testing of prototype models of cooled lithium liquid-metal capillary-porous system by stationary plasma in PLM

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The problem of plasma-wall interaction in tokamaks and other fusion devices includes the problems of studying the stability of lithium liquid metal components facing plasma, formulated in the works of S.V. Mirnov, see [1]. The work carried out tests of prototypes of a cooled lithium liquid metal capillary-porous system (CPS) in a sta[[1]](#footnote-1)\*)tionary plasma of plasma device PLM (plasma linear multicusp) [2]. Experimental models of cooled lithium CPS were made at “Red Star” JSC from molybdenum in the form of a cooled container filled with lithium in a molybdenum grid, the area of ​​the lithium surface facing the plasma was 4x2 cm2. The prototype lithium CPS was installed in the plasma discharge, the plasma flow was directed normally to the surface of the CPS, the diameter of the hot zone was 35 mm. Parameters of helium plasma during testing: magnetic field on the axis - 0.01 T, in cusps - up to 0.2 T, electron temperature ~ 2 eV with a fraction of hot electrons up to 50 eV and more, plasma density of more than 1x1012 cm-3, plasma heat load on the surface of the lithium CPS reached 1.8 MW / m2. The temperature of the lithium surface in the CPS was monitored using a pyrometer-thermal imager.

In experiments without cooling for 120 minutes of plasma irradiation, the temperature of the lithium surface facing the plasma reached 464 °C. After two hours of evaporation of lithium, an oval region with a relatively large thickness of the lithium melt remained on the CPS surface.

In experiments with cooling under plasma irradiation for 145 minutes of the prototype lithium CPS with water flow cooling, no significant changes in the temperature of the coolant at the outlet from the cooling system were recorded. With an increase in the thermal load on the surface of the lithium CPS from 0.05 to 1.8 MW / m2, the temperature of the cooling mixture increased by only 1 °C. At loads from 1.0 to 1.8 MW / m2, the temperature difference of the cooling flow at the inlet and outlet did not exceed 2 °C. The module temperature did not rise above 50 °С, the cooling system provided intensive cooling of the module. The temperature of the CPS surface facing the plasma exceeded 400 ° C. After plasma irradiation, composites of lithium compounds with oxygen, carbon and nitrogen are formed on the surface of the models, and a highly porous surface with a developed relief is formed.

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References

1. Mirnov S.V. Journal of Nuclear Materials.- 2009.- 390(1).- P.876-885
2. Budaev V. P. et al. VANT ser. Thermonuclear fusion. - 2017. - Vol. 40, No. 3. - P. 35
1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLIX/Mu/ru/CC-Karpov.docx) [↑](#footnote-ref-1)