THE MULTIPACTING SIMULATION FOR THE NEW-SHAPED QWR USING TRACK3P*

C. Zhang#, S. He, Y. He, S. Huang, Y. Huang, T. JiangR. Wang, M. Xu, Y. Yang, W. Yue, S.H. Zhang, S. Zhang, H. Zhao
Institute of Modern Physics, Lanzhou, Gansu 730000, China

Abstract
In order to improve the electro-magnetic performance of the quarter wave resonator, a new-shaped cavity with an elliptical cylinder outer conductor has been proposed [1]. This novel cavity design can provide much lower peak surface magnetic field and much higher R_a/Q_0 and G. The multipacting simulation has been done for this new QWR cavity using ACE3P/TRACK3P code, in this paper the simulation results will be presented and analyzed.

INTRODUCTION

In the Heavy Ion Accelerating Facility (HIAF) of IMP, superconducting quarter wave resonators (QWRs) with frequency of 81.25 MHz and β of 0.041, 0.085 will be applied to accelerate the ion beams from 0.3 MeV/u to 17 MeV/u. Because of the extremely high design voltage for the β =0.085 QWR cavity, an elliptical cylinder outer conductor shape has been proposed for it (see Fig. 1).

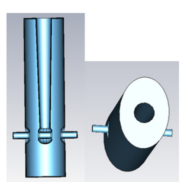

Figure 1: The elliptical cylinder outer conductor QWR model for multipacting simulation.

MULTIPACTING SIMULATION

Parallel codes Omega3P and Track3P which are developed at SLAC have been used, to obtain the field maps and then to analyse the multipacting barriers [2, 3]. When doing the multipacting simulation, one half of the QWR cavity was used taking advantage of the symmetry. Seed particles were initiated on all the RF surfaces. The accelerating gradient was scanned up to 6 MV/m firstly to locate the multipacting band, and then much finer scan interval was used in order to study the multipacting band in detail. 2 eV was used as the initial energy for primary and secondary emissions to study its effect on multipacting and typical niobium secondary electron yield *(SEY) was applied to estimate the multipacting strength* (see Fig. 2). At each field level, 50 RF cycles were used as total running time to obtain resonant trajectories.

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# claire335@gmail.com

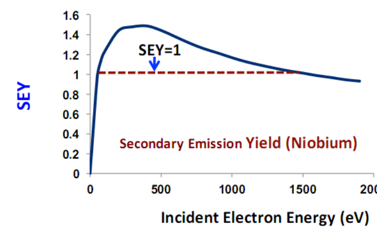

Figure 2: Secondary electron yield (SEY) for Niobium on the dependence of impact energy. The impact energy range relevant to the peak SEY is 150~700 eV. Resonant electrons with impact energies in this range are most dangerous to lead to hard multipacting.

MULTIPACTING SIMULATION RESULTS

Multipacting band at low field level

The distribution of resonant particles identified by Track3P presented the multipacting bands occurred at low field levels, Figure 3, 4 show the expanded plot around this multipacting band and impact positions.

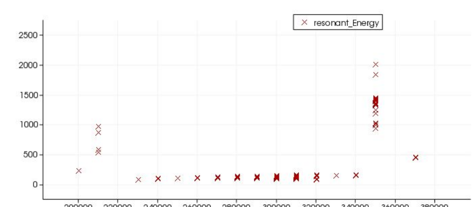

Figure 3: Impact energy vs. accelerating gradient at low field level.

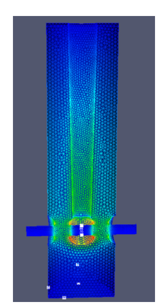

Figure 4: Impact positions at all field levels.

There are two multipacting bands, one at field levels of 0.2 ~0.34 MV/m with impact energies 80~160 eV in the beampipe region (see Fig. 5, 6); the other at around the accelerating gradient of 0.35 MV/m with impact energies 700~2000 eV in the bottom part of the cavity. In consideration of the peak SEY energy for Nb (see Fig. 2), such two bands are expected to be a soft barrier.

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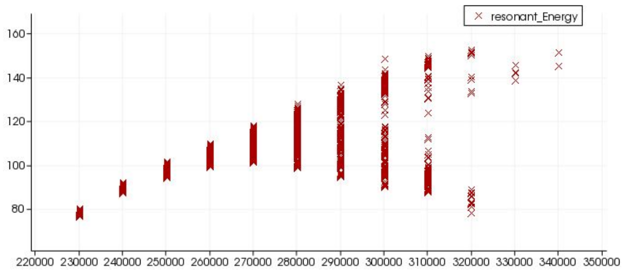

Figure 5: Impact energy vs. accelerating gradient of 0.2~0.34 MV/m.

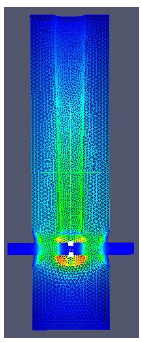

Figure 6: The beampipe impact positions for the accelerating gradient of 0.2~0.34 MV/m.

Rounding effects on Multipacting

Since it is a common method of reducing the B_{peak} near the short plate location by rounding the joints between the short plate and the inner and outer conductors, here let's see what this procedure will bring to the multipacting activities in the cavity. In order to check how the rounding will affect the multipacting status, the simulation will be done for the three situations-(a) rounding only the inner conductor joint, (b) rounding only the outer conductor joint (see Fig. 7) and (c) rounding both joints, separately.

As for the first two cases, the multipacting occurrences are very similar to that of the flat short plate QWR, both in the impact energy span (see Fig. 8, 9) and in the impact positions (see Fig. 10, 11).

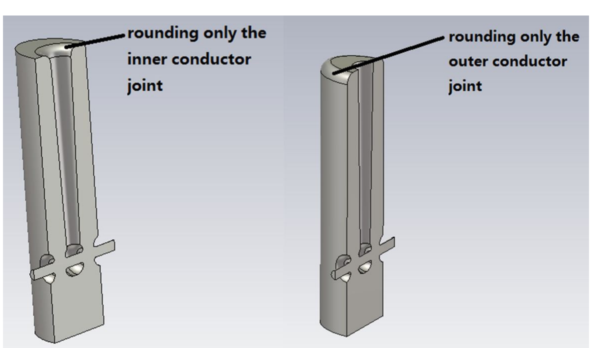

Figure 7: Rounding only one joint between the short plate and the inner or the outer conductor.

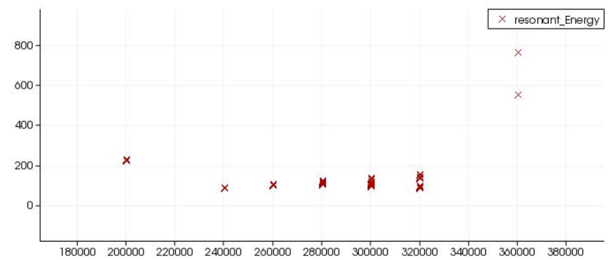

Figure 8: Resonant particle distribution for the case of just rounding the inner conductor joint.

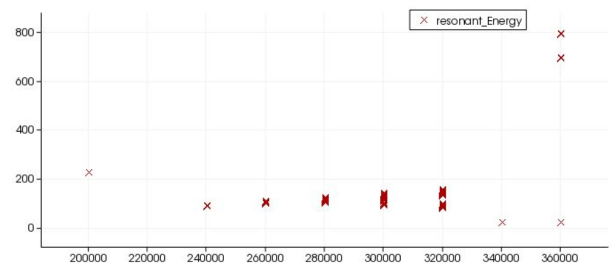

Figure 9: Resonant particle distribution for the case of just rounding the outer conductor joint.

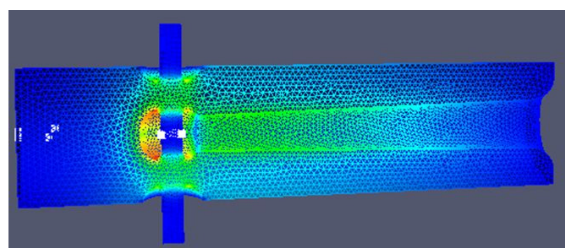

Figure 10: Impact positions for the case of just rounding the inner conductor joint.

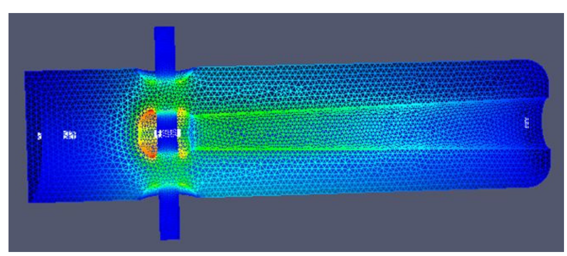

Figure 11: Impact positions for the case of just rounding the outer conductor joint.

However, the multipacting resonances are very critical for the third situation (see Fig. 12). Firstly, the resonant trajectories are expanded to the short plate region and the middle outer conductor (see Fig. 13); and secondly, the impact energies have spread around the peak of the SEY curve (see Fig. 14, 2). As a result, the attempting to lower the Bpeak by rounding both the joints can incur a very serious multipacting in the cavity. The final electro-magnetic design choose not to round the either of the joints speciously since the elliptical cylinder outer conductor cavity shape can offer low enough B_{peak}.

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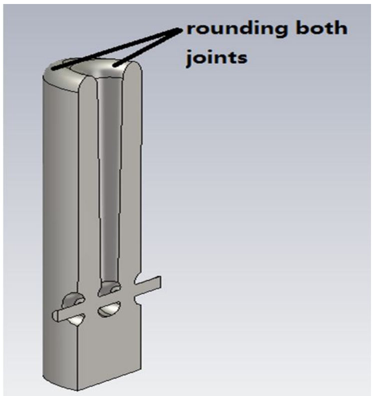

Figure 12: Rounding both joints between the short plate and the inner and the outer conductor.

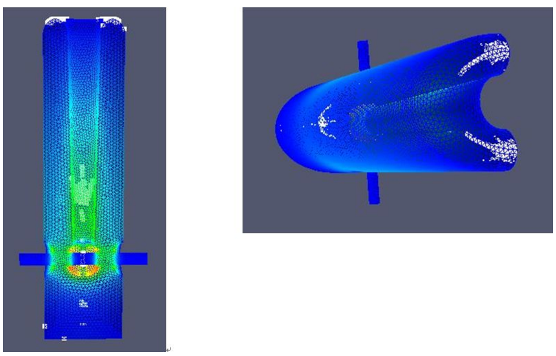

Figure 13: Impact positions for the case of rounding both joints.

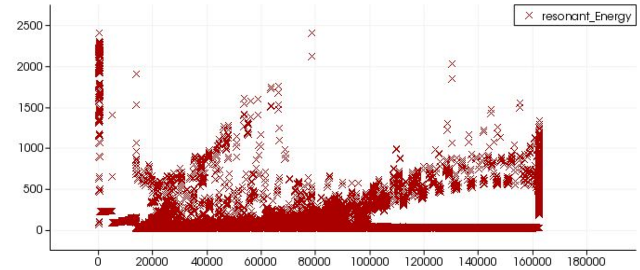

Figure 14: Resonant particle distribution for the case of rounding two joints.

SUMMARY

Track3P was used to analyze the multipacting bands in the elliptical cylinder outer conductor shaped QWR cavity. Only multipacting bands at low field levels were found and the impact energy distributions showed that no hard multipacting bands exist in the cavity. However, rounding the joints between the short plate and both the inner and outer conductors will cause more multipacting bands. The fabrication and test of the prototype cavity is in need in order to see if the experimental data will be in agreement with the simulation results.

REFERENCES

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