MODELING AND OPTIMIZATION OF NEUTRAL BEAM INJECTORS FOR the DEMO-FNS FUSION NEUTRON SOURCE

Ananyev S.S., Panasenkov A.A., Dlougach E.D., Klischenko A.V., Kuteev B.V.

NRC Kurchatov Institute, Moscow, Russia, [Ananyev\_SS@nrcki.ru](mailto:Ananyev_SS@nrcki.ru)

Steady-state operation of a fusion neutron source (FNS) requires plasma heating and current drive by means of additional power delivered by neutral beams. Six neutral beam injectors (NBI) will provide DEMO-FNS [1] machine with additional heating power up to 30 MW, with neutral particle energy 500 keV. NBI systems developed for ITER can serve as the prototype for DEMO-FNS, as both systems have similar ion source current, with accelerated beam power in ITER NBI (1 MeV) being twice as large as in DEMO-FNS. We have conceptually considered the injectors integration into the tokamak complex, the change in its basic parameters as compared with the ITER injector, and described the injector and its key components design [2]. The choice of injector configuration and operational parameters are based on computer simulations [3].

The problem of effective neutralization of high energy source ion beam and its transportation to tokamak plasma requires a 3-dimensional analysis involving tens of input parameters. The code-based optimization target is to obtain the NBI geometry and operational conditions which would allow for minimum beam losses along the beam path as well as the thermal loads reduction on the injector components with account of cooling circuits arrangement. The report presents the general approach of NBI optimization and the specific methods of the solution related to DEMO-FNS injector. The main factors affecting the beam transportation efficiency, including beam steering inaccuracies and background magnetic fields, are considered, the relevant operational restrictions are stated. The results of the optimization technique include the most effective «self-consistent» geometry of the injector and the source beam, the operational intervals, the beam total losses during the neutralization and transportation, the beam power profile evolution and the thermal loads distributions – for all injector components, and under different scenarios of operation. These results are proposed for engineering design of target NBI system. Preliminary estimates of the beam attenuation in a tokamak plasma are carried out and load profiles on the first wall are plotted. The injection path magnetic shielding calculations results are given to ensure acceptable values of the magnetic field induced by tokamak magnetic systems. Considered issues of NBI gas supply and analyzed tritium inventories scenarios in its various design.

References

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