



IAEA FEC 2014

Contribution ID: 136

Type: **Poster**

Studies of Dust Transport in Long Pulse Discharges in the Large Helical Device

Thursday, 16 October 2014 14:00 (4h 45m)

Dust transport study in magnetic plasma confinement devices has been attracting attention because it is concerned that dusts influence main plasma performances in nuclear fusion reactors. Exfoliated dusts consisting of accumulated impurity deposition layers can enter the main plasma to enhance impurity radiation.

The Large Helical Device (LHD) is a unique test stand for studying the dust effects because of the performance of steady-state operations with saturated wall conditions which are equivalent to situation in nuclear fusion reactors. Many incandescent dusts have been observed in ICRF heated long pulse discharges. Spectrometers have detected frequent spikes of iron emission induced by the dusts. Stereoscopic observations of the three-dimensional trajectories of the dusts using a fast framing camera show that the dusts exist in the peripheral plasma and do not penetrate into the main plasma for high heating power, while dust penetration were observed for low heating power.

A dust transport simulation code (DUSTT) was applied to investigate observations of the dust trajectories. It can calculate the time evolution of the force, heat, mass and charge balance of dusts in plasmas. The original DUSTT code is optimized to axisymmetric plasma configurations such as Tokamaks. Thus, the code was modified and implemented in a three-dimensional neutral particle transport code (EIRENE), which enables the analysis of dust transport in non-axisymmetric plasma configuration like a LHD. The LHD peripheral plasma is mainly composed of two magnetic structures: divertor legs and ergodic layers. The simulation shows that the peripheral plasma has two functions for preventing the dusts from the penetration. One is sweeping on the divertor legs by the plasma flow (mainly by ion drag force), and another one is evaporation on the ergodic layers by the effect of the heat load due to the high peripheral plasma temperature. It explains the observations in the long pulse discharges for the high and low ICRF heating power in LHD, showing that the dusts are swept off and are evaporated in the peripheral plasma for the high heating power.

It indicates that penetration of dusts, which size is in the range collected in the present devices, into the main plasma will be controlled in nuclear fusion reactors because of the evaporation of dusts by the high temperature peripheral plasma.

Paper Number

EX/P6-33

Country or International Organisation

Japan

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Session Classification: Poster 6