

§79. Power Balance Estimation Using Water Temperature Increment of Plasma Facing Component and Steady State Operation

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In FY2013, a water-cooling movable limiter installed on the vacuum vessel in low field side was used to measure a heat load distribution oriented from energetic electrons accelerated with an intense microwave of 8.2GHz. Plucking it out of the plasma area, the distribution of the heat load clearly changed over from the movable limiter to fixed limiters located just on the vessel surface in low field side, although total amount of the heat load is independent from the position of the movable limiter.

1. Introduction

Spherical tokamak (ST) has a possibility to realize a cost-effective future fusion power plant, which is coming from its further compactness and better stability to high β plasma. Conversely, the advantage naturally causes some difficulties that a figure of merit, P/R, is higher than that on other magnetic fusion devices such as conventional tokamaks, where P, and R show injected and productive power, and major radius, respectively. Therefore its heat load to plasma facing components (PFCs) on ST has been investigated intensively. The QUEST (Q-shu University Experiment with Steady State Spherical Tokamak) project focuses on the steady state operation of ST and monitoring of the heat load to the PFCs has been done with a calorimetric [1]. As the calorimetric technique is more accurate, applying it to long duration plasmas, QUEST can take advantage of its capability to maintain plasmas for a long time. It is indispensable that every PFCs should be cool down with some flowing water for any long duration plasmas, and the temperature increment of flowing water allow us to measure accurately the total heat load to the PFCs.

2. Experimental Apparatus

Several hot spots appeared on the outer vessel during long duration plasmas and resulted in significant out-gassing, which was sometimes preventing from maintaining long duration discharges. It can recognize as a local power unbalance, where heat load was exceeding its cooling capability. To further extend plasma duration, a movable limiter (ML) made of tungsten agglutinated on a copper base was installed to remove the local heat load. As the result, we could

obtain a 3 min discharge on an inboard null configuration. Since 2012 A/W (autumn/winter) campaign, four water-cooled outer limiters (OL) made of W have been installed and a 5 min discharge in a limiter configuration was successfully achieved. In this research, we investigated the width of the heat load to the ML and the OLs.

3. Experimental Results

The position of the ML from a plasma in an inboard null configuration was changed shot by shot. The heat load to the ML is mainly delivered by energetic electrons, because it is coming even when the ML locates significantly far from the core plasma. Total amount of the heat load to the PFCs located on the outer vessel is almost constant as shown in Fig. 1. In this measurement, a water cooling system did not work and temperature increment of PFCs itself was used. It should be made sure its accuracy to compare a measurement with cooling water.

Only little heat was coming to the ML when it located at 0 and 5 mm, where 0 mm means the same surface position of the OLs on design drawings of QUEST. Inserting it into plasma area more, a part of heat changes over to the ML. The width of the heat load measured with the ML was less than 10mm and it was so narrow. However, the width measured with the OLs was significantly longer than that measured with the ML. It seems to indicate that further investigation is required.

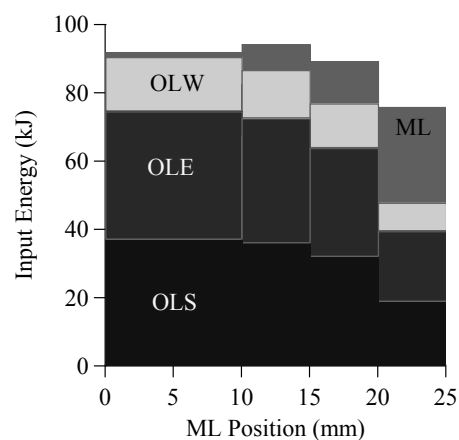


Fig. 1 Heat load dependence on the movable limiter position is plotted. Each abbreviation is ML: movable limiter, OLW: outer limiter on the west side, OLE: outer limiter on the east side, OLS: outer limiter on the south side.

Summary

Heat load measurement was done with a monitoring of temperature increment of a movable and three fixed limiters. When the movable limiter was plucked out, heat load was deposited on the fixed limiters and total amount of heat load was still kept approximately constant.

[1] K.Hanada *et al.*, Plasma Science and Technology, to be published (2014).