§31. Liquid Surface Movement Test and RF Power Dissipation Loss on Liquid Stub Tuner

Kumazawa, R., Mutoh, T., Seki, T., Nomura, G., Shinbo, F., Ido,T., Watari, T.

In the previous section, we reported the reliable performance of the liquid stub tuner in high RF voltage with long pulse. Here we will present the capability for the liquid stub tuner to be a tool to respond the temporal plasma loading resistance changes and the negligible dissipation power due to the low liquid dielectric loss tangent. To verify its feasibility for feedback control in impedance matching, we tried to move the liquid surface to reduce reflected RF power fraction during 46kV operation as shown in Fig.1. 12% of reflected RF power fraction can be reduced to almost 0% within half second by shifting the liquid surface by 2.7mm. The velocity of the liquid surface movement is 0.5cm/sec. In this experiment the Q value is high, so several mm shift can restore the negligible reflected RF power fraction. During ICRF heating on the LHD plasma, however, the plasma loading resistance is one order of magnitude larger than the present value, so that the required liquid surface shift may exceed several cm. We will have to develop the system with a faster movement of the liquid surface.

We examined the RF dissipation loss in the liquid stub tuner. The time evolution of the liquid temperature is shown in Fig.2. The maximum temperature increase is 26°C at 40kV/30min operation, which is almost saturated in time. Figure 3 shows the liquid temperature increase with various RF voltage in 30min in two cases where the inner transmission line is cooled and both transmission line are cooled by water. The other solid curve shows the temperature increase in the thermally isolated liquid calculated with RF dielectric loss power for $\tan\delta=2\times10^{-4}$ in 41MHz operation and a liquid heat capacity of 0.36cal/g. The estimated liquid temperature increase, T_{liq} is calculated in following equation:

$$T_{liq}(^\circ C)=0.07V_{rf}(kV)^2 \qquad (1)$$

The dielectric loss is calculated to be 5.4kW in 45kV operation. When the plasma loading resistance is 5Ω and RF heating power is 2.0MW, the RF loss power fraction due to the liquid dielectric loss is 0.27%, which is negligibly small.

References

1) Kumazawa, R., Mutoh, T., et al., Proceeding of 18th Symposium on Fusion Technology(1996), P-D-20, to be published.

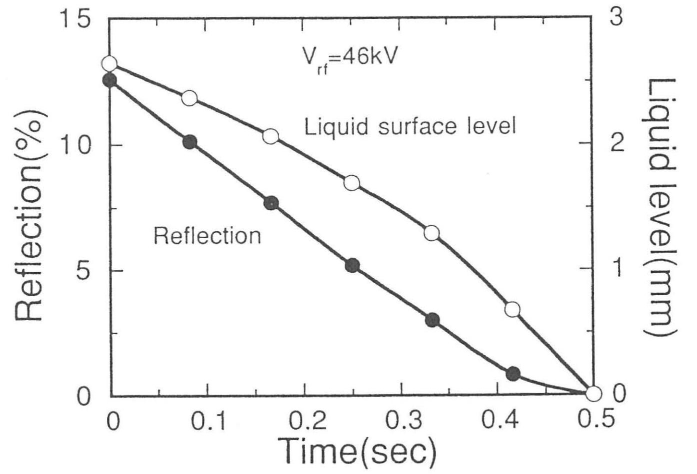

Fig.1 Reduction of reflected RF power fraction by moving liquid surface.

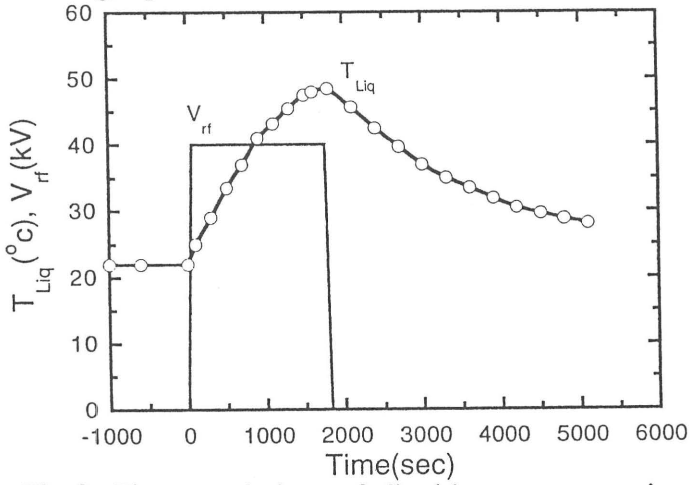

Fig.2 Time evolution of liquid temperature in 40kV/30min operation.

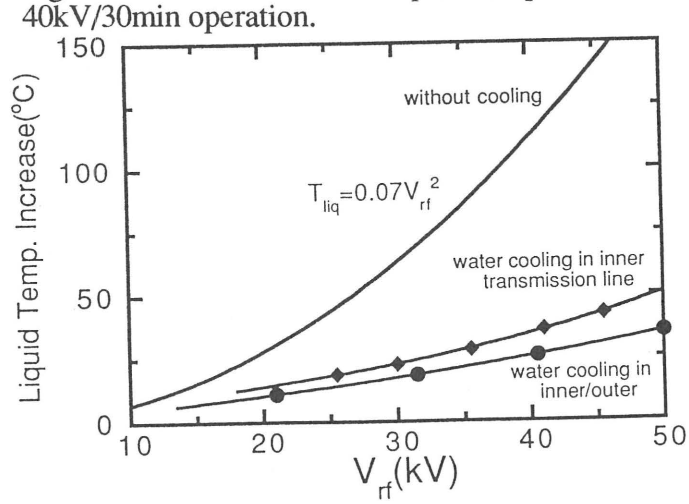

Fig.3 Dependence of liquid temperature increase on RF applied voltage in cases of no cooling, inner transmission line water cooling, and both transmission lines water cooling.