. In addition to mechanical maintenance, the insulation was also examined, and little deterioration of the stator insulation was noticed. We decided to replace the motor unit in the summer maintenance period.

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

Fig. 2. Compressor unit with the new motor.

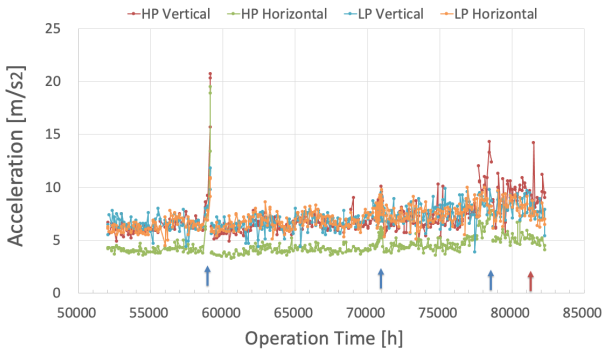

Fig. 3. Vibration acceleration of the compressor unit.

We performed two continuous operations of the BigRIPS cryogenic plant in 2022. The first operation period was from February 22 to June 13 and the second was from November 16 to December 28. Between these dates, we replaced the motor unit with a new one (Fig. 2). Figure 3 depicts the vibration accelerations in the vertical and horizontal directions as functions of the total operation time. Three rapid increases in the vibration acceleration at the operation times of 59,000, 71,000, and 78,541 indicate that the damage in the bearing unit occurred in December 2016, June 2019, and December 2022.[1] The red arrow at the operation time of 81,235 hours indicates the replacement of the motor unit. Although the vibration acceleration does not change significantly, the typical operation current of the motor unit decreased from 30.0 to 26.6 A.

In 2022, another incident occurred: the damage of the first expansion turbine T1 in the refrigerator. We visually inspected T1 and T2 turbines during every summer maintenance. It was found that the blades of the expansion wheel of the T1 turbine were broken (Fig. 4). The T1 cartridge was then sent to its manufacturer, Linde, and disassembled. Linde reports that the fractured surface indicates the typical characteristics of a low-cycle fatigue (LCF). The expan-

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sion and compressor turbine wheels are replaced with new ones and re-assembled with new axial bearings. Before remounting the T1 cartridge on the refrigerator, we investigated the inside of the refrigerator using a fiberscope. No fragments but tiny metal dust was found in the downstream piping of the T1 expansion turbine. After the dust was removed using a vacuum cleaner, the T1 turbine was mounted on the refrigerator. We switched the refrigerator on for pre-cooling on November 16, and the STQ1-5 cryostats were filled with liquid helium on December 3. Although the average liquefaction rate of 26 m^3/h is the same as before, the rotation speed of 4450 rps of the T1 turbine during the steady-state operation was lower than its design value of 4600 rps. The origin of the LFC and the lower rotation speed of the T1 turbine are currently under investigation.

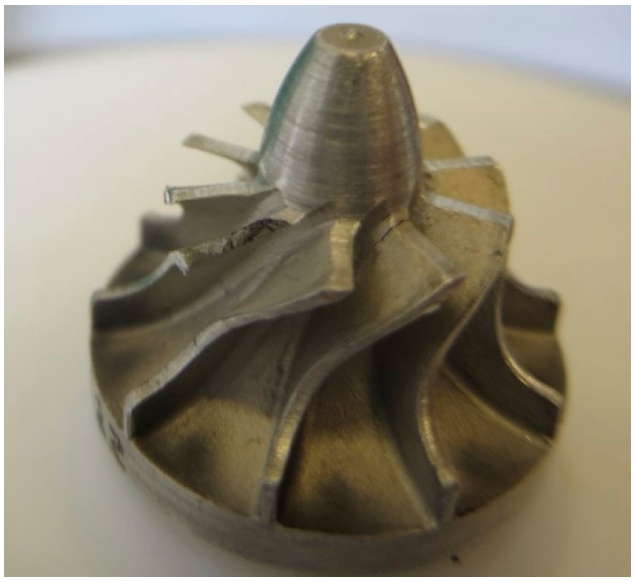

Fig. 4. T1 expansion turbine wheel with broken blades.

Reference

1) K. Kusaka *et al.*, RIKEN Accel. Prog. Rep. **55**, 182 (2022).