

ELECTROMAGNETIC AND MECHANICAL DESIGN OF HIGH GRADIENT S-BAND ACCELERATOR IN TTX

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Abstract

Thomson scattering x-ray source is an essential scientific research tool in x-ray imaging technology for various fields. Upgrading plan of replacing the 3-meter S-band linac with a shorter structure operating at higher gradient in Tsinghua Thomson scattering X-ray source (TTX) is undergoing so far, aiming to enhance the accelerating gradient from 15 MV/m to 30 MV/m. Detailed parameters of couplers and mechanical design of acceleration structure are presented in this work.

INTRODUCTION

The Advanced X-ray sources, including X-ray free-electron-lasers facilities and Thomson scattering facilities, are widely used in many research area such as molecular biology and material sciences. In Tsinghua University, the compact Thomson x-ray scattering (TTX) source facility had been built. The energy of the electron beam is 50 MeV. The current beam line layout of TTX is presented in Fig. 1 (a), the details of parameters are described in ref [1].

We are now planning to upgrade the beam energy of TTX to 150 MeV. As shown in Fig. 1, two X-band accelerating structure are used to boost the energy. Due to the limitation of space in the bunker, the currently operated S-band structure must be replaced by a short one. The accelerating gradient of the new S-band structure is higher in order to keep the same the beam energy of 50 MeV before the X-band system is ready.

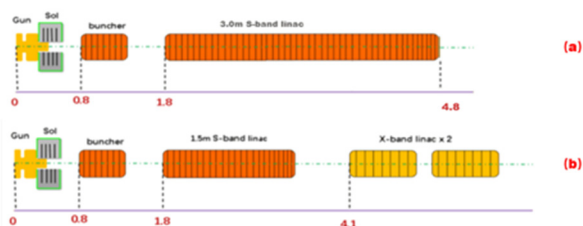


Figure 1: Present linac layout and upgrade proposal.

The new S-band travelling wave structure is designed to working in $3\pi/4$ mode. The design parameters of the structure had been previously described in refs [2] and [3]. In this work, we will present the design of input/output couplers and the full tapered structure.

ELECTROMAGNETIC DESIGN

The parameters of the S-band TW structure without couplers had been revised from the initial version described in ref [2]. The updated parameters are shown in Table 1.

Table 1: Parameters of S-band TW Tube

Parameters	Value
Frequency	2856.00MHz
Phase advance per cell	$3\pi/4$
Length	1.456m
Cell numbers	37
Period	39.36mm
Iris half aperture	10.22mm~8.13mm
Cell radius	42.53mm~42.17mm
Elliptical iris long axis	9.54mm
Elliptical iris thickness	5.3mm
Filling time	923ns
Group velocity (v_g/c)	0.00724~0.00302
Shunt impedance	66.2M Ω /m~72.0M Ω /m
Input power	30MW
Gradient	31.5 MV/m~29.9MV/m

Coupler Design

The dual-feed input and output couplers had been designed, as shown in Fig. 2. Dimensions of the geometry were carefully tuned in order to achieve the good matching state for the power feeding, as shown in Fig. 3.

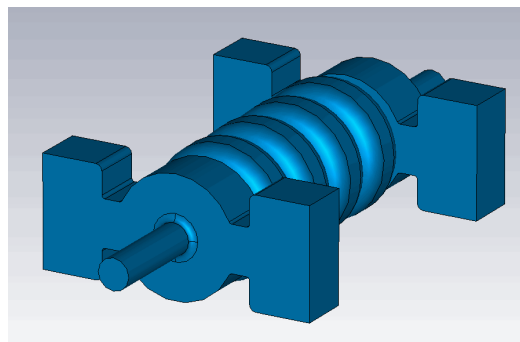


Figure 2: Individual coupler model with four cells.

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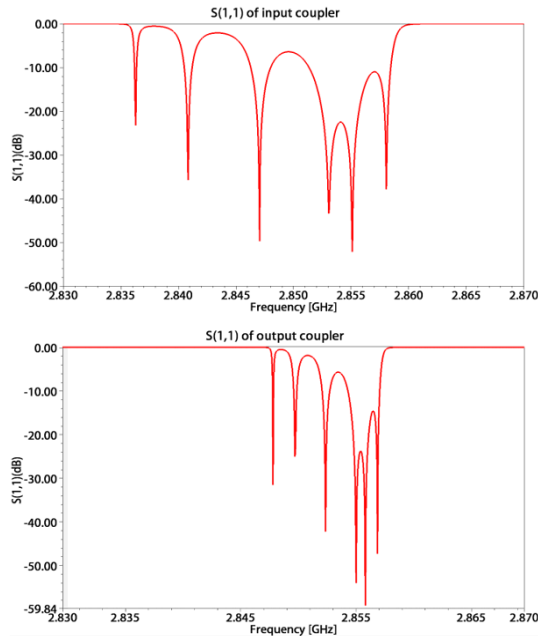


Figure 3: Reflection of the input and output couplers.

Full Structure Design

The whole S-band accelerating structure are showed as Fig. 4.

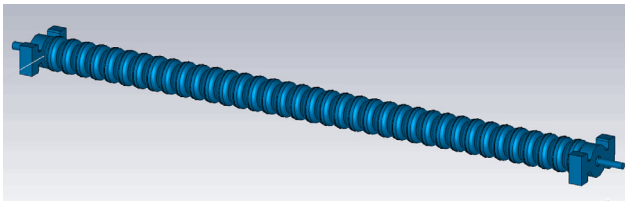


Figure 4: Completely electromagnetic model of S-band TW tube.

Stimulating the electromagnetic field along the axis and draw the amplifier and phase, as shown in Fig. 5.

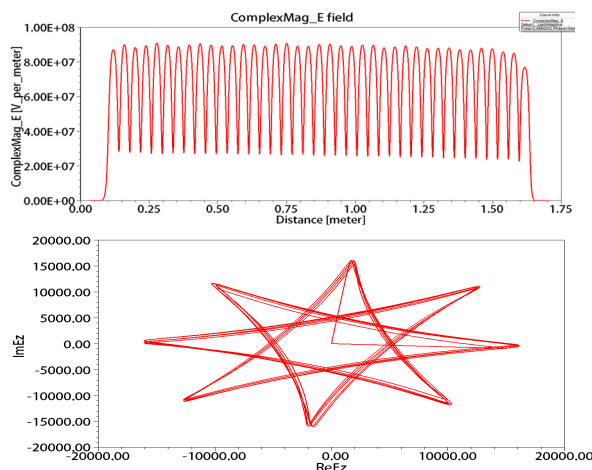


Figure 5: simulation results of amplifier and phase in accelerating tube with couplers.

MECHANICAL DESIGN

Half Cavity Design

The S-band accelerating structure will be machined piece-by-piece and brazed together. As shown in Fig. 6, each piece contains the geometry of one full iris and half of the cavity cells in both side.

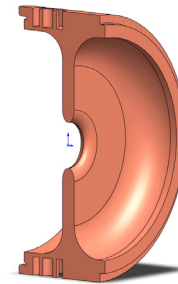


Figure 6: Mechanical model of individual cavity design.

Coupler Design

At the beginning and ending of accelerating tube, different structure had been designed because of individual cavity design for input coupler and output coupler, as shown in Fig.7.

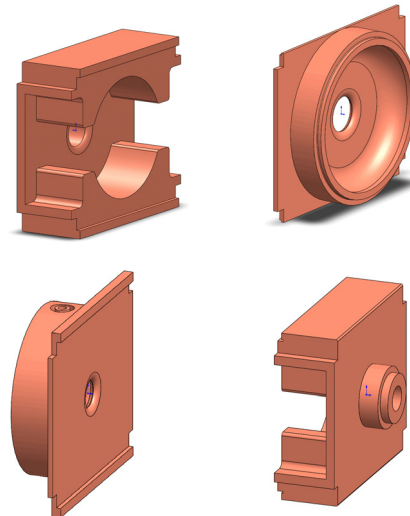


Figure 7: Mechanical design of input/output couplers.

Whole Structure Design

Figure 8 shows the geometry of the full S-band structure. Tuning pins are utilized on each cell to correct the cell frequency. External cooling water lines will be weld on the structure wall and split for 12 sections suited for manufacturing requirement.

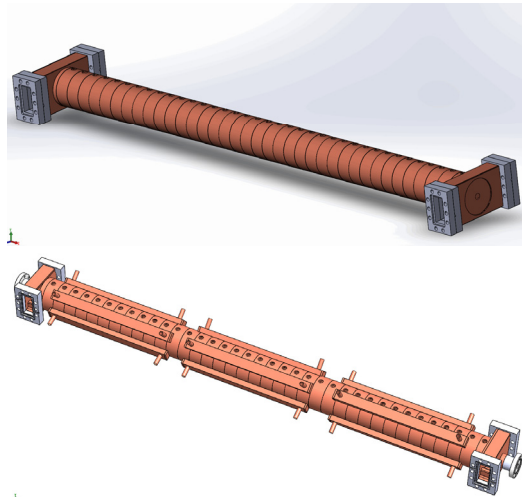


Figure 8: Mechanical design of the full structure.

CONCLUSION

The initial design of S-band TW tube with 1.5m length is finished. Mechanical drawing design are in progress and will be fixed continuously. Manufacturing procedure will be carried out in the near future.

REFERENCES

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