DEVELOPMENT OF TECHNOLOGY FOR FABRICATION OF PROTOTYPE ION EXTRACTION GRID FOR FUSION RESEARCH

M. R. JANA and P. RAM SANKAR

Steady state Superconducting Tokamak (SST-1) has a provision of Neutral Beam Injection (NBI) system which can deliver 1.7 MW neutral hydrogen beam power at 55 kV for heating plasma ion temperature to ~ 1 keV. Considering neutralization efficiency and beam power loss the extracted ion beam power would be 5 MW at 55 kV. This implies that the extracted ion current is 90 A which is very high and large extraction area consists of few hundreds of apertures are required. Transport of this large area beam through the beam line components are major technical challenge. Ion beam optics calculation shows that maximum hydrogen ion current could be extracted at 55 kV from 8 mm diameter single shaped aperture of 3 grid accel-decel extractor system is 116 mA for beam divergence of 1^{o}. Therefore, to extract 90A current from ion source the required numbers of shaped apertures are 774 which are accommodated in extraction area of 230 mm × 480 mm. During beam operation extractor grid received heat load of 175 w/cm^2 and the same is removed by dense network of 22 semi-circular (r=1.1±0.05 mm) cooling channels embedded between the rows of shaped apertures drilled in OFHC grid base plate of thickness 4.2 mm. The required surface flatness of OFHC copper plate is 100 µm and positional tolerance of aperture is ±60µm. Fabrication of ion extractor grid is very complex and several technology are involved e.g. Friction Welding (FW), CNC machining and copper electro-deposition. None of Indian industry has experience in these technology as a result manufacturing of extractor grid could not proceed. Due to these constraints we have initiated prototype development of ion extractor grid to establish methodology of these technology and generation of data base. Results of various prototype development are satisfactory. Friction Welding for joining of SS304L rod to actual size OFHC copper grid base plate is successfully developed. The joining strength is 264 MPa and FW joint leak-tightness is 1.5×10^{-10}T-l/s Technology for making embedded cooling channels inside OFHC copper plate by electrodeposition of copper is established on prototype grid plate which is $1/10^{th}$ of actual size. The mechanical and electrical properties of electrodeposited OFHC copper are: tensile strength is 252 MPa, micro hardness is 61 HV, electrical conductivity is 101 IACS. Machining work is carried on $1/10^{th}$ of actual size of grid plate and required various dimensional tolerances are achieved. The experience obtained during this phase of prototype development shall be useful for fabrication of actual size ion extractor grid in India.