3-3 Demonstration of Voltage Holding with the World's Largest Fine Ceramic Ring

—Progress on Development of a 1 MV Accelerator for Heating and Current Drive in ITER—

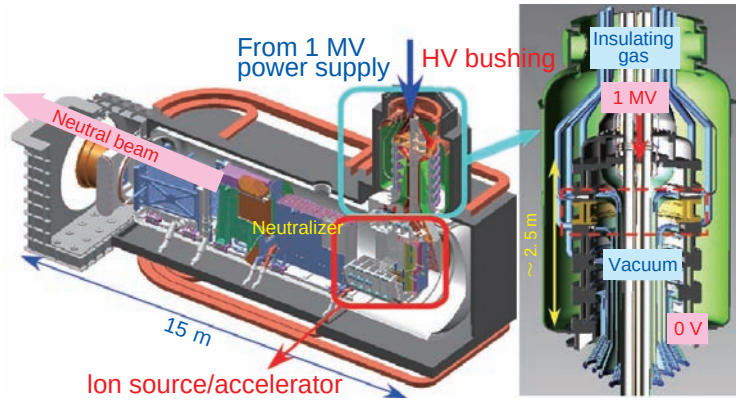

Fig.3-9 ITER NBI system and high voltage bushing
The high voltage bushing acts as a bulkhead between the gas region and a vacuum. While providing 1 MV insulation, the bushing is also a feedthrough for supplying electric power and cooling water for the ion source and accelerator in vacuum.

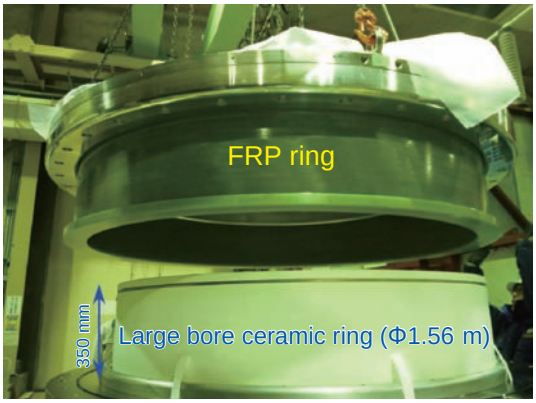

Fig.3-10 Full-size mockup of high voltage bushing
A full-size double-layered insulator consisting of a ceramic ring and FRP ring was manufactured. This simulates one stage of the high voltage bushing in the ITER NBI.

Neutral beam injection (NBI) is one of the key technologies for plasma heating and current drive in ITER. In the ITER NBI, a 1 million volt (MV) electrostatic accelerator is equipped to produce deuterium negative ion beams. A conventional insulation method to sustain high voltage in an accelerator is gas insulation with SF_6 gas. However, the accelerator in the ITER NBI is exposed to a radiation environment and electric current is induced in the insulating gas in such an environment, which results in power dissipation, and thus the accelerator must be installed in a vacuum. A high voltage (HV) bushing is then required to be mounted between the transmission line from the 1 MV power supply in the SF_6 gas and the accelerator in the vacuum. The HV bushing, which acts as a bulkhead and a feedthrough, is composed of a five-stage insulator to sustain 1 MV insulation (Fig.3-9). Since many conductors must be located inside the ceramic ring sustaining 1 MV insulation, the dimensions of the ceramic ring must be 1.56 m in diameter, 29 cm in height, and 5 cm in thickness. However, in conventional manufacturing methods the diameter has been limited to less than 1 m, and hence to establish a manufacturing method for the large ceramic ring has been a long-standing issue, for over ten years. To make the HV bushing a reality, JAEA and Kyocera Cooperation succeeded in manufacturing the world's largest ceramic ring (1.56 m in diameter) with a newly-developed forming method. A joining technique by brazing of the large ceramic ring with Kovar (a nickel alloy) was also developed in collaboration between JAEA and Hitachi Haramachi Electronics Co., Ltd.

JAEA manufactured a full-size mockup with the brazed ceramic, which simulated one stage of the HV bushing, as shown in Fig.3-10. To suppress breakdown triggered at the joint of the ceramic and metal, stress rings developed in R&D activity for the ITER accelerator in JAEA were installed in the mockup.

In the high voltage test of the mockup, 240 kV were sustained stably for over 1 hour. This is 20% higher than the rated voltage for each ceramic ring (200 kV), and thus the voltage holding capability required in the ITER NBI was verified for the first time. The present result supports development of the ITER NBI. Application of the vacuum insulation technique is expected to promote development of a "SF_6 gas free" high voltage component, which will be useful in the power industry.

Reference

Tobari, H. et al., Development of the High Voltage Bushing for the ITER NBI, Journal of Plasma and Fusion Research SERIES, vol.9, 2010, p.152-156.