Replacement of main coils of RRC-W sector magnet

Y. Watanabe,[*1] M. Kase,[*1] N. Fukunishi,[*1] T. Maie,[*1] K. Kumagai,[*1] M. Nagase,[*1] O. Kamigaito,[*1] S. Fukuzawa,[*2] M. Hamanaka,[*2] S. Ishikawa,[*2] K. Kobayashi,[*2] Y. Kotaka,[*2] R. Koyama,[*2] T. Nakamura,[*2] M. Nishida,[*2] M. Nishimura,[*2] J. Shibata,[*2] N. Tsukiori,[*2] and K. Yadomi[*2]

The RIKEN Ring Cyclotron (RRC) has been in stable operation for over 27 years, and it is expected to work as a first-stage energy booster in any acceleration mode of the Radioactive Isotope Beam Factory (RIBF) in the future. Recently, some problems caused by age-related deterioration have often been occurring in the RRC. In 2011, a layer shorting was found at the upper main coil of the RRC-E sector magnet, and we replaced it with a new one in the summer of 2012. [1] Furthermore, the lower main coil of RRC-W sector magnet also showed signs of layer shorting in June 2012. This layer shorting of the RRC-W sector magnet was a recurrence of the instance of shorting experienced and repaired in 1999. We again attempted to repair it, as in 1999, but the fluctuations of the coil voltage and magnetic fields were not fully improved. So, we decided to replace the damaged lower main coil and the deteriorated upper main coil of the RRC-W sector magnet with new main coils in FY2013. Fabrication of the new main coils required four months, and the replacement task had been scheduled over a period of eight weeks within the summer maintenance period. This was done because we had no experience in replacing the lower main coil of the RRC in our twenty-six year operation. Table 1 lists the replacement schedule of the main coil of the RRC-W sector magnet in 2013.

In the replacement task, three difficulties were anticipated, as shown in Fig. 1. The first one is how to deposit and store yokes, poles, the main vacuum chamber, and the beam injection line that was removed temporarily in the RRC room. Because of their heavy weight and large size, these removed parts were carried to and stored on the S, N, and E sector magnet, in addition to the south side of resonator No. 2, and in front of the shield door between the RRC room and the D room. The removed main coils were carried out from the RRC room and stored in the IRC room. The second difficulty is that we have to loosen and tighten 13 bolts for fixing the vacuum chambers onto the magnetic pole surfaces. Since these bolts were in the deep and narrow vacuum chamber, we ran a test successfully by using an air drive tool having a long grip in advance in the winter of 2013. The last difficulty is the silver alloy brazing of copper pipes used for cooling water and electrification of trim coils. 116 pipes were cut to remove main vacuum chamber and poles, and parts of the cut pipes were newly fabricated and cleaned for a new silver alloy brazing. Because of the high number of copper pipes, it took a week to braze these pipes with a silver alloy. Furthermore, because several pipe fixing plastic plates were used for the fixation of pipes and maintaining vacuum, we had to frequently investigate the vacuum leak from the sub-vacuum chamber.

Table 1 Replacement schedule of main coils in 2013.

Mar.	Initiation of production of new main coils
11-31 Jul.	Removal of resonators, beam injection line, valley chamber, yokes, main coils, main chamber/poles, certain cables, pipes, decks, etc.
1-10 Aug.	Fabrication/cleaning of copper pipes for trim coils
5-16 Aug.	Carrying in and out of main coils, restoration of main chamber/poles and vacuum test
19 Aug. - 6 Sep.	Restoration of yokes, beam injection line, resonators, valley chamber, certain cables, pipes, decks, etc.
26-31 Aug.	Silver alloy brazing of copper pipes and leak test
6-13 Sep.	Starting up of RRC

*1 RIKEN Nishina Center
*2 SHI Accelerator Service Ltd.

The present performance of the RRC-W sector magnet is greatly improved, as shown in Fig. 2. Though the magnetic field of the RRC-W sector magnet before the replacement had been fluctuating over a wide range of ±5ppm, at present, the RRC-W sector magnet has a stable magnetic field without a fluctuation.

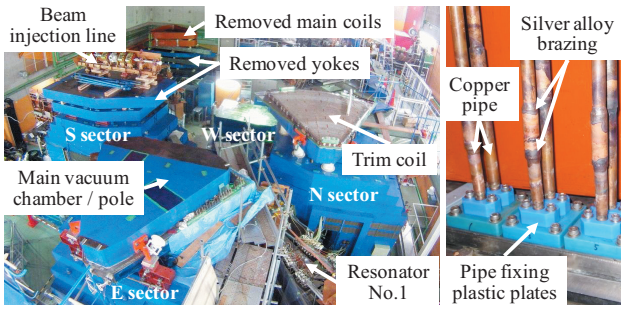

Fig. 1. Deposition and storage of removed parts and copper pipes of trim coil after silver alloy brazing.

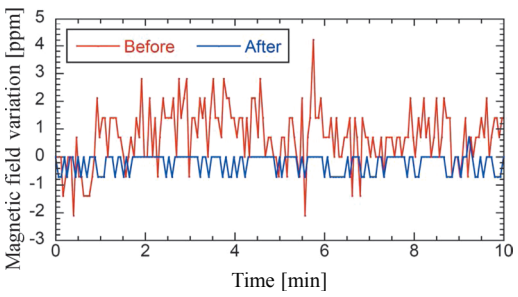

Fig. 2. Fluctuation of magnetic field before and after the replacement of main coils.

References

1) Y. Watanabe et al.: RIKEN APR 2012, p.130.