§41. Density, ICRF Power and Pulse Length Operated in Steady State Experiment in the 9th Cycle Experiment

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Higher density operation is important for a steady state experiment. One reason is a slowing down of high-energy ions. The other is an engineering study of experimental devices for a steady state operation. During the long pulse operation, sparks are observed in the vacuum vessel. One of causes of plasma collapse is thought an iron impurity influx accompanied with the sparks. Frequency of the sparks is related with an electron density. When the line-averaged electron density is high, the sparks are rare. One possible speculation of source of the sparks is high-energy ions accelerated by ICRF waves. High-density operation is effective to decrease the high-energy ion tail and the sparks. Possibility of plasma collapse during a steady state operation will go down by a high-density operation. In case of a high power steady state operation, heat load on the divertor and the vacuum vessel is large. It will contribute to investigate an engineering evaluation of LHD for a steady state operation.

In the steady state experiments in the 9th cycle experimental campaign, higher density operation using a high power ICRF heating was carried out at the beginning. Figure 1 shows the maximum of a line-averaged electron density against the ICRF power. Symbols are classified by the experimental dates. Data of the 8th cycle experiment are also plotted. Figure 2 shows the pulse length of the ICRF pulse as a function of the ICRF power. The steady state experiment was started at an injection power of about 1 MW and a line-averaged electron density of 1 $x10^{19}$ m^{-3} and a pulse length of 10 seconds. The ICRF power was increased and the pulse length was extended after that. The maximum density was about 1.8 x 10^{19} m^{-3}. This is lower than that of the 8th cycle's value for the same ICRF power. The plasma with an electron density of 1 x 10^{19} m^{-3} was sustained for 4 minutes and 45 seconds with an ICRF power of 1.35 MW. These power and density were almost same as target values for the 9th cycle steady state experiment. However, many sparks occurred and a long pulse discharge using a high power ICRF heating became difficult later. Higher power and longer pulse trial may have caused the problems in the ICRF antenna and the vacuum vessel. Traces of arcing were found at the ICRF antenna when inspection was conducted in the vacuum vessel after the experiment. The ICRF power was controlled with watching the sparks for the further long pulse experiment. A line-averaged electron density was reduced with the ICRF power.

Data from the 8th and the 9th cycle experiments in Fig.2, it seems that there is some threshold that the discharge extends to more than 1000 seconds. If the pulse length reached to around 400 seconds, possibility to get longer was high. This will help for an efficient steady state experiment as a criterion.

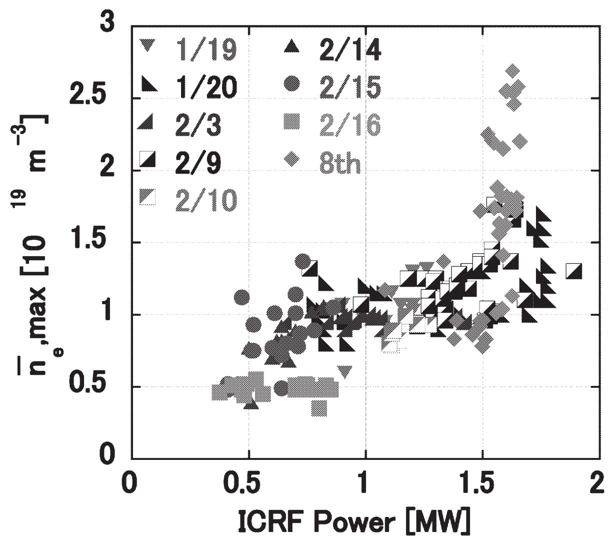

Fig. 1. Maximum of a line-averaged electron density against the ICRF power.

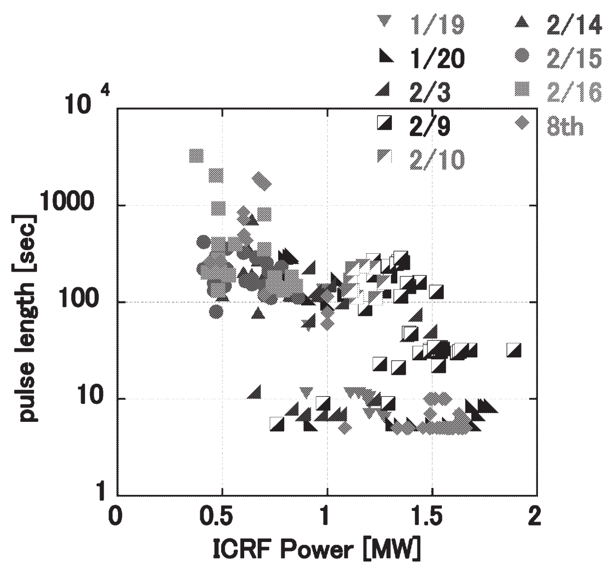

Fig. 2. Pulse length of the ICRF pulse as a function of the ICRF power.