MANUFACTURING OF THE MAIN ACCELERATOR WITH TESLA-LIKE 9-CELL SRF CAVITY AT PEKING UNIVERSITY *

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Abstract

Peking University is striving for constructing a superconducting radio-frequency accelerator test facility (PKU-SETF) to provide coherent radiations [1]. A cryomodule consisting of a China made 9-cell TESLA type cavity was designed and constructed for this purpose, which is expected to provide 15-20 MeV energy gain at an operating temperature of 2K. Some technical issues in the manufacturing progress are reported, including the tungsten inert gas (TIG) welding of the LHe vessel and the superconducting cavity, the demagnetization of the vacuum vessel made of pure iron, and the manufacturing of the main power coupler.

INTRODUCTION TO THE MAIN ACCELERATOR FOR PKU-SETF PROJECT

To provide coherent radiations, the PKU-SETF was initiated by the PKU-SRF group as a mid-term goal [2]. It consists of a 5 MeV DC-SRF injector and 20 MeV main accelerator; the beam transport loop with two arcs is designed to match with the main accelerator. An undulator and a chicane are inserted in the loop to produce 4-8 micron laser light. The PKU-SETF will be implemented in 3 steps, to provide from THz radiation to IR laser through undulator and optical cavity, and high flux X-ray through Compton backscattering.

The core part of the accelerator is a home-made 9-cell TESLA type cavity [3], as shown in Fig. 1. It is made of fine-grian niobium from OTIC with RRR 300, and fabricated according to DESY specification. By cooperation, the cavity was tested at JLab and achieved a preliminary result of 23MV/m.

Figure 1: The home-made 9-cell TESLA type cavity.

The structure of the main accelerator is shown in Fig. 2. The cryomodule consists of the cavity, cryogenic system, main coupler, tuner, supporting and suspending structure, and vacuum vessel. The accelerator will be commissioned at 2K after helium liquefier system produced by the Linde Company is ready. The designed parameters of the accelerator are shown in Table 1.

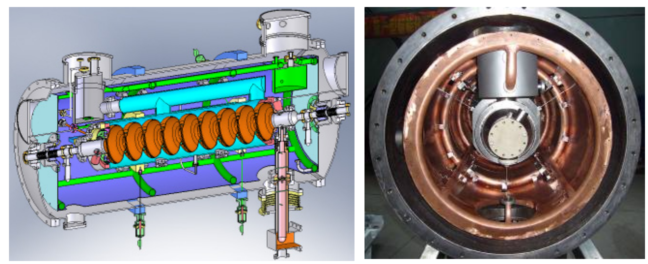

Figure 2: Schematics and side view of the main accelerator

Table 1: Designed parameters of the accelerator

RF frequency	1.3 GHz
Accelerating voltage	17 MV
Bunch charge	20 ~ 50 pC
Electron beam average current	1.6 ~ 4.0 mA
Macro pulse length	2 ms
Rep. frequency of macro pulse	10 Hz
Energy spread (rms)	0.24%
Transverse emittance (rms, n)	~ 3 μm
Cryogenic losses (stand-by)	12W at 2K

TIG WELDING OF THE LHE VESSEL AND THE CAVITY

The transition part of the cavity made of NbTi was TIG welded with the LHe vessel made of Ti, while two rings and a bellows made of Ti were also welded as the alignment structures. The whole welding process was carried out in a glove box filled with argon, which was shown in Fig. 3; the oxygen content in the gas could be control under 0.06%.

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Figure 3: The glove box, and the seams to be welded

DEMAGNETIZATION OF THE VACUUM VESSEL

As magnetic field would be trapped in Nb during NC-SC phase transition to cause residual resistance, the geomagnetism field should be shielded under 20 mGs for residual resistance lower than 7 nΩ. In our accelerator, the vacuum vessel made of pure iron (trademark DT3) serves as the single magnetic shielding. As calculated by CST 2008, the maximum magnetic field on the axis is 5 mGs if the vessel is 8 mm thick and positioned perpendicular to the geomagnetism.

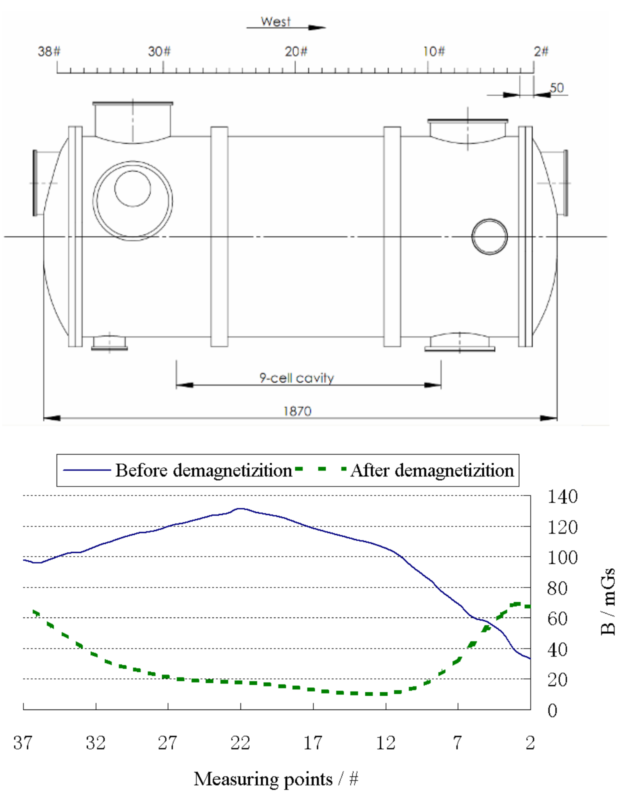

Figure 4: Magnetic field on the axis (EW direction).

Though, machining process caused degradation of the permeability, as well as magnetization of the whole vessel. The measurement right after machining showed that the max magnetic field was more than 130 mGs. So an AC demagnetization with Bmax of 1.6 T was applied to the vessel and the covers; this progress had decreased the magnetic field to 20 mGs, as shown in Fig. 4.

MANUFACTORING OF THE MAIN POWER COUPLER

The design of the main coupler is based on the capacitive coupler of KEK [4][5]. It consists of four parts that sealed by flanges between each other, as shown in Fig. 5. The most outstanding properties of the coupler are the low stress on the ceramic window and the feasibility to assemble and maintain.

Figure 5: Components of the main coupler.

The geometry of the coupler was optimized and a frequency bandwidth of 50MHz with voltage standing wave ratio (VSWR) < 1.1 was achieved. The designed static heat load at LHe system is 0.8W, and the temperature of the cold window is supposed to be lower than 200K.

The inner conductors are made of OFHC copper, and the outer conductors are made of stainless steel plated with Cu; the cold window is made of 95% alumina covered by TiN. The whole coupler has been finished, and will be tested soon.

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