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

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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 $\beta$ 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 $\beta$ =0.085 QWR cavity, an elliptical cylinder outer conductor shape has been proposed for it (see Fig. 1).

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.

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

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.

* Work supported by 91026001 Nature Science Foundation
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Proceedings of LINAC2012, Tel-Aviv, Israel
TUPB056

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ISBN 978-3-95450-122-9

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2E Superconducting Linacs
Rounding Effects on Multipacting

Since it is a common method of reducing the $B_{\text{peak}}$ 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).

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 $B_{\text{peak}}$ 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 $B_{\text{peak}}$. 
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