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First RF Conditioning of the KSTAR ICRF Antenna

Young-Dug BAE [a*], Jong-Gu KWAK [a], Son-Jong WANG [a], Jae-Sung YOON [a], Sung-Kyu KIM [a], Suk-Kwon KIM [a],
Churl-Kew HWANG [a], Young-Soon BAE [b], Jong-Su KIM [b], and Mi JUNG [b]
[a] *Korea Atomic Energy Research Institute,*
1045 Daedeokdaero, Yuseong-gu, Daejeon 305-353, KOREA
[b] *Nuclear Fusion Research Institute,*
52 Yeoneun-dong, Yuseong-gu, Daejeon 305-806, KOREA
[*] *Corresponding author: ydbae@kaeri.re.kr*

1. Introduction

The KSTAR (Korea Superconducting Tokamak Advanced Research) ICRF (Ion Cyclotron Range of Frequency) antenna [1,2] was installed in the KSTAR vacuum vessel in July 2007. In general, an antenna conditioning should be implemented to provide clean surfaces of the antenna and other RF components, and to reduce a desorption of the impurities. We have carried out the first RF injection to the ICRF antenna, and an antenna conditioning. We have also performed some experiments to figure out the multipactor phenomena [2,3] at the ICRF antenna.

2. KSTAR ICRF System

The ICRF antenna has been installed in the KSTAR vacuum vessel as shown in Fig. 1. The antenna is plugged in through the main horizontal port (O-port), and it can change its radial position by up to 100 mm from the innermost position, with the machine under a vacuum. The antenna has four center-grounded current straps located in cavities separated toroidally by septa. Figure 2 shows the schematics of the KSTASR ICRF system. Presently two of four current straps are connected to the RF transmitter through the matching circuit, and the others are grounded at the ends of the vacuum transmission lines. Each current strap is grounded at the center and it has two coaxial ports. The top and bottom ports of are connected to form a resonant loop, which consists of one current strap, one tee and two arms connecting them. Each arm consists of a 6-inch vacuum transmission line, a vacuum feedthrough, a part of a pressurized 9-inch transmission line, a changeable U-link for phase shifting, and a DC break. The two tees are connected with each other through a U-link at another tee which is connected to the feed line from a RF transmitter through a double liquid stub tuner. The ICRF system can be operated at any frequency in the range of 25-60 MHz by using six changeable U-links and a double liquid stub tuner. The main transmission line connected from the RF transmitter to the stub tuner consists of a 64-m long 9-inch coaxial line, which is pressurized with N_2 gas at 3 kgf/cm^2 to increase the standoff voltage. The RF transmitter consists of three amplifier stages, and the nominal output power of the final power amplifier is 2 MW for 300 sec. The 2 MW transmitter is presently under commissioning. For the first RF power injection to the ICRF antenna and the antenna conditioning experiment, we used another RF transmitter which has a maximum output power of 5 kW.

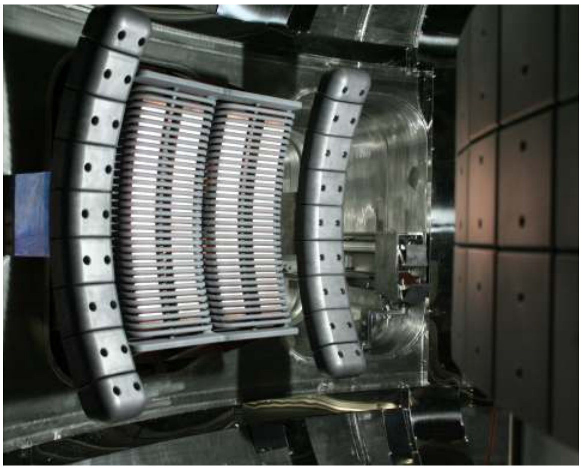

Fig. 1. The ICRF antenna has been installed in the KSTAR vacuum vessel in July 2007.

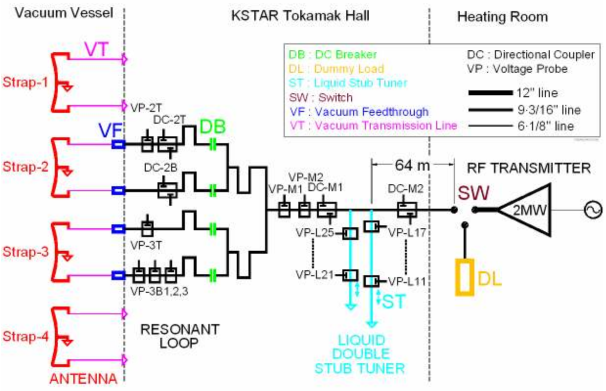

Fig. 2. Schematic diagram of the current ICRF system.

3. Experiments

Prior to the antenna conditioning, several RF shots were injected to the antenna at a low RF power level in order to check the integrity of the ICRF system. Typical time evolutions of the RF power and the vacuum pressure is as shown in Fig. 3. The pulse duration was limited to 1 sec and the pressure was measured at the pumping duct which was far from the antenna. When the RF pulse was injected to the antenna, the pressure was immediately increased by the gas desorption from the surfaces on which a RF current was induced, for example, current straps, Faraday shield tubes, cavity walls, and vacuum transmission lines. The pressure had a maximum at 2 sec after the RF pulse was terminated, which is due to the migration time from the antenna to the vacuum pumping duct. During the RF pulse we measured the partial pressure of several gases. The increase in the hydrogen pressure was found to be most prominent, which is similar to that of other machines [5]. Nitrogen and CO_2 pressure fairly increased. H_2O pressure slightly increased.

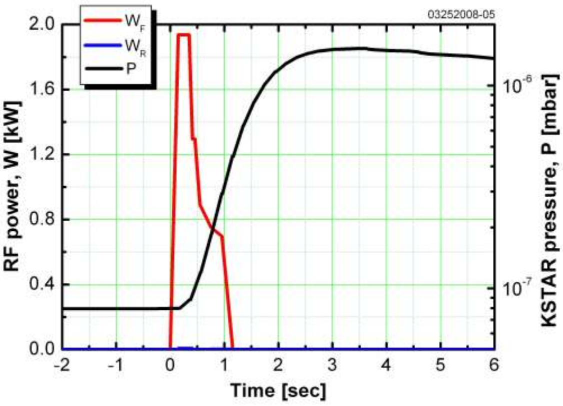

Fig. 3. Typical time evolutions of the forward power (W_F), reflected power (W_R), and vacuum pressure (P) for a 1-sec RF conditioning shot.

Figure 4 shows a conditioning process. Consecutive RF pulses of 1-sec duration were applied to the antenna with a periodic time of 20 (or 30) sec for about 22 min. The pressure increase was significantly decreased, which meant the conditioning was effectively accomplished. The maximum pressure was 1.5×10^{-6} mbar for the first pulse, and it was decreased to 2.0×10^{-7} mbar for the last pulse.

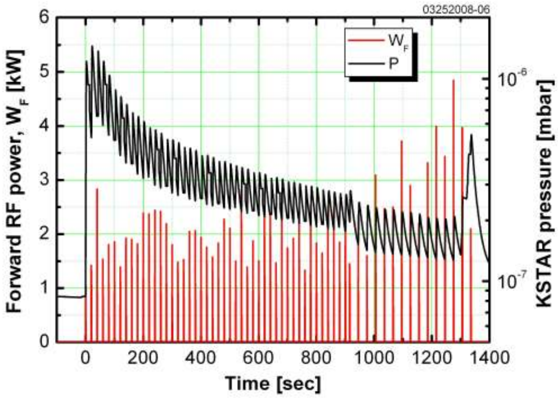

Fig. 4. Time evolution of the KSTAR vacuum pressure during an antenna conditioning.

In order to investigate the multipactor discharge, we applied an RF power with a continuously decreasing pulse form. At below 0.1 kW of the RF power, the multipactor discharge was ignited, which caused that the reflected power was abruptly increased and the line voltage was simultaneously dropped as shown in Fig. 5. The multipactor discharge could be easily avoided by applying a higher RF power.

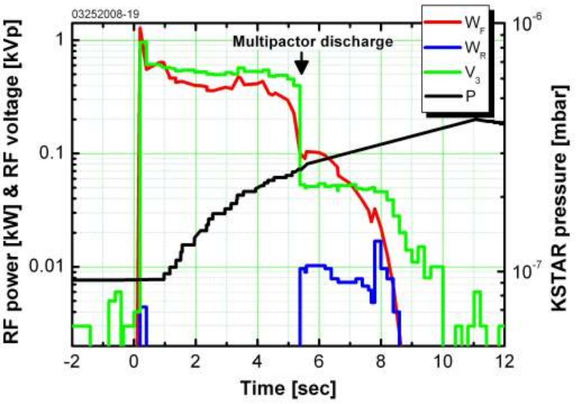

Fig. 5. Multipactor discharge occurred below 0.1 kW RF power.

4. Conclusions

The first RF power injection to the KSTAR ICRF antenna was performed successfully, and an antenna conditioning was carried out. During the conditioning process, the pressure increase was significantly reduced, which showed the antenna was effectively cleaned to decrease the gas desorption. As a future work, we will perform a similar work at a higher power level.

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