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Performance of High Heat Flux Test of Positive Ion Neutral Injector Ion Source Back Plate

M. R. Jana, S. M. Belsare, K. S. Bhope, B. Choksi, N. S. Contractor, S. S. Khirwadkar, P. K. Mokaria, N. P. Patel, T. H. Patel, R. Swamy and S. Tripathi

Institute for Plasma Research, Bhat, Gandhinagar – 382428, Gujarat, India

Email: mukti@ipr.res.in OR muktijana@gmail.com

ABSTRACT

- The Back Plate (BP) is a cathode of the PINI ion source.
- Functions of BP: Holding permanent magnets and filaments, provides vacuum integrity to the plasma box and confinement of ion source plasma
- Heat removal component of ion source: 2 MW/m^2
- Fabrication of BP has critical challenges and complex technology involved.
- As a Make in India program, we have successfully manufacture BP
- In this poster, we described the performance of high heat flux (2.5 MW/m^2) test of BP to validate the reliability during operation.

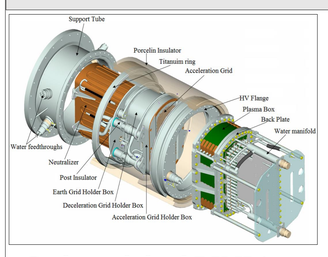
1. CRITICALITY IN THE FABRICATION OF BP

•Magnet Positioning Plate: Machining of magnets grooves and drilling holes for filament feedthroughs in SS304L plate of size 667 × 397 × 27 mm^3

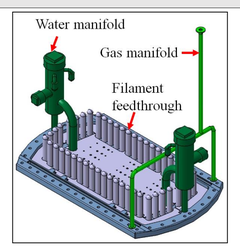
• Cooling Plate: Machining of 35 inner and 8 outer cooling grooves each of size $4^{+0.1} \times 1.8^{+0.2}$ mm^2 on OFHC copper plate of size 588 × 318 × 4 mm^3

• Large area Vacuum brazing OFHC cooling plate with SS304L magnet positioning plate.

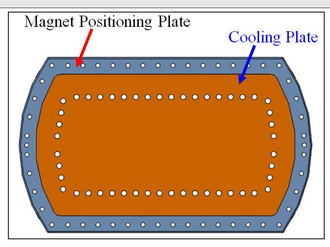
2. COMPONENTS OF PINI ION SOURCE BACK PLATE



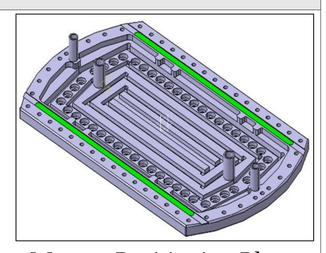
Cad model of PINI ion source



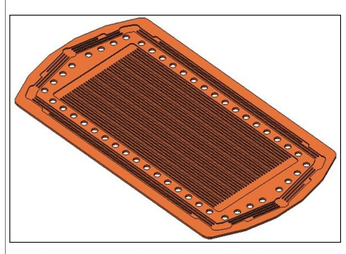
Assembly of BP



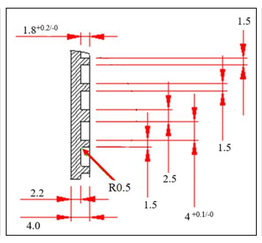
Bottom view of BP



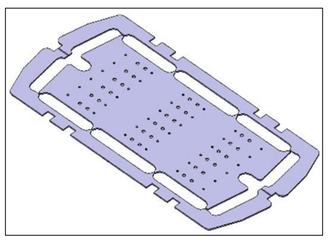
Magnet Positioning Plate (667 mm×397mm×27 mm)



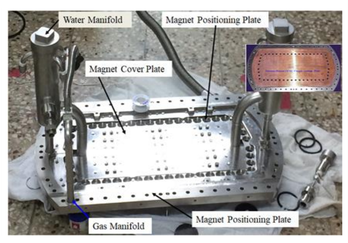
Copper Cooling Plate (588 mm×318mm×4mm)



Cross-section of Cooling Plate



Magnet Cover Plate (590 mm×293mm×2mm)



Fabricated Back Plate

3. ACCEPTANCE TEST RESULTS AT ROOM TEMPERATURE

- Vacuum brazed Joint strength: 100 MPa
- 16 bar He Pressure for 30 min
- 16 bar water pressure for 30 min
- Leak rate: 10^{-9} T-l/s

4. HIGH HEAT FLUX TEST EXPERIMENT

• *Experimental Procedure*

Helium Leak testing

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Hydro test at 8 bar for 10 min

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Helium Leak rate ~ 3.8 × 10^{-9} mbar l/s

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Mounting of PINI Back Plate in Vacuum Chamber of HHFTF along with RTD Sensors and Helium Leak testing of entire assembly including cooling line

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Target mapping with EB rastrering pattern, Thermal Diagnostics and Vacuum Pumping

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Heat Flux testing on 200 × 400 mm^2 area of PINI Back Plate at incident power up to 200 kW

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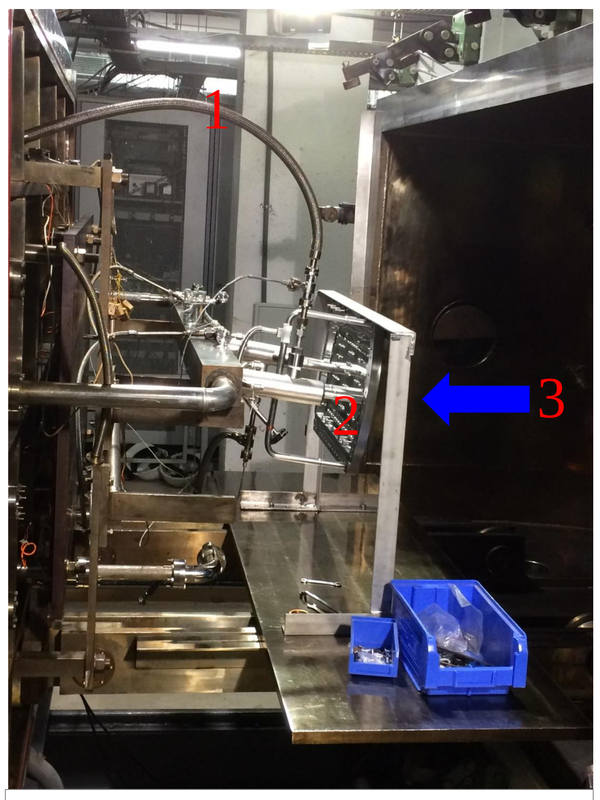
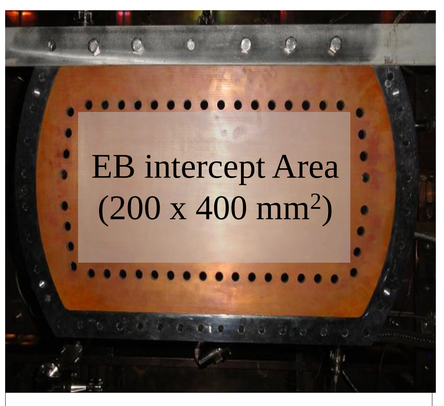
Disassembly of PINI Back Plate from HHFTF



BP is assembled inside vacuum Chamber,1: Pressurised water line, 2: BP attached with fixture, 3: EB



OFHC Copper Cooling plate before EB Test

OFHC Copper Cooling plate after EB Test

5. DIAGNOSTIC & DATA ANALYSIS

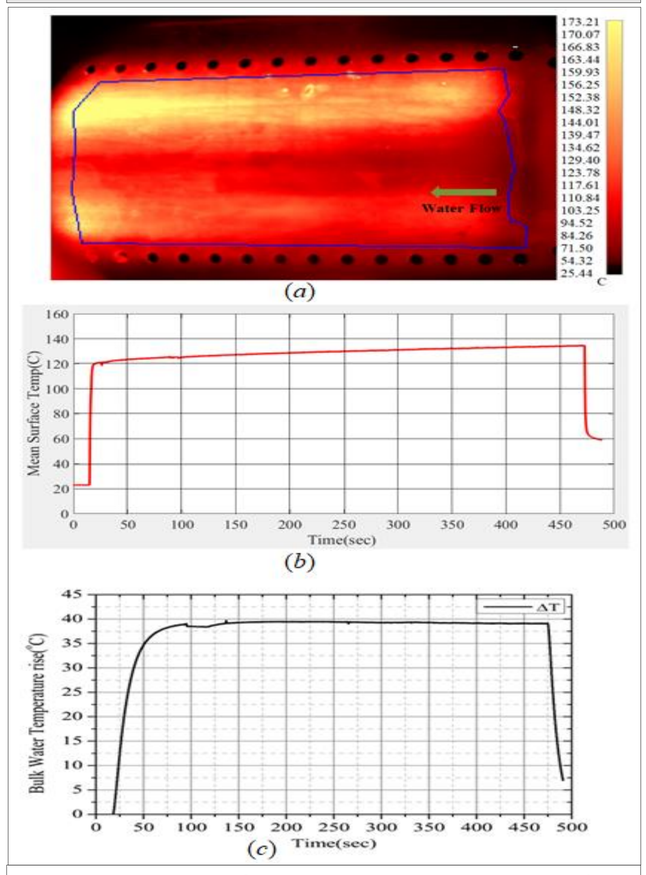


Fig.(a) IR image of cooling plate, (b) mean surface temperature of cooling plate, (c) bulk water temperature rise during long pulse (458 s) with scanned EB heat load of 2.5 MW/m^2.

6. RESULTS

- Incident Heat Load: 200 kW (Electron Beam power)
- Electron Beam Energy: 45keV
- Background Operating Pressure inside vacuum chamber: 2.4×10^{-4} mbar of Argon
- Pulse length of EB heat load: 458 sec
- Water flow rate: 60 LPM
- Water pressure: 8.2 bar
- Water flow velocity: 8 m/s
- Pressure Drop : 4 bar
- Inlet water temperature : 35^o C
- Bulk temperature rise: 40^o C
- Average surface temperature: 134^o C
- Heat transfer coefficient: 28 kW/m^2 ^{o}C
- No water leakage found during experiment

7. CONCLUSIONS

• M/s Hind High Vacuum Pvt. Ltd. Bangalore, India has successfully manufactured PINI ion source Back Plate (BP) after one failure in vacuum brazing. Acceptance tests are satisfactory.

• Performance and reliability of BP during PINI ion source operation is checked at High Heat Flux Test Facility (HHFTF) centre with Electron Beam power of 200 kW scanned over OFHC copper cooling plate for 458 sec and mean surface temperature is 134^{o}C. The bulk water temperature rise is 40^{o}C.

•High flux experiment of PINI ion source Back Plate shows that it can sustain steady heat load of 2.5 MW/m^2. Due to limitation of electron beam power we could not test for more heat load.

• Fabrication of Back plate has technical challenges in CNC machining and vacuum brazing of large area OFHC copper cooling plate with SS304L magnet positioning plate.

•Back Plate is one of critical components of PINI ion source which is manufacture in India and gives us a self-reliance for manufacturing of ion source for Neutral Beam Injection system for fusion research.

8. REFERENCE

P. K. Jayakumar et al, Fusion Technology 1 (1998) 419 - 422.