Operation test of kicker system with new PFN capacitors

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In the rare-RI ring (R3) facility, the kicker system is a key device for injecting and extracting particles one-by-one. Recently, we have succeeded in magnetic field flattening during injection duration and extending the extraction duration, thereby improving the experimental efficiency.[1] However, the ceramic capacitors used in the pulse forming network (PFN) of the kicker power supply were broken several times due to insulation breakdown after 1 day of operation with a charging voltage of 45 kV to 55 kV in the 2021 mass measurement experiments.[2,3] This failure, which interferes with the execution of the experiment, must be repaired quickly. We report the progress of the repair work.

The PFN, consisting of sixteen capacitor and inductor sections, forms a high-voltage unit together with a thyratron and other components.[4] The high-voltage unit is installed in a tank filled with insulating oil. The capacitor HP40-H132-00 we have used so far is made by the former AVX corporation (Kyocera AVX now). It has a three-layer structure and is insulated with molded resin. The outer diameter is 38 mm, the length is 47 mm, the rated voltage is 80 kV, and the capacitance is 375 pF.

A failure analysis was performed by Kyocera. The central part of the three-layer structure was found to be particularly damaged (see Fig. 1(b)). The damage was so severe that it is difficult to pinpoint the cause, but the following are possible causes: 1) due to the part of dielectric layer is slightly weak, 2) due to the stacked element structure, the central element overheated, and then the increase in dielectric loss and further overheating caused an electron avalanche, or 3) due to electric field concentration on the washer between the elements. Thus, it is thought that the stacked elements structure could not withstand our use of the repetition of the high-voltage charging within 200 μs and the instantaneous discharging by thyratron. Then we decided to replace it with a single-layer structure capacitor, a commercially available product with proven track record.

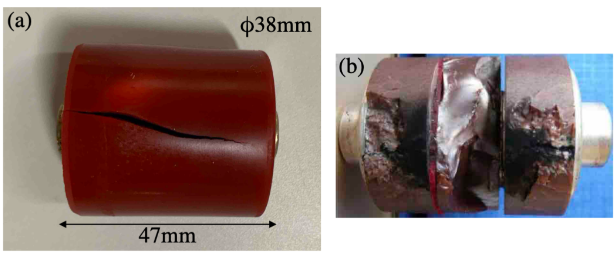

Fig. 1. (a) shows broken AVX capacitor, and (b) shows internal damage revealed by Kyocera.

Figure 2(a) shows a new capacitor FHV-10AN made by TDK corporation. The outer diameter is 38 mm, the length is 33 mm, the rated voltage is 50 kV, and the capacitance is 700 pF. Two TDK capacitors are connected in series to make almost the same capacitance as the AVX one. Figure 2(b) indicates the output currents when operated at a charging voltage of 55 kV. It can be seen that the waveform (blue-line) obtained with TDK capacitors is almost the same as that (black-line) obtained with AVX capacitors.

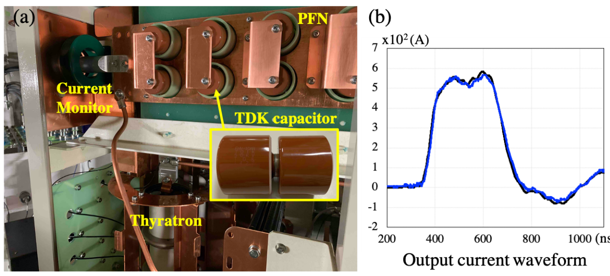

Fig. 2. (a) shows installed new capacitors. (b) indicates output signals from current monitor (details in text).

There are eight high-voltage units in total. Currently, the two high-voltage units for one twin-type kicker magnet have been replaced with TDK capacitors. Recently, we conducted 5-days continuous operation test for all units with a charging voltage of around 50 kV. As a result, five of the six units with AVX capacitors failed again. On the other hand, the two units with TDK capacitors had no problems. We concluded that the use of TDK capacitors would solve the above three concerns and enable stable continuous operation. Therefore, the remaining six high-voltage units will also be replaced with new capacitors soon.

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References

1) Y. Yamaguchi *et al.*, RIKEN Accel. Prog. Rep. **54**, 100 (2021).
2) A. Ozawa *et al.*, RIKEN Accel. Prog. Rep. **55**, 13 (2022).
3) S. Naimi *et al.*, RIKEN Accel. Prog. Rep. **55**, 14 (2022).
4) Y. Yamaguchi *et al.*, Phys. Scr. **T166**, 014056 (2015).