§30. High Voltage/Long Pulse Test of a Liquid Stub Tuner on ICRF Heating System

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In ICRF heating experiments, the plasma loading resistance changes gradually with density and/or suddenly in an L-H transmission. These result in the increase in the reflected power from RF antenna. A liquid stub tuner can be a tool to solve above problem because it is allowable to move the liquid surface without RF breakdown. The liquid stub tuner with movable liquid surface works as a conventional stub tuner. A difference in RF wave length between liquid and gas is utilized. Then it is important to demonstrate that it works with a high RF voltage of more than 50kV and the liquid surface can be moved without RF breakdown, which will be discussed in the next section. A 260cm long liquid stub tuner was constructed with 104mm inner copper transmission line and a 204mm outer aluminum transmission line. Cooling water flows inside the inner and on the outer transmission line. Silicon oil is used as the liquid. The relative emissivity is 2.72 and the dielectric loss tangent is 10^{-4} to 5×10^{-4} at 10-100MHz. The low vapor pressure is the main reason why the silicon oil is chosen. The vapor pressure is less than 0.1torr even in 240°C.

In the annual report 1994-1995, we already reported the test result of 5-6kV with 50sec operation[1]. It was then installed on the RF oscillator side in a double stub tuner system on the ICRF heating R&D system. We moved it to the antenna side as shown in Fig.1 in the previous section, because higher RF voltage can be applied to it[2]. In the series of tests, the RF antenna was not connected because the vacuum pressure increase prevented higher RF voltage with long pulse. We obtained impedance matching with an operating frequency of 41MHz. Figure 1 shows RF voltage distribution in liquid and in 3 atmospheres nitrogen gas with a peak RF voltage of 61.3kV. The RF voltage is measured in 8 ports. The liquid surface is located at 112cm, which is measured from the bottom of the liquid stub tuner. It is found that the RF wave length is shorter by a factor of root square of the difference of relative emissivity between in the liquid and in the gas.

We tried the liquid stub tuner in high RF voltage with long pulse operation. Figure 2 shows results achieved so far in RF voltage and operation period. 61.3kV and 50kV are achieved in 10sec and 30min operation, respectively. These figures are higher than 58kV/10sec and 40kV/30min, which were achieved in the whole transmission system as described in the previous section. The RF transmission capability is calculated to be 3.75MW/10sec and 2.5MW/30min, respectively, when we assume the LHD plasma loading resistance is 5Ω. We decided that the liquid stub tuner can be adopted as a reliable stub tuner in the LHD ICRF heating transmission system.

References

1)Kumazawa, R., Mutoh, T., et al., Annual Report 1994-1995, p.87.
2) Kumazawa,R., Mutoh, T., et al., Proceeding of 18th Symposium on Fusion Technology(1996), P-D-20, to be published.

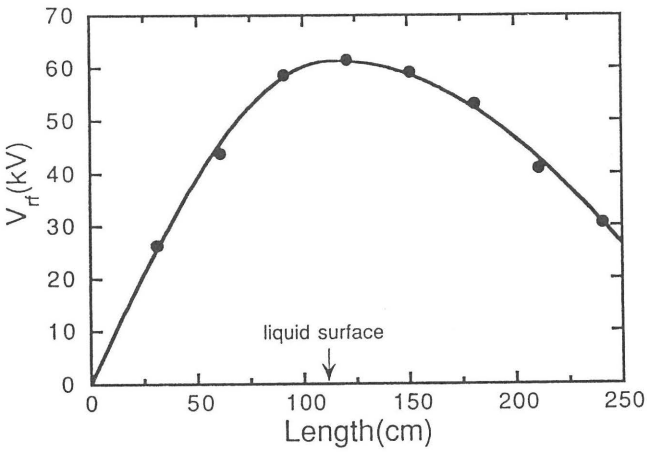

Fig.1 RF voltage distribution in 61.3kV operation.

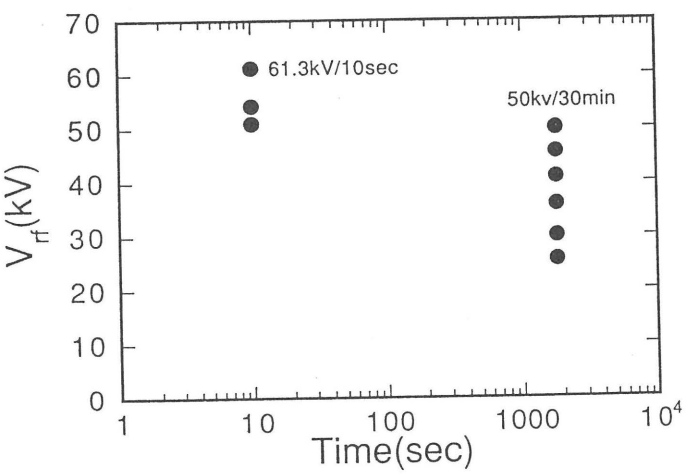

Fig.2 RF voltage and pulse length achieved in liquid stub tuner.