

THE SUPERCONDUCTING CH CAVITY DEVELOPING IN IMP*

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Abstract

The Cross-Bar H-type (CH) cavity is a multi-gap drift tube structure operated in the H21 mode [1]. The Institute of Modern Physics (IMP) has been doing research and development on this type of superconducting CH cavity which can work at the C-ADS (accelerator driver sub-critical system of China). A new geometry CH cavity has been proposed which have smaller radius. It's suitable in fabrication, and it's can reduce cost too .Detailed numerical simulations with CST MicroWave Studio have been performed. An overall surface reduction of 30% against the old structure seems feasible. A copper model CH cavity is being fabrication for validating the simulations and the procedure of fabricating niobium cavity.

INTRODUCTION

C-ADS project with ambitious requirement regarding beam power and quality need new superconducting linac development. Superconducting Crossbar-H-Mode (CH)-cavities have two important features meet with the requirements of C-ADS. Superconducting CH cavity have high real estate gradients compared to conventional low-beta ion linacs, this feature will reduce the amount of cavity prominent. For the cross bar structure, CH cavities are more rigidly. This feature satisfy the harsh requirements of C-ADS about reliable. As this reasons, superconducting CH cavities have been choose as a backup cavity type for the C-ADS(see Fig.1). With respect to C-ADS actual application, one prototype of superconducting CH cavity (f=162.5MHz, beta=0.067, 6 cells) is presently being development in IMP.

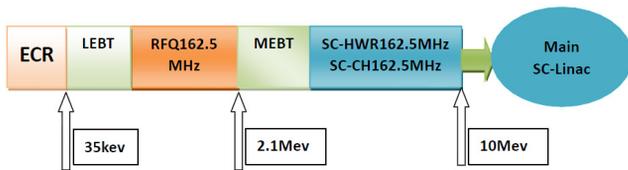


Figure 1: Layout of Injector-II for C-ADS.

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NEW SHAPE SUPERCONDUCTING CH CAVITY

The superconducting CH cavity has electric and magnetic field structure similar with combine the 4-vane RFQ and DTL's. We can use a semi-analytical approach to estimate basic parameters like frequency. The parameter Rt and r1 are represent the radius of CH cavity and the tube radius of CH cavity respectively. Using this equivalent, we can get the resonance frequency with the radius Rt as following [1]:

$$\omega \approx c \left(\frac{0.73}{Rt^2 \left(\frac{25}{144} + \frac{25}{72} \ln\left(\frac{Rt}{r1}\right) - 0.2 \right)} \right)^{1/2} \quad (1)$$

In case of the superconducting CH cavity of IMP, the frequency is 162.5MHz, r1 was 0.03m. Using the formula (1) can give radius Rt of the CH cavity is 0.29 meter. We have using the software CST to simulation. The radius of CH cavity is 0.32 meter [2].

The superconducting CH cavity is a complex cavity. With the radius of 0.32 meter, there are big surface. This means a large amount of high pure niobium needs and a more chance to come across defects. As in superconducting cavity, perfect surface is important for the cavity quality [3]. This size of CH cavity is not easy to protect from defects and contaminates or not suitable in the vacuum chamber of electric beam welding machine.

We try to cut a part of the girder called undercut [4] (see Fig.2).This undercut will increase inductance in the end of cavity, as this will increase the length of current flow. Increased inductance will lower the resonance frequency that we can get a smaller cavity structure in the same frequency (see Fig.3).

When we change the size of undercut in the girder of CH cavity, the radius will reduce with the width of girder liner. At most, we can reduce the radius of cavity by 20% (see Fig.4). As the radius reducing, the surfaces of the cavity reduce by 30% (see Fig.5).

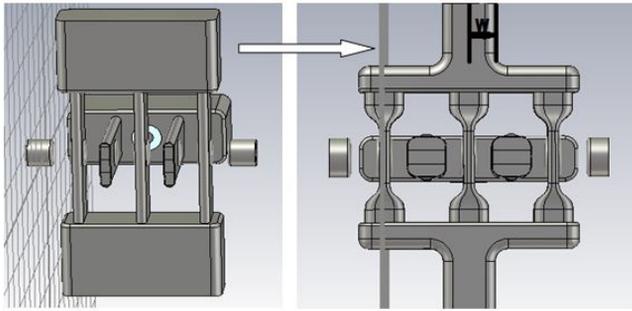


Figure 2: The copper CH cavity structure (left) and the CH cavity of use undercut in girder (right).

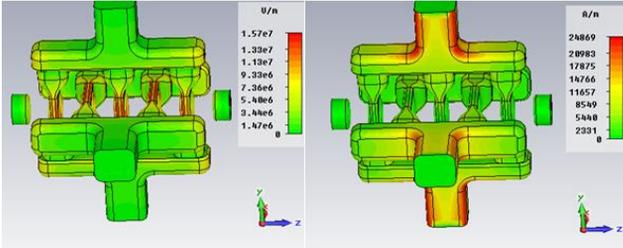


Figure 3: The electric field of use undercut CH cavity (left) and the magnet field of use undercut CH cavity.

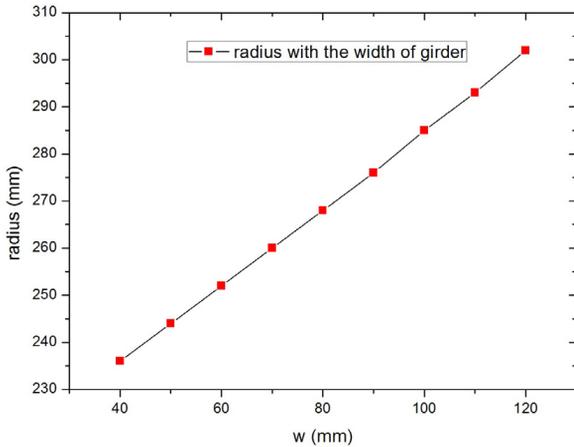


Figure 4: The radius of CH cavity with the width of girder.

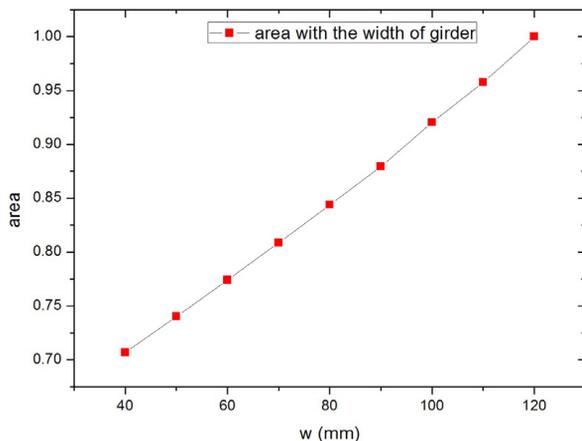


Figure 5: The surface of CH cavity with the width of girder.

This reduction has such advantages: as the cavity size became smaller, deep drawing dies became smaller too. It's easy to hand; the last electron beam welding joint have smaller length, less risk to burn a hole, easy to change position at the EBW; smaller use of high purity niobium, lower cost; less chance to come across defect in surface [4].

Field distribution variation with different undercut girder

The usage of undercut girder leads to a more homogeneous field distribution along the beam axis because the volume for the magnetic field is increased (see Fig.6).

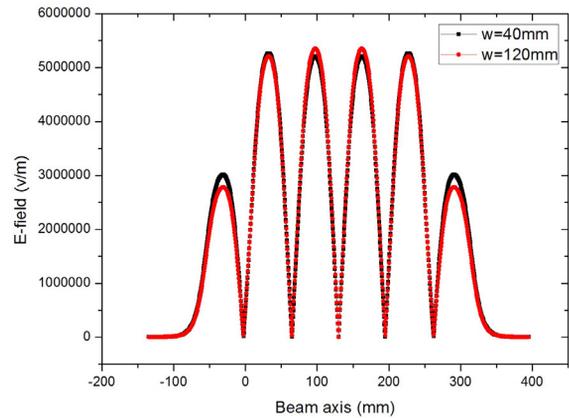


Figure 6: Field distribution of CH cavity with the different width of girder.

Frequency variation with different undercut girder

The frequency tuning is by compress and pulling the two side of cavity along beam axis. Different undercut girder influence the F/l (see Fig.7).

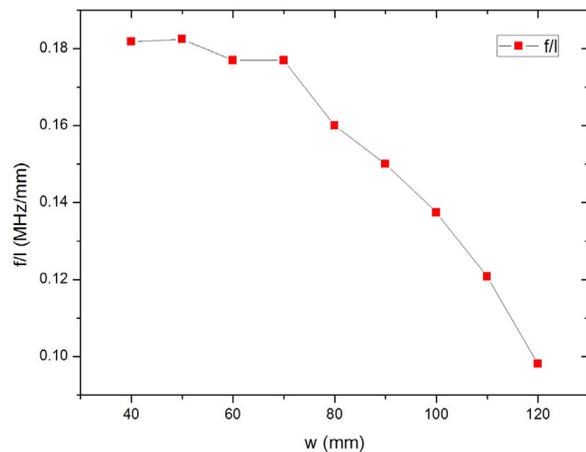


Figure 7: F/l of CH cavity with the different width of girder.

Copper prototype CH cavity fabrication

A copper prototype CH cavity has been built (see Fig.8) to validate the electromagnetic simulations, such as frequency (see Table1), field distribution along the beam axis, coupler size and position, tuning ability. And the CH cavity structure is complicate, need to check the design of dies and the path of electron beam weld in the fabrication.

Table 1: The EM parameters of the copper CH cavity

| Parameter | Value | Unit |
|----------------------|-------|----------|
| Frequency | 162.5 | MHz |
| Beta | 0.067 | |
| Ra/Q0 | 670 | Ω |
| G | 47 | Ω |
| E_{peak} / E_{acc} | 5.3 | |
| B_{peak} / E_{acc} | 6.37 | mT/ MV/m |



Figure 8: Parts of copper CH cavity.

OUTLOOK

We have design a superconducting CH cavity with smaller size. The future optimization will focus on lower the E_{peak} / E_{acc} and B_{peak} / E_{acc} , that it should be possible to reach higher effective voltages . The normal copper CH cavity will be finish at the end of 2012.

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