Heat loads on FTU liquid lithium limiter

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In a future reactor the choice of the better material exposed to the plasma is still an open question. One of main requirement to be satisfied is the capability to withstand the high heat load in the range 10-20 MW/m^2 during normal operation in a future reactor as well as the peak power released by ELMs in H-mode operation. Furthermore two other issues should be tackled: erosion and dust. Both questions are strictly related to the life time of the plasma facing component exposed to the plasma and, consequently, to the operation time of a future reactor. On FTU, since the end of 2005, we have started an innovative program having as main goal the possibility to expose a liquid surface to the plasma.. The small wetted area of the FTU liquid lithium limiter doesn't allow to use it as main limiter for all the duration of the discharge so that it is always set in the shadow of the main toroidal limiter. In this condition, heat loads up to 2 MW/m^2 are normally withstand by the liquid lithium limiter without any surface damage and problems to the FTU operations. To increase the heat load on the liquid lithium limiter for a controlled limited period we have decided, during the discharge, to shift down the plasma column towards the liquid lithium limiter. The surface temperature of the three liquid lithium limiter units is measured by means of a special three–channel fiber–optic HgCdTe infrared detector developed for FTU to control fast variations of temperature during plasma discharges[1].The surface temperature remains constant although the plasma column is pushed on the liquid lithium limiter. This saturation of the surface temperature can be understood if we consider the dependence of the evaporation rate versus the surface temperature between 250 °C and 550 °C that it increases of five orders of magnitude. The evaporated lithium forms a strongly radiative cloud all around the three units limiting the power load on the surface of liquid lithium limiter as also observed in T-11[2]. This is a self protective mechanism that prevents damage to capillary porous structure and gives a limit to lithium production by evaporation. We don't observe any accumulation of lithium into the discharge as it can be also inferred from the time evolution of the Li III line growing up until the temperature is reaching the maximum value and then it remains quite constant. These observations are in agreement with experimental data and calculations reported in a previous paper in which thermal analysis of the heating dynamics has been carried out by using ANSYS code. This self protective mechanism could simplify the heat removal problem in the reactor by transferring the main energy flux to vessel wall by radiative processes. The liquid lithium limiter mounted on FTU is an object aimed essentially to verify the physical and technological feasibility to expose a liquid material to the plasma. A new project has been already developed and the phase of its construction is starting. The new limiter will be actively cooled and refilled and should be able to withstand up to 10 MW/m^2 for four seconds. This module has been designed having in mind the idea that, putting together many of them, it is possible to build a wide panel acting as main limiter on FTU or that it can be used in a divertor device.

[1] A.Alekseyev et al. EPS Conf. Roma 2006 http://epsppd.epfl.ch/Roma/pdf/P1_162.pdf

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