THERMO-HYDRAULIC ANALYSIS OF THE FIRST MIRROR AND ITS COOLING SYSTEM FOR THE ITER CORE CXRS DIAGNOSTIC

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The port plug for the ITER core charge exchange recombination spectroscopy (core CXRS) is located in upper port #3. Its primary function is to transfer light in the visible part of spectra emitted by interaction between plasma ions and diagnostic neutral beam (DNB).

In the analyzed design option of the core CXRS port plug has three major parts. The "port shell" encloses and supports the "shielding cassette" which, in its turn, encloses and supports the "retractable tube". The tube carries the first mirror (M1) with a shutter. The cassette forms periscope-like optical path and should serve within the whole ITER lifetime.

The most important part of the CXRS diagnostic system is the First Mirror (M1), which is responsible for acquisition and transportation of the optical signal of required quality from the ITER plasma to detectors. At the same time, the First Mirror is the most vulnerable component of this system working in drastic and severe conditions caused by its location in the direct view of the plasma.

The temperature states of the first mirror, shutter and head of the retractable tube are determined by two factors, namely, by energy fluxes from the plasma due to neutrons and electromagnetic radiation on the one hand, and by the mirror and shutter cooling efficiency on the other hand. The heat exchange by radiation (in infrared spectra) between the mirror, shutter and inner walls of the BSM module forming together the closed optical system contributes as well to temperature state of the first mirror and shutter.

The numerical analysis of expansion of the energy fluxes emitted by the plasma in the optical channel formed by the hole in the blanket module (BSM) and surfaces surrounding the first mirror (M1) allowed us to determine the attenuation factor, which is about ~ 40 for the energy transmitted from the BSM aperture to the first mirror M1 by the neutron and radiation fluxes (mostly by X-rays and UV): only 10÷13 kW/m^2 from the 500 kW/m^2 radiation flux entering the optical channel will attain the first mirror M1.

The computation demonstrates that, the first, helium is the best candidate among the analyzed gases (He, N_2, Ar) to be used as a coolant to maintain the first mirror temperature in the required operational range of 350±50°C giving the highest heat transfer coefficient and the lowest hydraulic losses at moderate flow rates (v_{gas}= 40÷60 m/s) and, second, optimization of the cooling channels configuration together with an increase in the gas velocity and/or with heat transfer intensifiers makes it possible to provide the required M1 temperature conditions.