HIGH CURRENT SUPERCONDUCTING CAVITY STUDY AND DESIGN*

Z.C. Liu#, J. Gao, S. Jin, J.Y. Zhai, H.J. Zheng, Y.L. Liu, T.X. Zhao, IHEP, Beijing, 100049, China
F. Wang, PKU, Beijing, 100871, China

Abstract

IHEP is developing a new type of high current superconducting cavity called slotted cavity proposed in 2010. The cavity is suitable for accelerating high beam current in Energy Recovery Linac (ERL). The cavity can extremely dump high order modes (HOMs) in the cavity to keep a high beam current threshold in the linac. We have studied and designed a three cell cavity and the fabrication is ongoing.

INTRODUCTION

Superconducting cavity is developed in two directions. One is high accelerating gradient and the other is high beam current. High current superconducting cavity plays a very important role in the application of high brightness XFEL, ERL and etc. The Beam Breakup (BBU) threshold is an important parameter for the high current cavity. For the usual high current cavity with large beam pipes, the BBU threshold is about several hundreds milliampere. But for the cavity with slotted structure, the BBU threshold can reach ampere level [1]. Therefore the slotted cavity study is begun and the aim is to make it usable for future high current accelerator.

DESIGN PRINCIPLE

The 1.3 GHz superconducting slotted cavity is used to accelerate electron bunches with a current of 100 mA, or larger. To accelerate 100 mA CW electron bunches, we need to follow these principles in the cavity design:

1) Proper cell numbers. As the HOM can be highly absorbed through the slotted structure, the cell numbers are more optional. However, to simplify the fabrication and lower the cost, for the test cavity, we choose a 3-cell cavity to do related research.
2) To get higher accelerating gradient, E_{pk}/E_{acc} and B_{pk}/E_{acc} should be optimized.
3) No hard multipacting barrier caused by cavity shape and the slotted structure.
4) Frequency can be easily tuned.
5) Easy to fabricate.

A 1.3GHz slotted superconducting cavity was studied and designed using CST-MWS [2]. The cavity parameters are shown in Table 1. And the cell shape parameters are shown in Table 2.

Figure 1 shows the electric field and the field flatness of π mode in the cavity. The shape was optimized to make the field flat and E_{pk}/E_{acc} and B_{pk}/E_{acc} low.

*Project 11275226 supported by NSFC
#zcliu@ihep.ac.cn

Table 1: The 1.3GHz Slotted Superconducting Cavity Parameters

Type	Elliptical
Operating frequency (MHz)	1300
Working gradient(MV/m)	15
Q_0	1×10^{10}
Beta	1
No. of cell	3
Dia. of iris (mm)	41.152
R/Q (Ω)	268.9
E_{pk}/E_{acc}	3.57
B_{pk}/E_{acc} (mT/(MV/m))	5.72
Field flatness (%)	>97

Table 2: The 1.3GHz Superconducting Cavity Cell Shape Parameters

Parameters	Center cell	End cell
L (cm)	57.7	57.7
R_{iris} (cm)	41.152	48.733
Requator(cm)	103.899	103.899
A(cm)	37.904	35.434
B(cm)	23.825	23.55
a(cm)	10.83	16.786
b(cm)	16.244	16.244

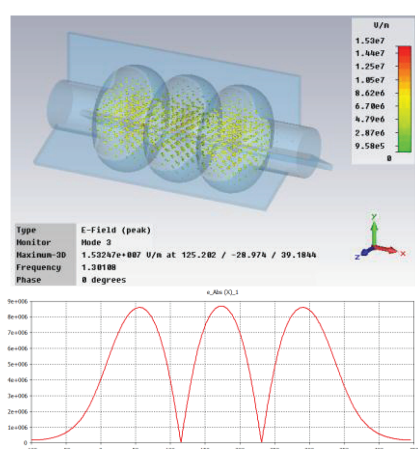

Figure 1: Electric field of π mode in the cavity (up). The field flatness of π mode (down).

MULTIPACTING

To achieve high accelerating gradient, one needs to eliminate the hard multipacting barrier in the cavity. Track3P [3] is used to simulate the multipacting phenomenon in cavity.

The criterion of multipacting event is that the particle resonant trajectories have successive impact energies within the right range for secondary emission yield (SEY) bigger than unity. Figure 2 shows the SEY of normal niobium.

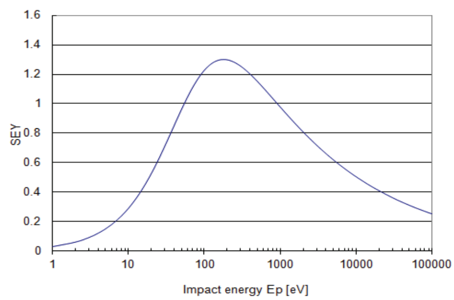

Figure 2: SEY of normal niobium.

We have simulated the multipacting phenomenon of the 1.3GHz slotted cavity without tuning parts for E_{acc} from 1MV/m to 20MV/m with an interval of 1MV/m using the whole cavity. The simulation results show that there is no hard multipacting barrier in the cavity (see Fig.3). The multipacting of the slotted cavity with a type of tuning parts was simulated for E_{acc} from 1MV/m to 40MV/m with an interval of 1MV/m using the whole cavity (see Fig. 4). The results show that the tuning parts will cause some resonant trajectories between tuning parts and the slot wall. Further optimization on the shape of tuning part will be done in future.

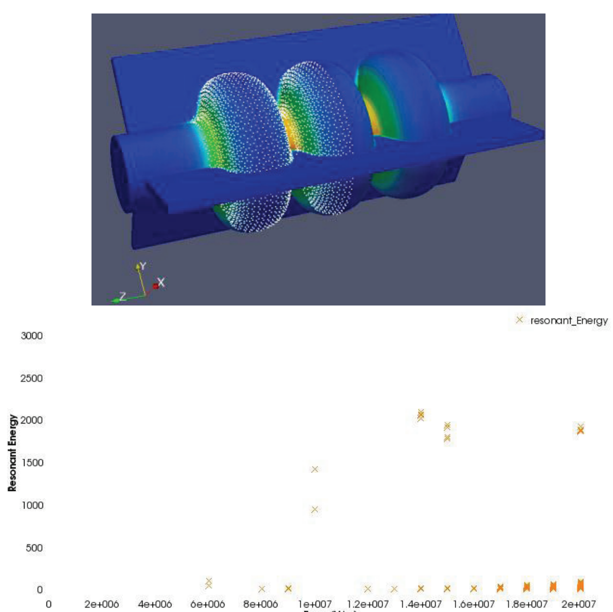

Figure 3: The initial emitting points in the cavity (up). The impact energy versus E_{acc} of the 1.3GHz slotted cavity (down).

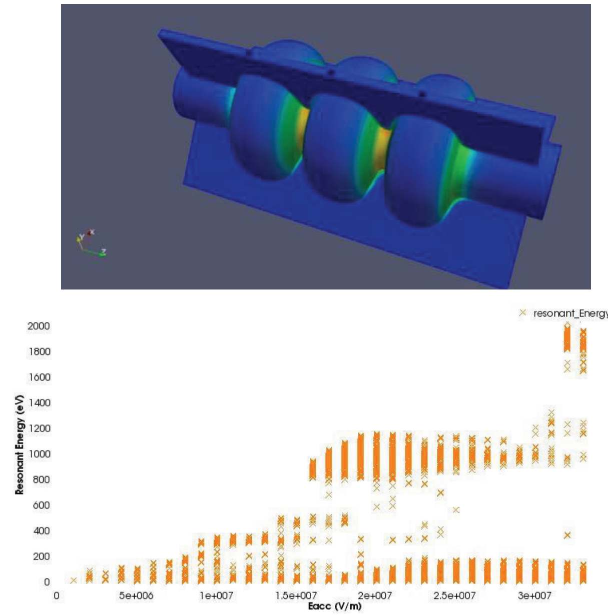

Figure 4: The cavity with one type of tuner (up). The impact energy versus E_{acc} of the 1.3GHz slotted cavity (down).

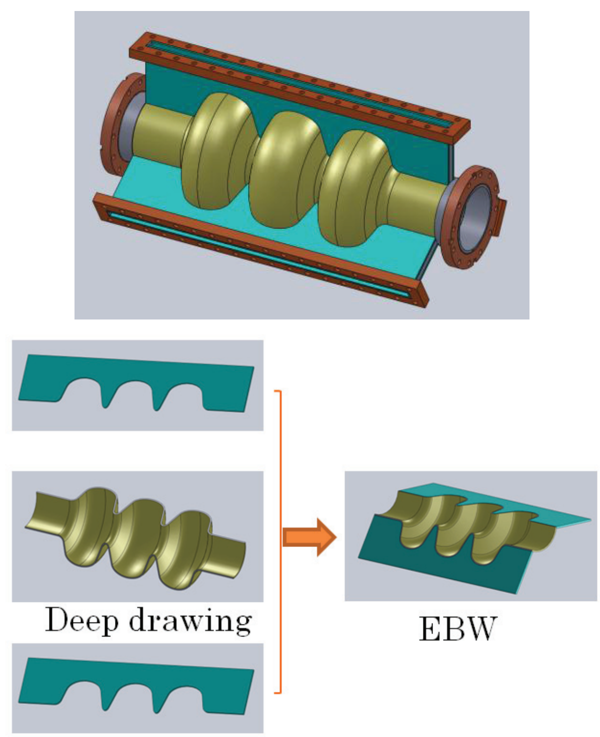

Figure 5: The mechanical structure of the slotted cavity (up) and the fabrication method (down).

The deep drawing of the cell shape is a key and difficult job. We will fabricate the cavity sector as shown in Fig. 5. Firstly, deep draw the cell shape and cut the slot wall; secondly, Electron beam (EB) weld them together to form a sector; then weld three sectors together.

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SUMMARY

A 1.3GHz slotted superconducting cavity has been designed for the high current superconducting cavity study. The results show that the cavity has a reasonable E_{pk}/E_{acc} and B_{pk}/E_{acc}. Multipacting was checked by Track3P and the results show no hard multipacting barrier in the cavity without tuning parts.

ACKNOWLEDGEMENT

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