INTRODUCTION

IFMIF-EVEDA (Engineering Validation Engineering Design Activities) project has been launched as part of the Broader Approach to Nuclear Fusion agreement, with the goal to produce the detailed design of the entire IFMIF (International Fusion Materials Irradiation Facility) project, as well as to build and test a number of prototypes, including a high-intensity CW deuteron accelerator. INFN, mainly through its LNL labs, Padua and Torino sections, will design, build and perform beam tests of the high intensity deuteron RFQ [1]. The RFQ will be installed at Rokkasho (Japan), as the main accelerating structure of the IFMIF prototype accelerator sketched in figure 1 (9 MeV 125 mA). The other elements of the Accelerator System, namely the ion source (ECR kind), one superconducting linac cryomodule, the RF system, the beam transport lines and the beam dump, are provided by the other two European partners, CEA (France) and CIEMAT (Spain).

THE PROTOTYPES

The Detailed Design Review of the RFQ took place in January 2010, with the validation of the design choices and the start of the construction. As part of the design justification different prototypes have been built and validated during 2009. The low power full scale RF model (approx. 9.8 m long) has been built to validate the tuning with single cavity configuration. The prototype was delivered in March and the tuning disposition and tuning algorithms were demonstrated with bead-pulling measurements (see figure 2) [2]. The construction of a technological model, corresponding to two brazed modules, is under way. The machining of the first module, mainly performed in house (Padova and Torino sections) has been concluded (see figure 3) within the end of the year and the brazing at CERN followed in winter 2009 with very positive results concerning the attainment of geometrical tolerances (see figure 4).
In the thermal test facility, equipped by Padua group in a clean room of LNL, the cooling channels effect has been simulated using the rough machined blocks of the second part of the technological model. In particular the heat coefficient of the smooth vane channel and of the threaded cooling holes on cavity wall was measured using ohmic resistors and an infrared camera for the temperature evaluation.

Finally a cooling skid prototype, corresponding to 1/3 of final system (300 kW power), able to control two independent circuits for the frequency tuning using the temperature difference between vanes and wall, has been designed at LNL and delivered in December 2009.

The design specifications and geometrical definitions of the RFQ cavity were reported last year and are confirmed (see figure 6). The cavity is now formed by 18 flanged modules, approximately 550 mm long showed in figure 7. The modules are assembled in three super-modules, separately aligned and belonging to separate cooling system circuits. The vacuum system is organized in 10 independent units, each using two gridded vacuum ports on the cavity; the nominal design foresees cryogenic pumps, but an alternative approach based on turbo-molecular pumps is under evaluation [3].

The main changes in the mechanical design of the cavity concern the cooling ducts lay out (i), the vacuum port geometry (ii) and the design of the vacuum and mechanical coupling of the modules (iii).

After the experimental results with threaded channels (M14) this option was at the end abandoned and the final design of the cavity foresees 28 smooth channels, 12 along the vanes, 16 on cavity walls for the removal of approximately 800 kW. The regulation of the temperature difference between these two families of channel allows the necessary ±100 kHz tuning of the RFQ frequency.

The vacuum port is made directly on the copper bulk of the RFQ, and the grids’ structure (width and transparency) is a compromise between pumping, RF detuning and heat removal efficiency. The volume compensation necessary to tune the cut off frequency is provided via the thickening of the vane base “w”, thus avoiding increasing the components stock during the pre-machining phases (figure 3).

Finally it was decided to de-couple the vacuum tightness flange and the mechanical coupling flange due to the relevant transversal dimensions of the cavity resulting on a very large diameter for a unique stainless steel bolted flange. The vacuum tightness is obtained by squeezing a bimetallic DELTA Helicoflex® joint on two symmetrical stainless steel flanges brazed on a groove of the cavity module ends.

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