

MULTIPACTING PREDICTION FOR THE 106.1 MHz QUARTER WAVE RESONATOR

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Abstract

The results of the numerical simulations of multipacting in the 106.1 Mhz Quarter Wave Resonator (QWR) are presented. The influence of the cavity geometry and inner surface properties on the discharge possibilities is studied. In this paper we compare CST PS and MultP-M 3D simulation results for multipacting in the cavity.

INTRODUCTION

In this paper different geometries of the Quarter Wave Resonators from the ISAC-II project are overviewed. These geometries are presented on the Fig.1. [1]

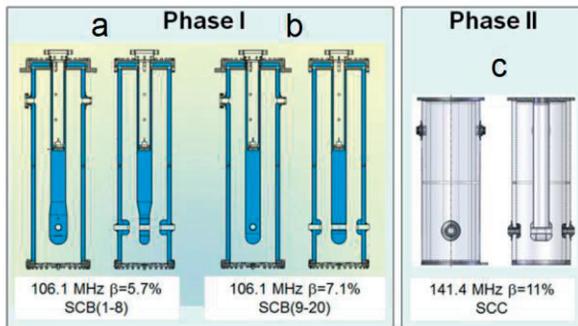


Figure 1: ISAC-II superconductive Quarter Wave Resonators.

The detailed results of the calculations comparing with the experiment data of the multipacting threshold for the 141.4 MHz cavity were presented in paper [2]. Simulations were carried out using 3D code MultP-M [3]. The good corresponding between this simulations and experimental data was obtained.

But at the time of calculations in view of MultP-M features and limitations and also without opportunity to carry out calculations in the different code, only 141.4 MHz geometry and partially 106.1 MHz at $\beta=7.1\%$ geometry were calculated. QWR 106.1 MHz at $\beta=5.7\%$ construction was impossible to simulate in view of inner conductor constructing complexity. The MultP-M code upgrade that was held in 2013 allowed us to construct and calculate QWR 106.1 MHz at $\beta=5.7\%$ geometry. The information about code upgrade was presented on the IPAC'14 conference [3].

MULTP-M SIMULATIONS

On the Fig.2 the electric field distribution on the cavity (Fig. 1.a) axis is presented.

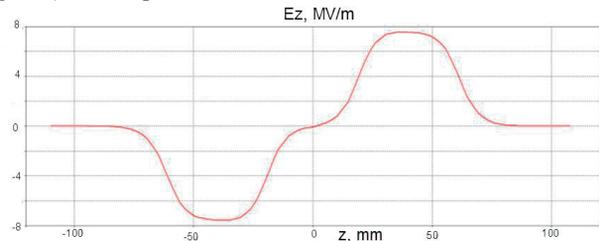


Figure 2: Electric field distribution through the z axis for the Fig. 1.a geometry; $E_{zmax}=7,85$ MV/m.

Using (1) and (2) relationship we can obtain that 1 of the normalize field value corresponds to the 0,4091 MV/m of the accelerating field.

$$U = \left| \sum_{j=0}^{n-1} \left[(Ez_j) * e^{\frac{i+k_j+dz}{\beta}} dz \right] \right| \quad (1)$$

$$E = \frac{U}{L} \quad (2)$$

Calculations results in the wide range of the accelerating field value for the three types of geometries are presented on the Fig.3 where one unit of the normalized field corresponds to the 0.4091 MV/m of the accelerating field. For the geometry on the Fig.3.c the result of the research [2] was used. Calculations were carried out for the 100 initial particles and the calculation time was corresponded to the 10 RF periods. Dependences of the increase in the number of particles in structure with the different accelerating field levels are presented on the graphs below.

Obtained graphs shows that despite the fact, that the range of the dangerous levels for the structure (c) is wider than for the (a) and (b) geometries, this geometry show the smallest particles number increasing during 10 RF periods.

Let's consider the initial range of the field levels. On the Fig.4 the dependences of the particle number increasing in the structure in the different accelerating field levels: in the 0 – 0.03 range. The calculation was considered for the 1000 particles, calculation time corresponded to 10 RF periods.

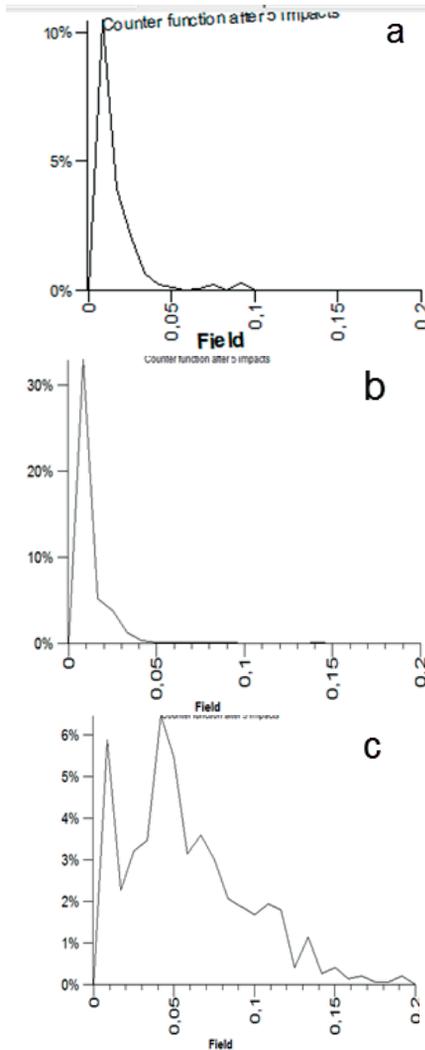


Figure 3: Dependences of the increase in the number of particles in structure with the different accelerating field levels QWR: (a) 106.1 MHz, $\beta=5.7\%$; (b) 106.1 MHz, $\beta=7.1\%$; (c) 141.1 MHz, $\beta=11\%$.

Fig. 4 shows that the initial ranges of the field levels also are close to each other, but the particles increase number for the (a) and (c) geometries is lower comparing with geometry (b).

The increasing of the calculation time to the 80 RF periods for (b) and (c) geometries shows the smaller particle increasing number comparing with 10 and 40 RF periods, that shows the decaying type of the trajectories. For the geometry (c) the existing of the soft multipacting barrier has been found during an experiment [2]. For the geometry (a) an increasing of the calculation time to 80 RF periods shows no particle increasing.

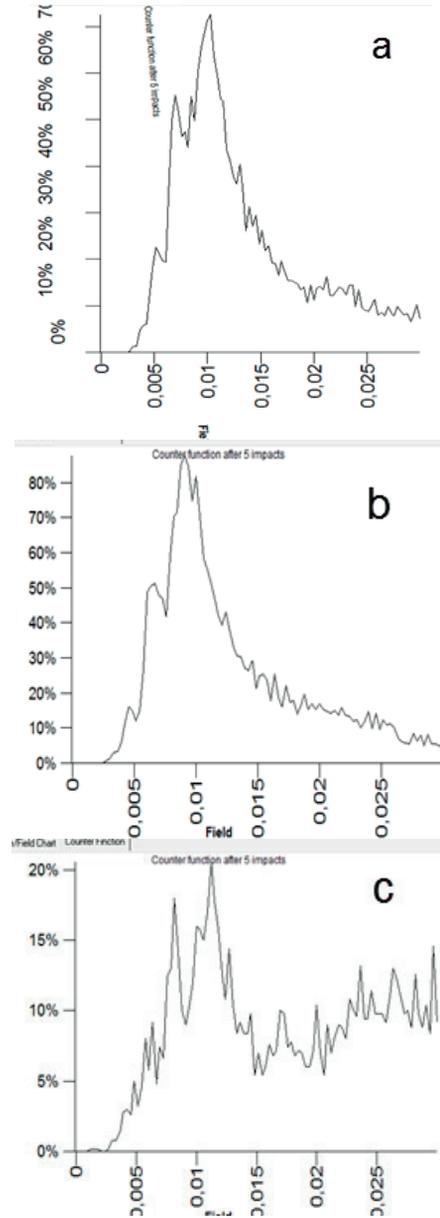


Figure 4: Higher precision. Dependences of the increase in the number of particles in structure with the different accelerating field levels QWR: (a) 106.1 MHz, $\beta=5.7\%$; (b) 106.1 MHz, $\beta=7.1\%$; (c) 141.1 MHz, $\beta=11\%$.

On the Fig.5 the obtained particle trajectories at the different accelerating field levels in the structure (a) 106.1 MHz, $\beta=5.7\%$.

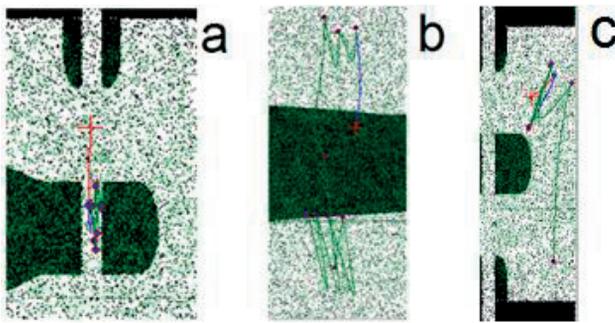


Figure 5: Particle trajectories at the different normalized field levels (a) $E_z=0.004$; (b) $E_z=0.008$; (c) $E_z=0.019$

From the obtained results we can see, that in the geometry (a) 106.1 MHz, $\beta=5.7\%$ particle trajectories are observed in the same areas (accelerating gap, donut-coaxial outer conductor, coaxial line) and at the same accelerating field levels as for the geometry (c) 141.1 MHz, $\beta=11\%$ [2]. At the field levels higher than 0.02, particle trajectories are observed at the areas donut and end gap. But returning to the graphs of the particles number increasing at the different accelerating field levels it should be considered that geometry (c) is the optimal regarding multipacting discharge prediction.

CALCULATION OF THE SEY INFLUENCE ON THE AVALANCHE DEVELOPING

Using CST PS code [4] for the QWR 106.1 MHz at $\beta=5.7\%$ the test multipacting calculations in different SEY levels were carried out. On the Fig. 6 are shown dependences of the particles number in the structure from the time for the surfaces with the different treatment [5]: (a) Air Discharge Cleaned, (b) Wet Treatment, (c) 300°Bakeout.

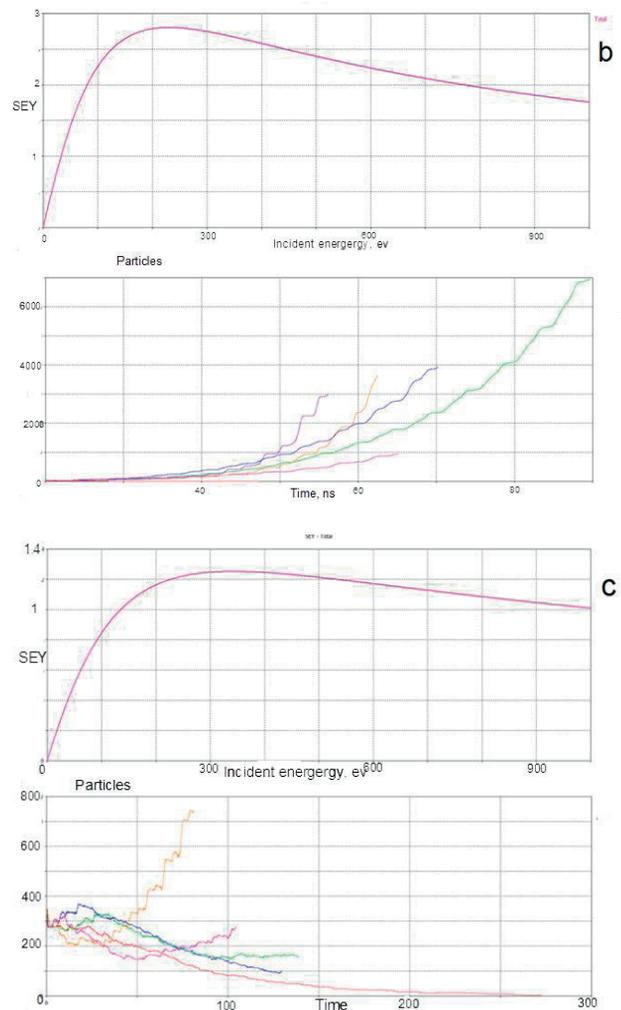
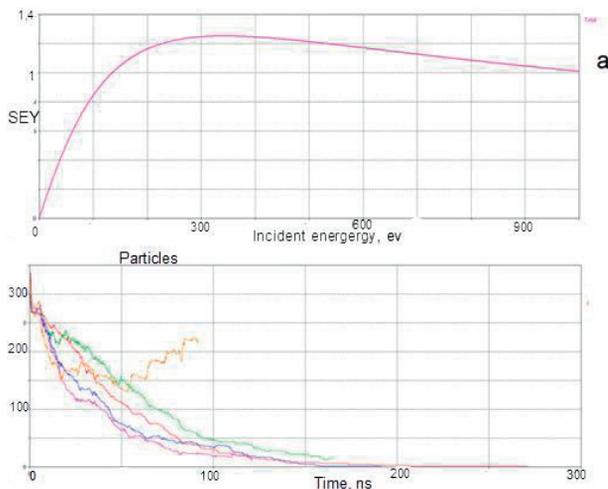


Figure 6: SEY dependences from the colliding energy between particles and Number of particles in the structure from the time for the surfaces with the different treatment type and with the different accelerating field levels. (a) Air Discharge Cleaned; (b) Wet Treatment; (c) 300°Bakeout.

Obtained results shows that the quality of the cavity inner surface has a great influence on the avalanche developing as a consequence of the secondary electron emission. We can see, that the wet treatment shows the worst results, the bakeout is sufficiently allows to narrow the field levels range, when the multipacting is possible. The Air Discharge Cleaned shows the best results.

CONCLUSION

The simulation of the multipacting discharge for the QWR 106.1 MHz, $\beta=5.7\%$ geometry. The most dangerous areas of the accelerating field value, regarding to multipacting possibilities [6], have been detected. The influence of the inner conductor geometry and inner surface treatment methods on multipacting possibilities has been shown.

REFERENCES

- [1] R.E. Laxdal, M. Marchetto, The ISAC post-accelerator, *Hyperfine Interact* (2014) 225:79–97 DOI 10.1007/s10751-013-0884-8, Springer Science+Business Media Dordrecht 2013
- [2] M.A. Gusarova, M.V. Lalayan, N.P. Sobenin, V.L. Zvyagintsev, MULTIPACTING SIMULATION IN ISAC-II SUPERCONDUCTING CAVITIES, Proc. of 23rd Particle Accelerator Conference PAC-09, Vancouver, Canada.
- [3] M. Gusarova, S. Khudyakov, I.I. Petrushina, Ya.V. Shashkov, New Possibilities of MultP-M Code, Proceedings of IPAC2014, Dresden, Germany
- [4] <https://www.cst.com/>
- [5] Thomas P.Wangler RF Linear accelerators, 2008 WILEY-VCH Verlag GmbH&Co. KGaA, Weinheim
- [6] Version 1.6.1 of the ESTEC Multipactor Calculator available at www.estec.esa.nl/multipac/