

Development of Technology for Fabrication of Prototype Ion Extraction Grid for Fusion Research

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Steady state Superconducting Tokamak (SST-1) has a provision for positive hydrogen ion based Neutral Beam Injector (NBI) to raise the tokamak plasma ion temperature ~ 1 keV with neutral hydrogen beam (Ho) power of 0.5 MW at 30 kV. Heart of NBI system is ion extractor system which consists of three grids each made up of OFHC copper. The beamlets originating from the extractor system is focused horizontally at 5.4 mm and vertically at 7 mm to reduce power dissipation at beam line components. The required beam divergence is < 10 . For long pulse operation, active water cooling is provided by an in-laid dense network of 22 wavy semi-circular ($r = 1.1 \pm 0.05$ mm) cooling channels in the space available between the apertures. The required flatness of the copper plate is 100 μm and positioning tolerance of aperture is ± 60 μm . All these stringent requirements dictates that fabrication of extractor grid is very complex process as it involves several critical technology e.g., (i) joining of SS304L stub rod with OFHC copper grid plate (ii) precision CNC etc. machining on large size OFHC copper plate for making shaped apertures and (iii) copper electroforming for fabrication of embedded cooling channels inside thin OFHC copper plate. None of these technologies are available in India. This paper describes the work done on prototype activities to gain experience in each of the above-mentioned technology areas. Friction welding (FW) is developed for joining of dissimilar metals of SS304L rod with OFHC copper plate with joining strength of 264 MPa. Then FW on actual size of OFHC copper plate is successfully done.

Critical tolerances required for CNC machining for drilling and shaping of apertures and milling in thickness of OFHC copper grid plate of size 180 mm \times 90 mm with 19 nos. of holes and 4 nos. of wavy semicircular cooling channel.

Copper electro-deposition of 2.5 mm thickness is done on the above-mentioned prototype grid sample using technique of periodic reversal process where 20 sec electro-deposition was followed by a 4 sec reversal. Test specimens were also electro-deposited along with the prototype grid plate for testing of mechanical properties and conductivity. The conductivity was 101 ± 1 % IACS with micro hardness values 56 to 61 HV5. All these experiences shall be useful for manufacturing of large size ion extractor grid in India.

Country or International Organization

India

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