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Numerical Simulation and Experimental Study on the Ejecting Electrons from the Prototype Negative Ion Source at ASIPP

A negative ion based neutral beam injection (NNBI) test facility is one of the significant components of Comprehensive Research Facility for Fusion Technology (CRAFT) in China. A quarter-size beam source for the CRAFT NNBI test facility has been developed firstly. It consists of a single driver RF plasma source and a negative ion accelerator. The typical extraction voltage is 4~8 kV and the acceleration voltage is 40~50 kV. In the accelerator, the grid electrodes contain plasma grid (PG), extraction grid (EG) and ground grid (GG). The PG and the EG are adopted the circular apertures while the GG is adopted the slot-type apertures. During a long-pulse beam extraction, it is found that the gas pressure in the beamline vacuum vessel has gradually increased and the temperature of the cryopump rises from ~8 K to ~20 K. Moreover, the vessel wall appears a high temperature after several long-pulse shots. The numerical simulation shows that the heat loads on the vessel wall are caused by the stray electrons ejecting from the accelerator. The stray electrons can be generated by the stripping loss of negative ions, the ionization of background gas, and the secondary emission from the grids. The slot-type apertures increase the number of stray electrons ejecting from accelerator. The location of hot spots measured by infrared thermography is consistent with the simulation result. In order to solve this problem, the electron dumps are designed to avoid the direct impinging of the ejecting electrons on the cryopump and the vessel wall. The experimental results indicate that the gas pressure is stable during the long-pulse beam extraction and the hot spots on the vessel disappear.

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