DTL CONSTRUCTION STATUS OF CSNS PROJECT

H.C. Liu[1,2#], S.N. Fu[1,2], J. Peng[1,2], S. Wang[1,2]
[1] China Spallation Neutron Source (CSNS), Institute of High Energy Physics (IHEP), Chinese Academy of Sciences (CAS)，Dongguan 523803, China
[2] Dongguan Institute of Neutron Science (DINS), Dongguan 523808, China

Abstract

The 324MHz Alvarez-type Drift Tube Linac (DTL) for the China spallation neutron source will be used to accelerate the H^- ion beam. It can provide 15mA peak current beam with energy gain from 3 to 80MeV. It consists of four independent tanks, of which the average length is about 8.6 m. Each tank is divided into three short unit sections for ease of fabrication and assembly. A hollow coil based electromagnet is accommodated in each drift tube for its compact structure. So far, the machining of all 12 tanks is completed; nine of those tanks are successfully electroplated. The ultimate vacuum and RF properties tests are successfully performed. The fabrications of 63 drift tubes for the first tank are also finished and about to install in CSNS site. The fabrication and test details are presented in this paper.

INTRODUCTION

The China Spallation Neutron Source (CSNS) Linac mainly consists of an H^- ion source, a LEBT, a 3 MeV RFQ, a MEBT and an Alvarez-type Drift Tube Linac (Figure 1) [1]. It will be constructed and tested until 2016.09. Main components of DTL are now under construction. We are scheduled to start the installing of 1st tank from September this year.

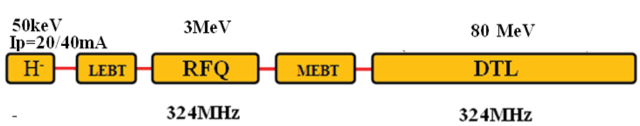

Figure 1: CSNS Linac layout.

DTL TANK

The tank is a vacuum vessel that provides a mechanically stable platform for the array of drift-tube assemblies, post couplers, and slug tuners. The tank also provides support and interfaces to the RF system, the cooling system and the vacuum pumping system. Each tank is equipped with 2 movable tuner and 12 fixed tuner equally distributed over the bottom of tank body. There are twelve straight water cooling channels embedded into the tank out-wall. An iris waveguide coupler was used to feed the power due to its simple structure, good power handling capability, small frequency perturbation in the cavity. The tank will operate in a sufficiently high vacuum for RF environment by using two 1000L/s ion pumps and 1 turbo-molecular pump for each unit tank (Figure 2).

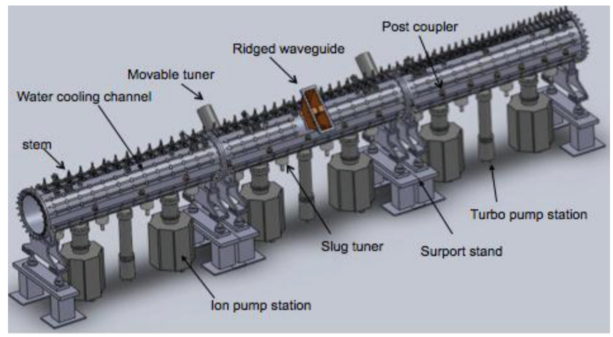

Figure 2: general drawing of DTL tank.

Tank Fabrication

For ease of fabrication, each DTL tank assembly is divided into 3 unit sections which can be bolted together to form one long assembly. Each tank section is approximately 3 meter long and is fabricated from 20# carbon steel. The machining of CSNS DTL tank is finished and the mechanical dimensions of each tank are measured. The length tolerance is -0.1to -0.3mm and the radius tolerance is within ± 0.1mm.The measured holes position precision is less than ± 0.1mm.

Figure 3: Tank fabrication.

Tank Copper Plating

Each DTL tank section was Copper plated to increase the electrical conductivity of the tank RF surfaces. The inner surface of the tank is copper plated in 200-250 μm thickness (Figure 4). We polished mechanically the surface after plating in order to satisfy the Ra 0.4 μm roughness. Up to now, 9 out of 12 CSNS DTL tanks have been electroplated. Including preparation and post treatment, each tank section is plated in approximately three weeks.

liuhc@aps.anl.gov

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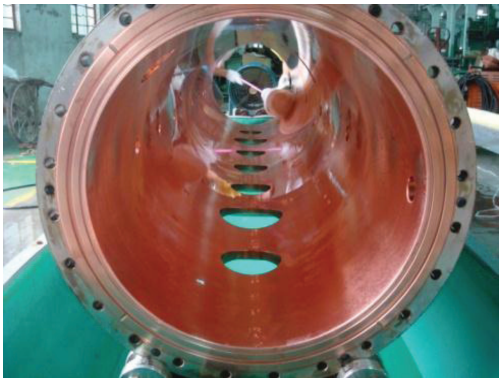

Figure 4: plated tank inner-view·

In order to check the adhesion between plating and basement, the tank was baked out and pumped (Figure 5). The ultimate vacuum pressure can reach $2*10^{-6}$Pa after 72 hours baking and 24 hours pumping with two ion pumps operation. Polishing and brush plating are needed in case of some defects occurred on the tank inner surface after baking and vacuum test.

Figure 5: bake out of DTL tank.

The RF properties of DTL1-1 are measured by using network analyser. All holes on the tank out wall are covered by copper plated plugs. The flat copper plated aluminium endplates are used for the measurement. The unloaded Q-value for TM_{010} mode is 90% of the calculated value.

Table 1: Q_0 of TM_{010} Mode for DTL1-1.

Tank No.			freq.(MHz)
DTL1-1	70099(78023)	90	405.03

Drift Tube

Each drift tube assembly is comprised of a body and stem. The DT shell and stem are made of oxygen free copper and cooled via the supporting stem. The fabrication process is complex and time consuming accompanied with a series of tests. All joints of the DT and the stem (34 mm in diameter) are welded by the electron beam welding (EBW).The space around the magnet in the DT is filled with the epoxy resin by a vacuum impregnation method.

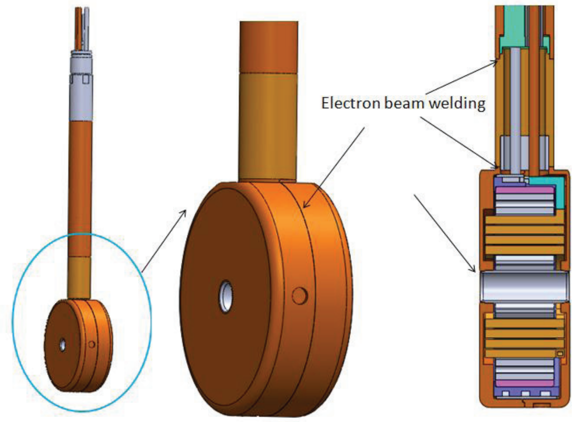

Figure 6: View of a typical Drift tube.

Figure 7: mechanical dimension measuring by three-coordinate measuring machine.

The accuracy of DT mechanical dimension is rather high, and the final DT profile is finish milling using NC milling machine to guarantee the size tolerance. Three-coordinate measuring results show that most of the machining tolerance is less than 20μm.

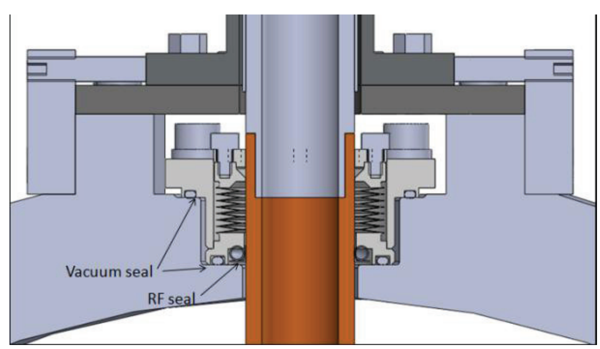

Figure 8: schematic layouts of DT stem assembly.

The drift tubes are mounted on a single port and their positions can be adjusted individually. The junction suppleness is provided by OFHC copper bellows. We chose elastomeric o-ring as vacuum seals and copper plated metallic spring as RF seals for the drift tube (Figure 8).

Electro-magnetic Quadrupoles

We adopted an electroformed hollow coil, the SAKAE type coil which has no bending radius, for its compact structure (Figure 9) [2]. The wire cutting and the Periodic Reverse (PR) copper electroforming method are applied to the coil manufacture process.

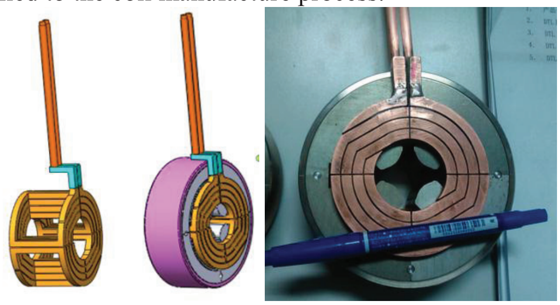

Figure 9: View of hollow coil and magnet.

After EMQ and DT assemblies, the deviation between the DT mechanical centre and the EMQ magnetic centre is measured by a rotating coil measurement system (Figure 10). The DT mechanical centre shift is modified using finish-milling based on the measurement result. Figure 11 shows the measured position of the quadrupole field centre from the mechanical centre defined by the excircle of the DT. It can be found that most of the deviations fall into the tolerable area ±30 µm. This deviation is small enough for our physical requirement. Besides, the higher-order multi-pole components are less than 0.3%. Furthermore, the rotating angle between EMQ and DT around longitudinal direction is also monitored during the fabrication process by using laser reflection principle and taking advantage of the rotating coil system. The rotating angle for all 63 DTs of DTL1 has a good consistence of less than ±3mrad.

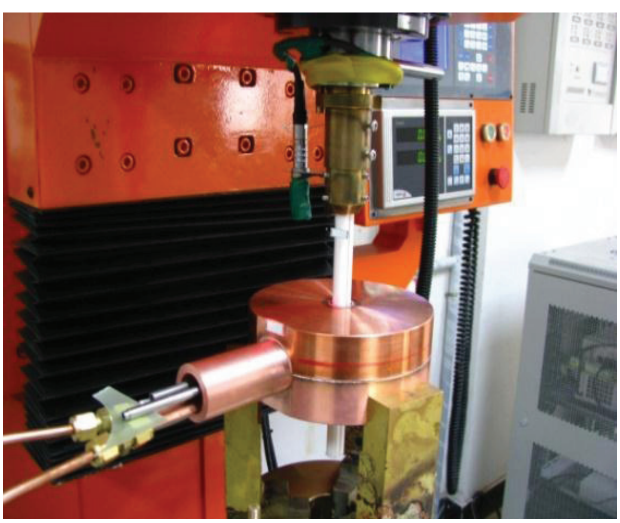

Figure 10: rotating coil measurement

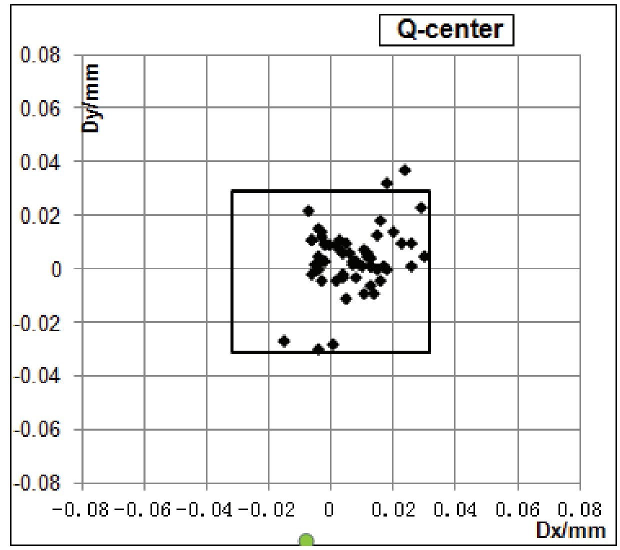

Figure 11: Deviation of the mechanical centre from magnetic field centre.

CONCLUSION

The construction of CSNS DTL is now in progress and several tests for cavity and drift tube are well performed. So far, the fabrication and measurement for 63 DTs of DTL tank1 are finished. In the meanwhile, tank machining has been finished and the copper plating on the tank inner surface is partially done. The DT assembly for DTL1 is scheduled to start in September 2014 and accordingly the commissioning of DTL1 is expected at the middle of 2015.

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