MECHANICAL DESIGN, FABRICATION AND INITIAL TESTS ON PROTOTYPE DRIFT TUBE LINAC AT IUAC

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Abstract

The Drift Tube Linac (DTL) project is a major subsection of High Current Injector project at Inter University Accelerator Centre (IUAC). It has been designed to accelerate ions from 180 keV/u to 1.8 MeV/u, using six IH type RF resonators operating at 97 MHz [1]. The required output energy of the DTL is decided by the minimum input velocity of nearly 6% of velocity of light, required for the existing superconducting LINAC. IH type resonators are the preferred choice for multiple gap DTL applications due to their high shunt impedance values. The mechanical design and CNC machining of parts and assembly of DTL were carried out at IUAC to validate the electrical design..

INTRODUCTION

Based on the electrical design, IUAC's first DTL tank is 84.5 cm in diameter and 38.7 cm in length with 11 gaps. All the solid modelling was done using Solidorks and design was verified for structural and cooling using Ansys12.0. The strategy we adopted was to prototype all the DTL structures closest to the original design and to validate them by conducting various tests. Only after validating the required parameters successfully proceed for the actual manufacturing of the parts on expensive copper material. Table 1, gives details of all DTL resonators required.

Tank #	Cells	Length (cm)	E Out (MeV/U)
1	11	38.5	0.32
2	13	73.4	0.55
3	13	94.4	0.85
4	11	86.5	1.15
5	11	99.2	1.46
6	9	81.6	1.80

Table 1: Specifications of Drift Tube Linac

PROTOTYPING

Prototyping Attempt - 1

In order to have understanding of the manufacturing technology and skill we made the first prototype tank with stainless steel and welded explosively bonded Cu-SS material near the high current density areas of ridge base and end plates. Ridges and Stems were made of aluminum to do quick CNC machining of the parts in - house. During assembly and test we found that there were leaks in the bonding as well as on the aluminum casting of the Ridges. With this first prototype tank we carried out bead pull test and frequency measurements etc, whose results were satisfactory as reported earlier. Figure 1 shows the first prototype tank.

Figure 1. Prototype Tank # 1

Prototyping Attempt - 2

We further modified the tank by avoiding bonded and cast materials, with modified ports as per our first DTL tank. In this prototype tank the end plates and ridges were made of low carbon steel to check the electroplating capability. Provision for additional cooling has been made by designing water sump near bottom side ridge base. The machined components were assembled in the second prototype tank, and again carried out low power RF tests.

A simple coaxial coupler was designed and installed in this tank. High power RF tests were done at 2.5 kW. Due to problem in RF amplifier we could not carry out rf test at higher power levels. All the results were satisfactory. By doing these exercises, got expertises in assembly, frequency correction by machining and cooling solutions. Presently this tank is ready to go for electroplating and after that we plan to do the high power test using couplers and tuners. Eventually this tank will be used as our test tank to do testing of couplers, tuners.

MANUFACTURING OF FIRST DTL TANK

Fabrication of the first DTL resonator is presently underway at vendors site in Canada. The tank is made out of forged cylinder of low carbon steel with wall thickness of 3.8 cm. End plates are made of solid copper having 3.0 cm thickness. The tank was tested for vacuum and found a deflection of 0.4mm during the evacuation. Tank was copper plated as per the RF requirements. Ridge base was machined after electro plating to get a flat and parallel surface. Meanwhile we fabricated copper ridges and stems for this tank at IUAC. Machining allowance of 1.5mm is provided on the stems for alignment. The assembly and power testing of the tank will be done after testing all the elements in the test tank. Figure 2 shows the tank during machining and before copper plating at vendors site.

Figure 2. First DTL tank during vacuum test

FABRICATION EXPERIENCE

Machining

It was decided that all the internal parts shall be made in at IUAC using in house CAM and CNC facilities of workshop. This made prototyping and modification faster and efficient. Special attempt was made for cooling of the tanks as well as the end plates. Stiffeners are provided to minimize the deflection. We have fabricated both cylindrical and flat type ridge bases. Tanks were also fabricated to mount the ridges with cylindrical and flat surfaces. Cylindrical base ridge has advantage that we can avoid machining of tank ridge base after copper plating.

Assembly

For assembly we used assembly fixtures as well as portable arm type CMM. The stems are bolted with ridges at their final locations and we achieved alignment accuracy better than ±50 microns. O-ring seals were made to seal the water channels. Fully assembled resonator was then vacuum leak tested at leak rate 10^{-9} mbar-l/sec. Bal seals are provided on the tank to end plate joints for the better RF conductivity.

CONCLUSION

Beam dynamics for the DTL has been optimized for the desired energy range. Electromagnetic design of the IH structure has been done and verified by making measurements on a full scale prototype fabricated. The frequency and voltage distribution results are in agreement with the calculations.

REFERENCES

[1] B.P. Ajith Kumar, J. Zacharias, R.Hariwal, R.Mehta & C.P.Safvan, "Beam Optics and Resonator Design for the 97 MHz DTL at IUAC", InPAC 2009, RRCAT, Indore