A.4: Development of OFE-Copper RF cavity for Indus-2

Indus-2 RF cavities at 505.8 MHz procured from foreign sources has been in use since 2004. With requirement of additional RF cavities for operation of insertion devices in the Indus-2 ring and to cater to aging issues of RF cavities, indigenous development of RF cavity was taken up as per the mandate of RRCAT. This will also provide spare RF cavities needed for round the clock operation of Indus-2.

A special work group was formed with experts from all the related activities in RRCAT for development, installation and deployment of RF cavities in Indus-2. After the physics design of RF cavity with existing beam dynamics requirement and available space in Indus-2, the dimension, shape and profile of RF cavity was finalised. After discussion, between two possible routes it was planned to manufacture the RF cavity with existing brazing facility in RRCAT. The mechanical design and steps of fabrication were finalised. Starting from basic raw material like oxygen free electronic (OFE) copper plates and bars, all the components were machined in our own workshops. Forming of two halves shells was done. Fixtures were developed for machining of inner profile half shells with varying wall thickness and outside grooves for vacuum brazing of cooling tubes.

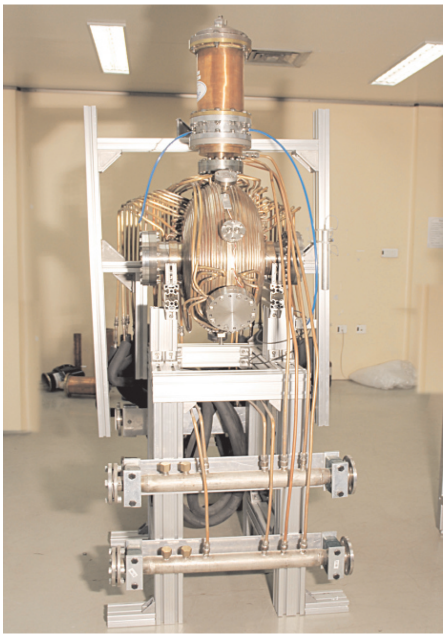

Fig. A.4.1: Fully fabricated RF cavity with Power coupler sensing couplers and cooling circuits.

Vacuum Brazing was carried out in four stages followed by some torch brazing and TIG welding to realize the cavity in final shape. Strict tolerance control on all brazing surfaces and geometrical accuracy within 0.25 mm on inner profiles was achieved. Alumina abrasive polishing followed by chemical processing was carried out to achieve high surface finish (Ra 0.25 µm) and cleanliness on inner surfaces of the cavity, compatible to high RF fields and ultra-high vacuum. No crevice or pockets on the joints was left and all excess silver brazing alloy was removed afterward. The most challenging part of development of RF cavity was conceiving of precision brazing fixtures and process planning for all the four stages. The largest joint (faces of two half shells) of mean diameter 530 mm and 20 mm wide, ten ports with copper to SS transition and Ø70 to Ø203 CF flanges in different orientation, 42 nos. of Ø10 mm cooling tubes were brazed successfully using the precision fixture in the vacuum furnace. Fully fabricated RF cavity is shown in Fig. A.4.1. All joints were leak tested up to of 5×10^{-11} mbar-litre/sec.

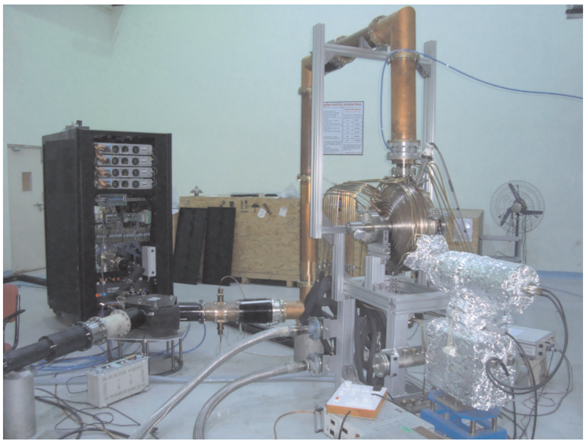

Fig. A.4.2: High power test set up for RF Cavity.

A high power RF input coupler consisting an alumina ceramic window and water cooled inductive loop is also designed and fabricated. Several pick up loops and antenna insertions are needed for sensing RF signals for RF control and diagnostic purposes were also designed and fabricated. After fabrication and vacuum leak testing baking of the cavity was performed by flowing hot water at 150 °C at 6 bar pressure through all the copper tubes for 36 hours. After cool down a vacuum level of 2×10^{-9} mbar in the cavity was achieved. Conditioning & high power test was carried out in a high power test set up installed in RF building as shown in Fig. A.4.2. RF power was delivered initially in pulsed mode up to the maximum available peak power followed by a gradual transit to CW mode maintaining a safe threshold vacuum level in the cavity avoiding multipaction and keeping RF power reflections and oscillations at minimum. Ultimate pressure of 4×10^{-10} mbar was achieved after RF conditioning. Net RF power of 33kW (CW) was delivered to the cavity successfully meeting the consistent operational requirements of Indus-2.

Reported by:
R. Kumar (ramesh@rrcat.gov.in), and M.R. Lad
On behalf of Indus-2 RF cavity development team