OPERATING EXPERIENCE OF KICKER MAGNET SYSTEM IN THE J-PARC 3GEV RCS

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Abstract

Technical issues of the kicker magnet system in the J-PARC 3GeV RCS are presented based on the operating experience during four years. For the high voltage cables, many scratches on the polyethylene surface were observed at the edge parts, the surfaces were reinforced by a semi-conductive layer with high-dielectric materials. For all matching resisters, the values have been increased due to deterioration with age, and the counter measure is under reviewing. For Thyratron tubes, a stable operation was established, and the beam stop rate by false operation was drastically reduced from 13% to less than 0.5%.

INTRODUCTION

The J-PARC 3-GeV Rapid Cycling Synchrotron (RCS) has been provided proton beam to the Material and Life Science Facility (MLF) as well as to the 50 GeV Main Ring (MR). Proton beam is accelerated from 181 MeV to 3GeV in the RCS and immediately extracted it to the beam transport line to the MLF and the MR. Extraction kicker system is used for this fast extraction. The RCS has been operated for the neutron and MLF users program from December 23rd, 2008.

For the RCS, 8 kicker magnet sections by the pulse width of 1μs and the rate of 25Hz, have been applied. For all kicker magnet sections, a stable operation has been strongly required to keep the RCS operation availability and to avoid an unnecessary activation by the false operation. For this purpose, their current waveforms always have been monitored on the RCS operation, and their maintenance works have been continued periodically.

In this paper, degradation of high-voltage cables and matching resisters of the RCS kicker magnet system are presented, and the operation history of Thyratron tubes is also described for the technical issues.

KICKER MAGNET SYSTEM

The main specification of the kicker magnet system is indicated in Table 1. This kicker magnet system has the total 8 kicker magnet sections [1-2]. Each magnetic section consists of two magnetic coils and two circuits and one DC power supply. In the one circuit, 4 high-voltage cables, one thyratron tube and two matching resistance are used for a rapid switching system. Since these high-voltage cables work a capacitance to charge up current, the cables size of ϕ30mm in diameter are employed for a DC60kV-3kA. Before the installation, the impulse withstand-voltage of 690kV for a pulse width of 1μsec had been tested.

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Table 1 Specifications of the Kicker Magnet System

The number of magnet section	8
Magnetic flux density	360～460Gauss
The number of DC power supply	8: 60kV
The number of thyratron tube	2/magnet
Pulse width	～1200ns
Repetition rate	25Hz
The number of high-voltage coaxial cable	4 cables /magnet section
Impulse withstand voltage of high-voltage cable	690kV
Matching resistor	4/ magnet

MAINTENANCE WORKS

During operation of the kicker magnet system, all current waveforms have been monitored automatically, and all data have been saved in the computer system. Whenever an interlock system works due to beam loss monitor or γ-ray and neutron monitor, therefore, it is able to check each current waveform for all magnet section.

For the maintenance works, one or two times have been done in a year. For a few circuit which had distorted waveforms had been monitored, insulation resistance of the cable and resistance value of the switching resistance have been measured. For Thyratron tubes, the characteristics have been tested using a switching test stand of the J-PARC.

TECHNICAL ISSUES

Table 2 shows the operation history of the kicker magnet system. In 2009, many miss firings of Thyratron were occurred, many adjustments by trial and errors were carried out. From this experience, know-hows for the stable operation were obtained. In 2010, degradation of the withstand voltage of some high voltage cables were measured, these inspections were done. In 2011, almost machine of the J-PARC had to be stopped during 9 months by the Japan earthquake. From January, 2012, the operation of the J-PARC was restarted, and degradation of all matching resistors was reported.

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Table 2: Operation History of Kicker System

Year	Technical issues
2009	Many miss firings of Thyratron tubes
2010	Dieletric breakdowns at connector of the high-voltage coaxial cables.
2011	The Japan Earthquake
2012	Degradation of matching resistor

Breakdown at the High-Voltage Coaxial Cables

Figure 1 shows a photograph of insulator surface of the high-voltage coaxial cable. Many scratches on the surface of polyethylene can be seen. This phenomenon was caused at near connector part, it was observed for all cables. Figure 2 indicates a dielectric breakdown at the same position. To avoid electric-field concentration, these surfaces were reinforced by a semi-conductive layer with high-dielectric materials.

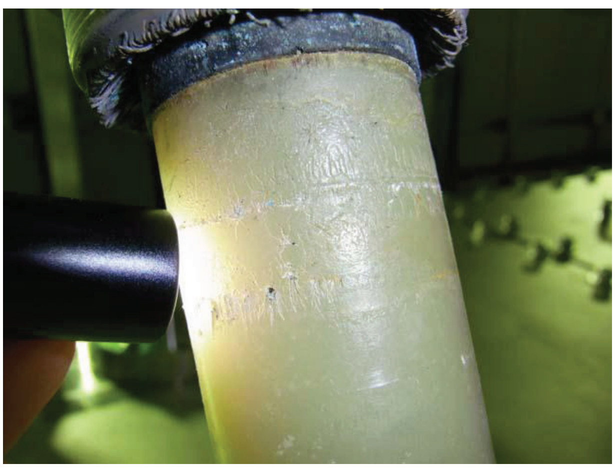

Figure 1: Scratches on the surface of polyethylene insulation layers.

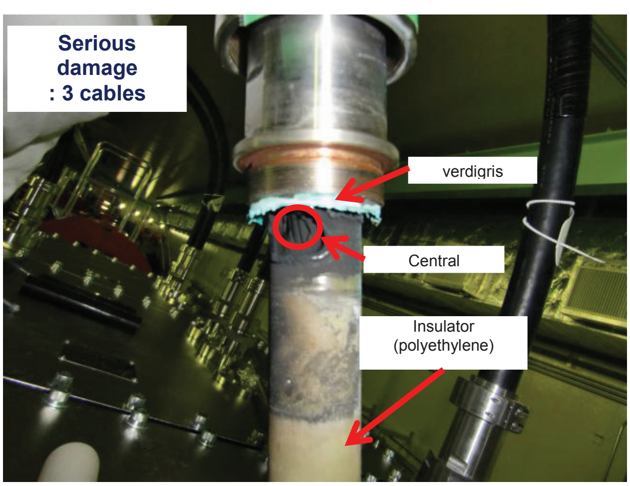

Figure 2: Dielectric breakdown at connector.

Resistance Degradation of Matching Resistors

Figure 3 shows a photograph of matching resistor. In 2012, all resistance values were measured, and it was found that some resistance values is increased to 30% of the specification (512.5Ω). By visual inspection, many cracks on the surface of paint film were observed. The cause has not been solved yet whether it is due to deterioration with age or not, the counter measure is under reviewing..

Figure 3: Matching resistor.

OPERATING HISTORY OF THYRATRON

The thyratoron tube of CX1193C which is produced by e2V technologies Ltd., has been used for this switch circuit. The number of 16 tubes is installed into the circuit. Table 3 indicates the number of replacement and the life time in each fiscal year. All tubes of 18 were replaced by new tubes in 2009, 11 tubes in 2010 and 8 tubes in 2012 were replaced. The number has been decreased every year gradually. Figure 4 shows the record of beam stop rate due to false operation of thyratron tube. In 2009, the beam stop rate of 2~13% was recorded. However, the rate has been decreased to less than 1% after March, 2010. Since it was found that adjustment of deuteron gauss by reservoir voltage is a technical key for a stable operation of Thyratron tubes, the adjustments have been done in every maintenance works. From this result, the false operation frequency was extremely decreased, and the

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beam stop rate was to be less than 0.5% in November, 2012.

Table 3: Number of Replace a Fresh Thyratron

Year	The number of replacement of thyratron tube	Operating hour (min)	Operating hour (max)
2009	18	600	4600
2010	11	2140	6791
2011	3	7777	8059
2012	8	8222	11904

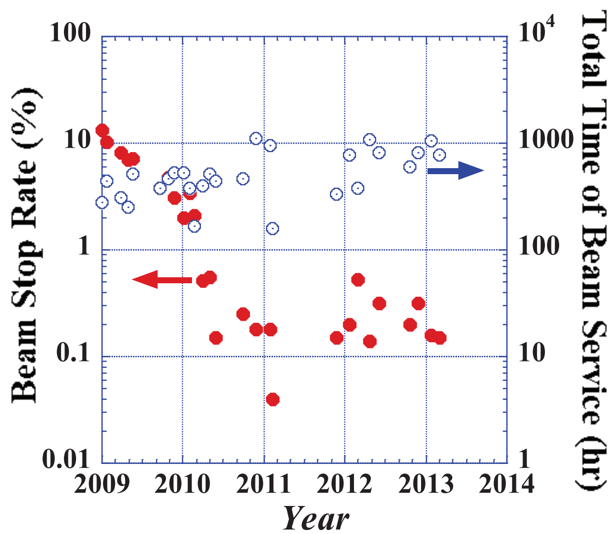

Figure 4: Record of beam stop rate in beam operation.

In Fig. 5, operating time of thyratron tube (CX1193C) versus the typical data is indicated. It can be seen that the reservoir voltage has been increased gradually by adjustments. Because deuteron gauss from the reservoir tank has been decreased gradually as operation time passes, the adjustment by increasing reservoir voltage is needed to keep deuteron pressure. This adjustment is indispensable for a stable operation, since deuteron gauss is applied to obtain a rapid current rise time.

NEW MODEL OF THYRATRON

The acceptance tests using the new model of CX2004X, are in progress, at the switching test stand of the J-PARC. Since deuteron gauss of this model is about 2 times much more than CX1193C one, by employing two reservoir tanks, a log life time more than CX1193C tube could be expected.

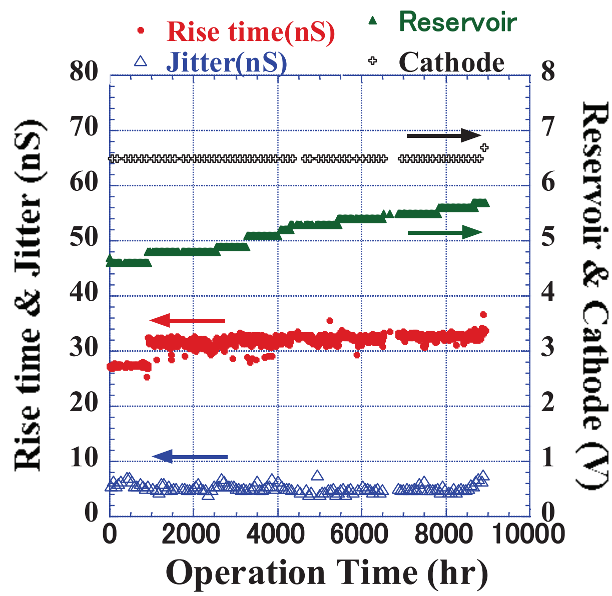

Figure 5: Typical data of Thyratron CX1193C.

SUMMARY

Almost 4 years have passed since the start of the J-PARC 3GeV RCS operation. A stable operation has been strongly required for all kicker magnet sections, to keep the RCS operation availability and to avoid an unnecessary activation by the false operation. For this purpose, improvements of the high-voltage cables and adjustments of the thyratron tubes have been done every maintenance works. For a stable operation of thyratron tubes, it is found that the adjustment of deuteron pressure is a key. From this result, the beam stop rate due to the false operation has been reduced to less than 0.5 % after November, 2012. In the next step, the acceptance tests using CX2004X tube which is expected for a long life time of more than 20,000 hours, are in progress at the switching test stand of J-PARC.

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