DOI: 10.34854/ICPAF.51.2024.1.1.023

DESIGN SELECTION AND PARAMETERS CALCULATION OF THE NEUTRAL BEAM CALORIMETER FOR INJECTORS OF TOKAMAK T-15MD *)

Bocharova E.V., Barkalov K.E., Eremin V.A., Nikulin V.A.

NRC 'Kurchatov Institute', Moscow, Russia

Neutral beam injector is a system that is used to heat and maintain current in fusion plants by injecting fast atoms of hydrogen and its isotopes. The calorimeter is an element of the injector's beamline. It is used to accept the beam power during injector adjustment, setting it up to the operating mode and diagnostics. With the open calorimeter, the beam enters the duct to tokamak and finally the tokamak's vessel [1].

The calculated power density of the beam injected into the T-15MD tokamak reaches tens of MW/m2, which means that the calorimeter will operate in modes of critical thermal loads, requiring the use of a tubular scheme and a V-shaped calorimeter with two panels, similar to the design of ITER injector's calorimeter [2]. Tilt of the panels about the beam axis allows to reduce the incoming power density to values not exceeding 10 MW/m^2. Each panel is a set of copper chromium zirconium tubes arranged in two layers. The front tubes partially overlap the rear tubes, preventing beam particles from passing through the panels. Twisted tapes are installed in the tubes to turbulise the flow.

The thermomechanical parameters of tubes for different diameters were analysed. Thermal calculation was carried out by the adiabatic cross-section method using analytical formulae based on experimental studies [3]. Also, the temperature fields, stresses and deformations of the tubes were calculated. Consequently, tubes with an outer diameter of 14 mm were chosen, as they are efficient enough to ensure receiving of all incoming power at the lowest water flow rate.

To diagnose the resulting beam power profile, a set of collectors receiving secondary-emission electrons is installed in the shadow of the front tubes [4]. A numerical evaluation of the total electron current per collector as a function of the distance between the layers of tubes was performed. A 5 mm distance was chosen because it provides sufficient current allowing diagnostics and adjustment of the beam axis aiming at the tokamak inlet.

References

[1]. Semashko N.N., Vladimirov A.N., Kuznetsov V.V. et al, Injectors of fast hydrogen atoms, Moscow: Energoizdat, 1981, 168 p.
[2]. Hemsworth R. S. et al. Overview of the design of the ITER heating neutral beam injectors, New Journal of Physics, 2017, V. 19, № 2, 21 p.
[3]. Yagov V. V. Heat transfer in developed bubble fluid boiling, Teploenergetika, 1988, №2, 4 p.
[4]. Barkalov K.E., Barkalov E.E., Panasenkov A.A, Experimental investigation of a high power long-pulse neutral beam profile diagnostic based on secondary electron emission, AIP conference proceedings, 2018, V. 2052, № 1, 7 p.

*) abstracts of this report in Russian