Incidents involving the DMT3 magnet in the beam transport line from SRC to BigRIPS

K. Kusaka,[*1] K. Yoshida,[*1] M. Ohtake,[*1] and Y. Yanagisawa[*1]

The DMT3 magnet in the "T-course" beamline is designed as a resistive-type magnet with saddle-shaped correction coils in addition to main coils. The correction coils are installed in the gap of the magnet and were originally excited with the main coils in series. The main coil has 72 turns and consists of 6 double pancakes, in which a 13.5×13.5 mm hollow conductor is wound 6 times in each layer. The correction coil, on the other hand, is a 12-turn double pancake. However, the layer isolation of the lower correction coil was damaged in an October 2017 incident.[1] Furthermore, the upper correction coil was found to be short-circuited in November 2019.[2] We then investigated the possible use of the DMT3 magnet without correction coils by increasing the energizing current.

As the maximum current of the original DMT3 power supply was 650 A, an additional auxiliary DC power supply was introduced in the DMT3 excitation circuit in a parallel connection. Water-cooled protection diodes were also used for safety.[2] At the end of the beam time in December 2019, we excited only the main coils in the DMT3 magnet using two power supplies with currents of 150 A and 563 A. We confirmed that the uranium beam focused on the BigRIPS target well and the main coils were well cooled with sufficient water flow. However, ramping the DMT3 power supply from 0 to 563 A with the simultaneous use of the auxiliary power supply with a current of 150 A caused instability; therefore, we were forced to ramp up in a stepwise manner to avoid instability.

In March 2020, we again tested power supplies for the operation of the DMT3 magnet without correction coils. Using the same excitation circuit, we energized the main coils while monitoring the voltage of each coil pancake. We found that the lower main coil was damaged.

Figure 1 shows the excitation voltage at each pancake of the DMT3 coils. Firstly, we energized the magnet by using the auxiliary power supply only with a current of 150 A. The voltages of all the pancakes coincided. We then further energized the magnet using the DMT3 power supply with a maximum current of 650 A. The total current was 800 A, which was larger than the current of 710 A used to transport uranium beams from SRC. The excitation voltages of the second and the fourth pancakes of the lower main coils decreased with time, while the voltage of other four pancakes increased because of the temperature rise of conductors. These unstable behaviors in excitation voltage indicate damage to the isolation between coil layers. We then decreased the current and re-energized with currents of 100 A and 610 A. The excitation voltage of all pancakes coincided in this case. We consider that the two pancakes are not critically damaged.

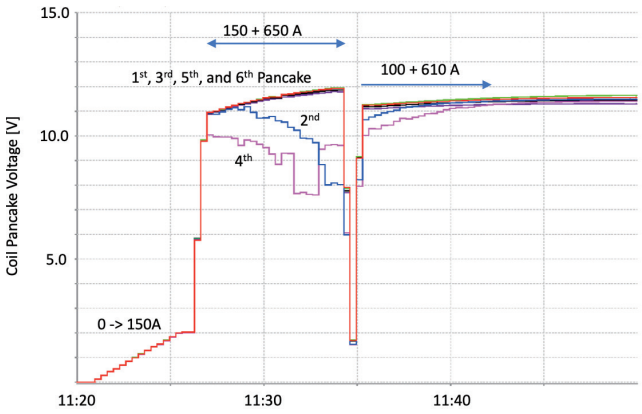

Fig. 1. Excitation voltage at each pancake of the DMT3 lower main coil.

Although the lower main coil of DMT3 was damaged, ^{238}U and ^{70}Zn beams were successfully transported from SRC to BigRIPS targets in 2020 beam time. We excited the DMT3 magnet with the main coils and undamaged lower correction coil, which was installed in 2018.

New main coils for the DMT3 magnet are now being designed and fabricated. The new main coil is designed so as to fit in the DMT3 iron pole and yoke. Furthermore, we increased the number of turns from 72 to 84 such that the original DMT3 power supply energizes the magnet without an auxiliary power supply. New main coils will be installed in early summer 2021.

References

1) K. Kusaka *et al.*, RIKEN Accel. Prog. Rep. **51**, 173 (2018).
2) K. Kusaka *et al.*, RIKEN Accel. Prog. Rep. **53**, 104 (2019).

*1 RIKEN Nishina Center