Operation of the BigRIPS cryogenic plant

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We operated the BigRIPS cryogenic plant for only 2,838 h in 2020 because the spring beam time was cancelled due to the declaration of state of emergency over COVID-19. The operation periods were from March 4 to April 24 and from September 25 to December 21. After the long shutdown of the RIBF facility, we started cooling down the warmed-up superconducting triplet quadrupole (STQ) magnets on October 2.

After successful cooldown operation, we excited STQ1 magnet with stepwise ramping. The STQ1 magnet is an air-core-type superconducting magnet and consists of three quadrupole coils, P1, P2, and P3, and one hexapole coil, SX.[1)] In contrast to the other STQ's case, we excite the coils P1, P2, and P3 separately after cooling down. Before simultaneous excitation of all coils, the coils P1, P3, and SX coils were excited up to their nominal current of 740 A, 628 A, and 32.5 A, respectively. However, when we ramped P2 from 610 A to 620 A, it quenched with a current of 620 A, which is 8 A less than the nominal current. This was the fourth quench of P2, and we consider that it a training quench.

Except for the quenching of P2, we operated the cryogenic system without any trouble. We measured the vibrations of the compressor unit and observed low oil contamination in helium gas during operations. The total operation time of the compressor unit was 75,060 h.

Figure 1 shows the vibration acceleration in the vertical and horizontal directions as a function of the total operation time. We have been measuring the vibrations of the compressor at the high-pressure and low-pressure sides since 2015. Two rapid increases of the vibration acceleration at operation times of 59,000 h and 71,000 h are indicated by arrows. They were caused by the damage of the bearing unit in December 2016[2)] and June 2019.[3)] The vibration acceleration mostly remained below 8 m/s^2 during the operation period. We consider that the exceptionally large value of 10.3 m/s^2 at 74,883 h in the vertical direction at the high-pressure side is due to measurement error.

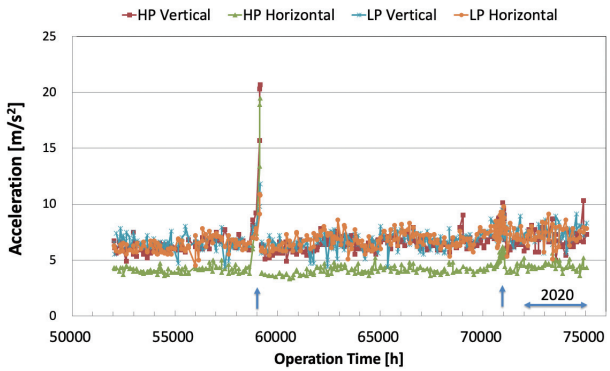

Fig. 1. Vibration acceleration of the compressor unit. The operation period in 2020 is indicated.

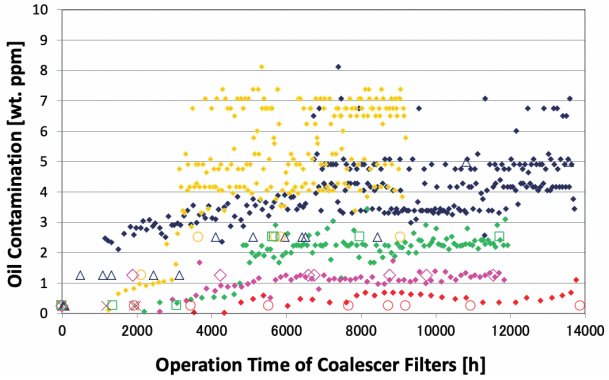

Fig. 2. Oil contamination at the entrance of the third coalescer vessel.

We measured the operation interval of the drain valves of the coalescer vessels in the compressor unit in order to evaluate the oil contamination level. We have replaced coalescer filter elements 5 times since 2008. The operation periods of the replaced filter elements were from August 2008 to July 2010, from September 2010 to July 2012, from September 2012 to July 2014, from September 2014 to July 2016, and from September 2016 to June 2019. Figure 2 shows an estimate of the oil contamination level at the entrance of the third coalescer vessel as a function of the coalescer filter operation time. The navy-blue, green, and yellow diamonds represent the estimates for the first, second, and third elements, respectively. The fourth and the fifth elements are shown with pink and red diamonds, respectively. The oil contamination values measured using the oil check kit are also shown. The open triangles, squares, and circles represent the results for the first, second, and third elements, respectively. The results for the fourth and the fifth elements are indicated by the open diamonds and circles, respectively. The drain valve of the coalescer vessel operated only once in 2020 after the last maintenance in 2019. The operation time and the estimate of the oil contamination level for the current coalescer are 3550 h and 0.05 wt.ppm, respectively, as shown by the brown diamond in Fig. 2.

Both estimations of the oil contamination level are consistent with each other, and the performance efficiency of the fifth set of filter elements seems to be better than that of the others.

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References

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