DESIGN OF A 2MEV X-BAND SIDE COUPLED ACCELERATING STRUCTURE *

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Abstract

An X-band bi-period side-coupled accelerating structure has been designed in this paper. The structure's working frequency is 9.3GHz. π/2 mode is chosen for the structure's stability. There are 11 accelerating cells, the first 5 work as non-light velocity part while the other 6 work as light velocity part. After CST simulation, the coupling constant between accelerating cells and coupling cells is 5%, efficient shunt impedance is 142MΩ/m. For the beam dynamic analysis, the particle energy is selected to be 2 MeV and the peak current is 60 mA for the radiation dosage limits by national standard. After Pamela optimization, the particle's capture efficiency is more than 30%. To feed power into the structure, a coupler is designed in the middle of the structure and the coupling coefficient is 1.4. The structure is manufactured and the measurement result accords well with designing value.

INTRODUCTION

Linear accelerators has been improved a lot since it was first invented in 1928. And nowadays it can be classified as mainly 2 kinds of them: traveling wave accelerators and standing wave accelerators. Both of them are widely used in industrial and civil area.

Nowadays, accelerators are developed to be smaller, compact and portable for industry inspection, customs detection, and cancer treating.

In recent years, portable X-band side coupled structures have been successively designed and proceeded all over the world such as America, Japan and Europe [1]. And still, there is no X-band side coupled structure designed in China yet, though an X-band axis coupled structure has been designed by Tsinghua University [2].

So we start to design a portable X-band side coupled accelerating structure which can be used in industrial and medical accelerators.

Table 1 shows the main parameters of the structure.

Table 1: Main Parameters of the Structure

Parameters	Value
Energy/MeV	2.0
Operating frequency/GHz	9.3
RF source	Magnetron
Peak current/mA	60
Input RF power/kW	320
Length of accelerating tube/cm	15
Coupling between cells	5%

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Structure Design

For a single cell, both accelerating cells and coupling cells are axial symmetry, we use Superfish to design each single cell.

Figure 1 shows the accelerating cell's design, respectively for the cell β=0.4 and β=0.95.

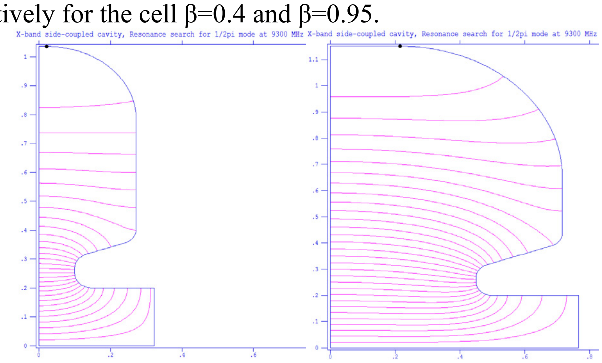

Figure 1: Accelerating cells β=0.4(left) and β=0.95(right).

After optimization, each single cell will work at 9.3GHz while the efficient shunt impedance of accelerating cell is about 140MΩ/m.

When the accelerating cell coupled with coupling cell, the structure is no longer axis symmetric. We use CST program for the design.

Figure 2 shows the basic period of the structure, working at 0 mode, π/2 mode and π mode, respectively.

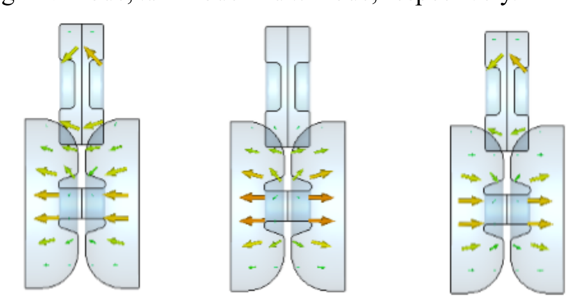

Figure 2: E-fields of 0 mode (left), π/2 mode (middle) and π mode (right)

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Coupling constant k_0 is chosen to be 5%, while the shunt impedance decreases by 17% compared to before it is coupled.

And after optimization, the stop band is closed at 9.3GHz.

A race-track shaped coupler is designed for the structure to input RF power. The coupler is chosen to be at the middle of the structure. Considering the beam loading effect, coupling factor β is chosen to be 1.4 which is over coupled.

Figure 3 shows the E-field along the axis of the structure with the coupler working at $\pi/2$ mode.

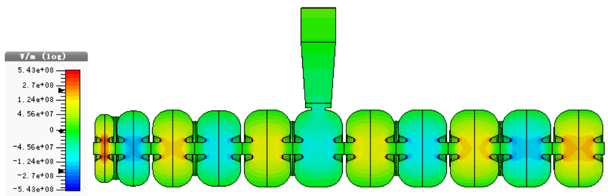

Figure 3: E-field along the axis of the structure.

Beam Dynamic Analysis

The RF fields of the 11 accelerating cells can be extracted from Superfish to Parmela for the beam dynamic analysis. In the simulation, the beam energy is 17keV and beam current is 60mA.

Figure 4 shows particle energy along the structure. The particle energy at exit gets 2.17MeV, which accords with the designing value

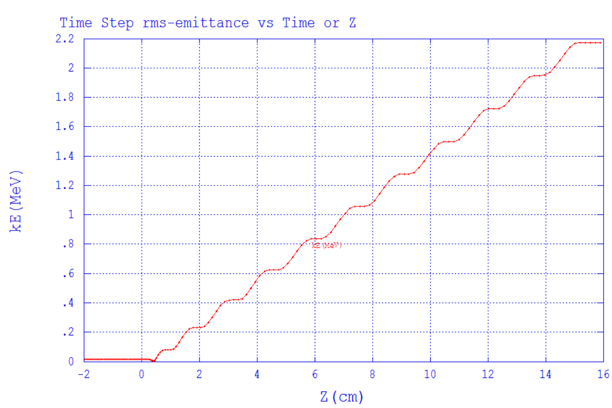

Figure 4: Particle energy along the structure.

Figure 5 shows the beam dynamic result at the exit. When the particle phase is 230°, the capture efficiency is above 30% and energy spectrum in 10% gets to be 76.5%. The results can be acceptable for our designing.

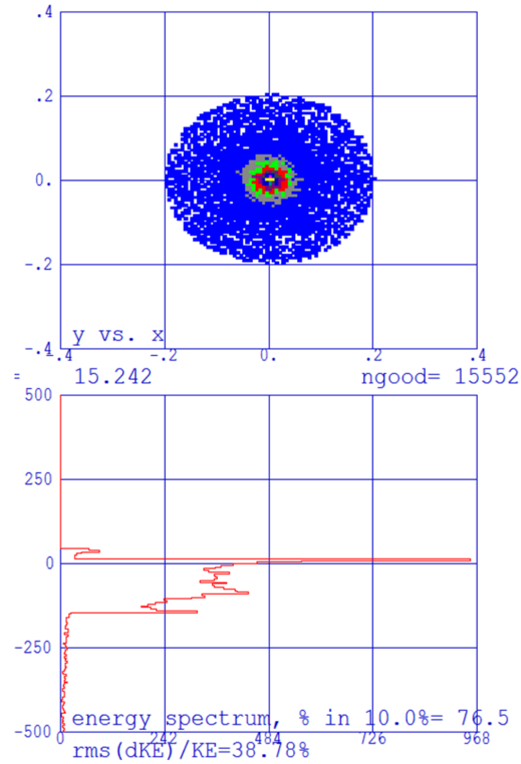

Figure 5: Beam dynamic result at the exit.

Manufacturing and Measurement

The structure has been manufactured. Figure 6 shows the single cell before welded. The cell is quite small in size when compared to a vernier caliper shown in the figure.

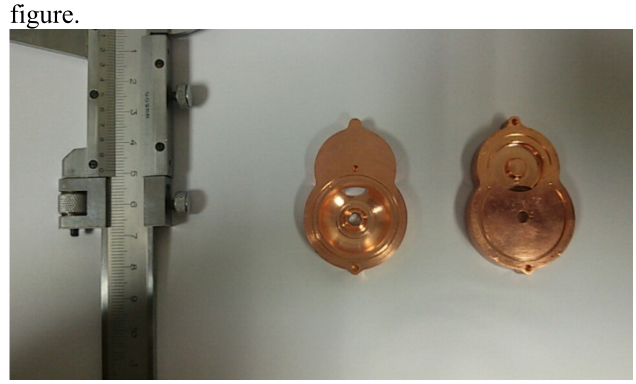

Figure 6: Single cell before welded.

And Figure 7 shows the structure made up by all the 11 accelerating cells and 10 coupling cells.

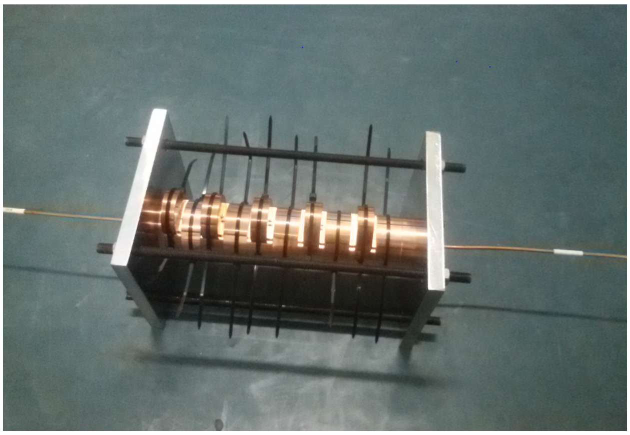

Figure 7: Structure manufactured before welded.

Figure 8 shows the measurement results compared with theory value, the measurement results accords well with the theory.

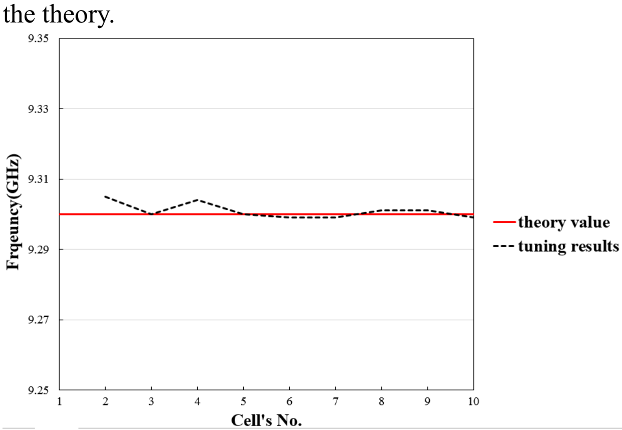

Figure 8: Measurement results compared with theory value.

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