18pB-017

Experimental study on electrical characteristics of a high temperature pure water for quality improvement of the ITER neutral beam injector power supply
ITER中性粒子入射装置 1 MV電源の品質向上に向けた高温純水の電気特性試験

Haruhiko Yamanaka, Kazuhiro Watanabe, Mieko Kashiwagi, Hiroyuki Tobari,
Tetsuya Maejima and Masaya Hanada, NB Heating Technology Group
山中 晴彦、渡邊 和弘、柏木 美恵子、戸張 博之、前島 哲也、花田 磨砂也
NB加熱開発グループ

Japan Atomic Energy Agency, 801-1, Mukoyama, Naka 311-0193, Japan
日本原子力機構 〒311-0193 那珂市向山801-1

Electrical characteristics of a high temperature pure water up to 180℃ has been investigated for a water choke system which supplies the high temperature water to the 1 MV potential from the ground. It was clarified experimentally that a resistivity of 5 MΩ・cm (ITER condition, 25℃) water decreased to 0.36 MΩ・cm at 180℃. Pure water with resistivity range of 5 MΩ・cm to 9 MΩ・cm showed the almost the same resistivity reduction characteristics. Final design of the 1 MV power supply components has been approved by ITER and manufacturing of the components are progressed on schedule.

1. Introduction

In advance to the ITER NBI system, Neutral Beam Test Facility (NBTF) which is a prototype ITER NBI is constructing at RFX institute in Padova, Italy under the collaboration between JAEA and EU. In the NBTF, a Cs seeded negative ion source will be mounted at dc -1 MV potential. Temperature control of the plasma grid to enhance the negative ion production has been designed by supplying high temperature pure water around 150-180℃. A water choke system which supply both the cooling water and such high temperature water for the negative ion source accelerator has insulation pipes against the dc 1 MV potential. It was widely known that the resistivity of the pure water decrease by increasing temperature. However the water resistivity a higher temperature than 100℃ was not clear. There are a few reports which show the resistivity at the higher temperature than 100℃ [1], but they are calculated values based on the ideal pure water.

To clarify the actual resistivity at higher temperature region up to 180℃, the experimental has been conducted in the high temperature water loop system.

This paper reports the result of the measurement on the high temperature water resistivity. It will be also reported present status of the manufacturing of the 1 MV power supply components.

2. Experimental setup of resistivity measurement

Figure 1 shows the experimental setup of the resistivity measurement of the high temperature pure water. This setup was installed in the water loop of the DATS test stand in JAEA. A temperature of the pure water was varied from 25℃ to 180℃. Two ceramic insulator tubes of 10 mm in inner and 400 mm in length were mounted in the loop. A high voltage was applied at the middle point of the two tubes and applied voltage and current were measured. Upper and lower flanges are at the ground potential. So the measured current is paralleled current of two tubes.

3. Experimental results and discussion

Figure 2 shows measured resistivity as a function of water temperature. Two different purities of water are described in the figure. One is 9 MΩ・cm water and the other is 5 MΩ・cm water. From these results, following things have been clarified [2].

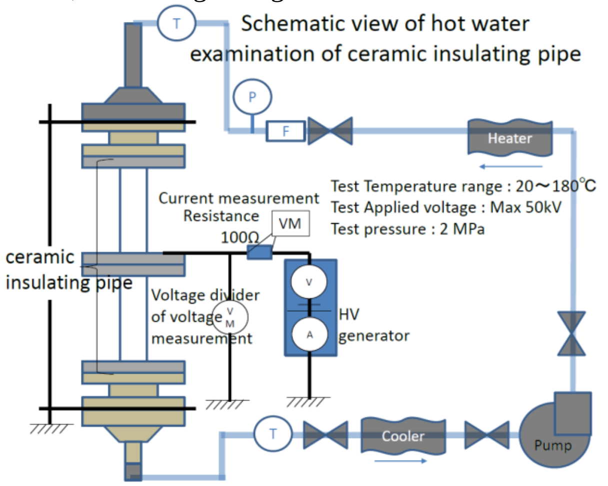

Fig. 1. Outline of hot water Experiment loop

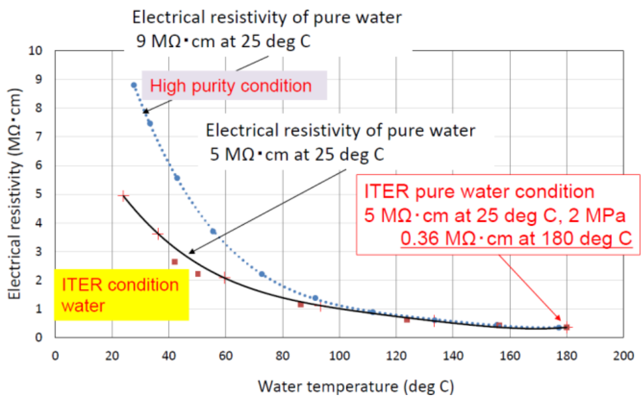

Fig. 2. Characteristic of two different purities of water

1) Even the different resistivity of 5MΩ・cm and 9 MΩ・cm at room temperature water showed almost the same resistivity at the higher temperature of 100℃.
2) The resistivity decreased by increasing the temperature and 0.36 MΩ・cm has been measured at the 180℃.
3) It has been confirmed that there is no dependence of pressure (1.5 ~ 2.5MPa) on the resistivity.

Based on the change in resistivity obtained by the measurement, it was estimated degree of heating by leak current due to decreasing of resistivity at high temperature region at the ITER water choke system. Additional heating about 6.5℃ by the leak current through the high temperature water was estimated. This can help the design of the temperature control device in the water feeding system.

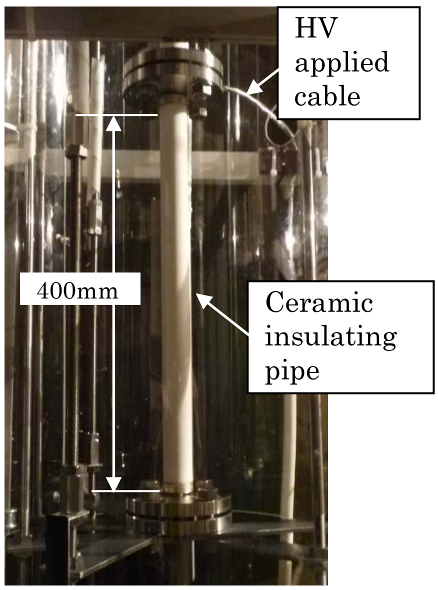

Fig. 3. Photo of connected ceramic insulating pipe

4. Design and manufacturing of 1 MV power supply components for NBTF

Final design of dc 1 MV generators and a 1 MV insulating transformer were completed. So the all components design has been finished. Final design review for these components has been conducted and all design has approved by ITER organization. Here, design of the dc 1 MV transformer will be reported as a major example. Development of a long pulse dc high voltage insulation is one of the most important issues in the 1 MV power supply.

Oil-impregnated paper layer insulation structure is being widely used in the transformer insulation. However, potential distribution in the insulator changed along to the time. In case a short pulse voltage, potential distribution is capacitive distribution. Namely voltage on the paper and oil layers are determined by capacitances of these materials. After the long pulse voltage application, voltage distribution is varied to the resistive distribution. A resistivity of paper is several tens higher than the oil, so the higher voltage is applied on the paper. For stable insulation, these characteristics has to be considered.

By the simulation which can treat such dc long pulse effect, the insulation structure has been designed. Figure 4 shows the structure of the transformer insulation. Recently the final design review of the power supply components has been finished and all design was approved by ITER. In parallel, manufacturing of approved components are being conducted on schedule.

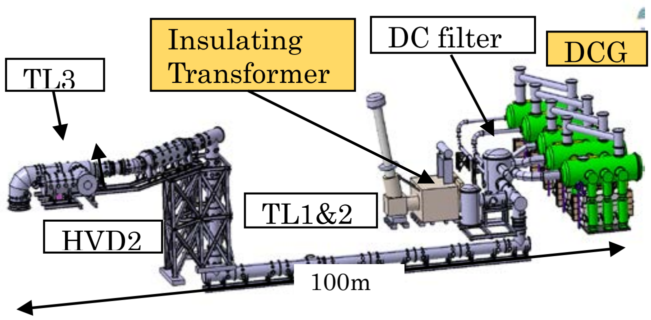

Fig. 4. Outline model of ITER NB power supply

References

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[2] JAEA-Technology 2014-037