OPTIMIZATION OF ELECTRIC FIELD DISTRIBUTION INSIDE MULTI-GAP CH-RESONATOR

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Abstract

RF H-mode resonators are frequently used in the most modern proton accelerators. For instance crossbar H-mode (CH) [1] resonators could be mentioned. For this cavity type the task of accelerating field flatness tuning is quite important. This paper presents the results of the electric field adjustment on the beam axis for different CH-geometries.

INTRODUCTION

The main goal during investigation was to achieve the even accelerating field distribution for the different geometries of CH-resonator. Main variable parameters are presented at table 1.

Table 1: The designed parameters

Number of periods	7; 9; 11;
Aperture diameter, mm	15; 20; 30
Beam velocity β=v/c	0,07; 0,08; 0,09; 0,10

The layout of the 7 and 9-gap CH- cavities is presented in Fig. 1-2. All CH-cavity designs considered operate at 324MHz and have a constant period D=βλ/2. Acceleration gap between drift tubes t=D/2.

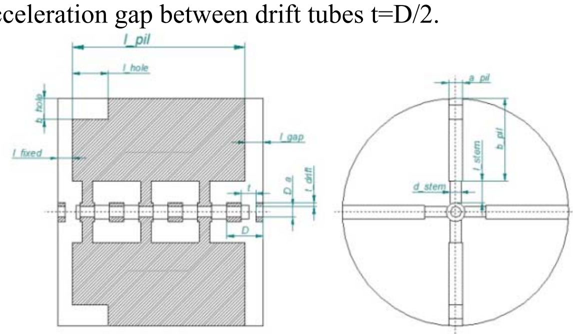

Figure 1: The designed layout.

To estimate the field flatness the uniformity factor was used:

$$k = \frac{E_{\min}}{E_{\max}} \cdot 100\%,$$

where E_{min} - minimal accelerating field amplitude, E_{max} - maximal accelerating field amplitude.

FIELD FLATNESS TUNING TECHNIQUE

To optimize both electric field distribution and effective shunt impedance geometry includes flat vanes (see Figs.1, 2.). Each vane (pylon) has one rectangular hole made on downstream pylon side. The opposite pylon part is flat but its position is variable and defined by parameter L_{gap}.

The tuning task consists of several steps. First the optimal start value of holding rod length l_{stem} and its optimal relation with the pylon height (b_{pil} / l_{stem} see Fig.1.) should be chosen for specified beam velocity, aperture diameter and number of periods. It determines initial values of field flatness (it should be better than 15-20%) and optimal values of effective shunt impedance

Then the most significant improvement on the field distribution is introduced by the length L_{gap} (see Fig.2.) between end walls of the tank and the pylon. Dependence of the field uniformity vs. this length is presented in the Fig.3. It could be mentioned that the best field flatness was obtained in case of zero gap (L_{gap}=0 mm). For such cavity geometry magnetic field distribution differs from the classical CH – resonator, it transforms in one common magnetic flux like in split-coaxial cavities [2]. According to the magnetic field distribution inside such geometry four separated magnetic fluxes around each vane combine in one common flux.

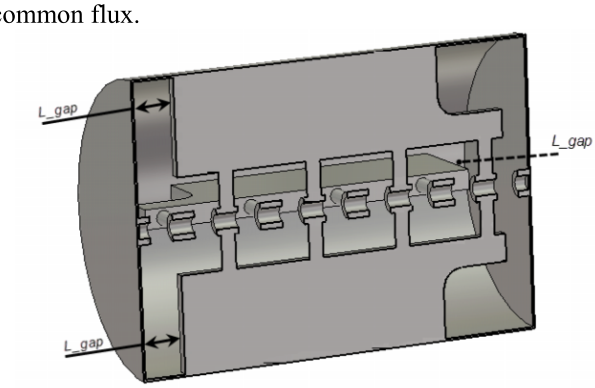

Figure 2: 3D-view of the CH-resonator. Each vane contains 1 rectangular hole and 1 movable sidewall (position defined with L_{gap} value).

It should be noted that resonant frequency and effective shunt impedance have some changes with L_{gap} variation: frequency shifts to 1-3% and effective shunt impedance changes to 5-15% depending on aperture diameter, number of periods etc.

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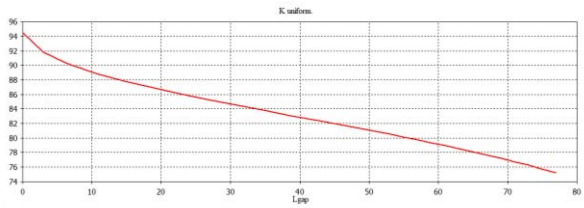

Figure 3: Dependence of the field flatness vs. L_{gap}.

DIFFERENT GEOMETRIES OPTIMIZATION

The case of zero gap between end walls of the tank and the pylon was used to tune the field uniformity for all investigated CH-geometries. In examples discussed below field flatness k is better 95%.

At the figure 4 the dependence of effective shunt impedance vs. particle velocity for the 7-gap model is presented. It should be mentioned that period D was changed according to particle velocity β. To achieve necessary field flatness for low β cases the holding stems were shortened.

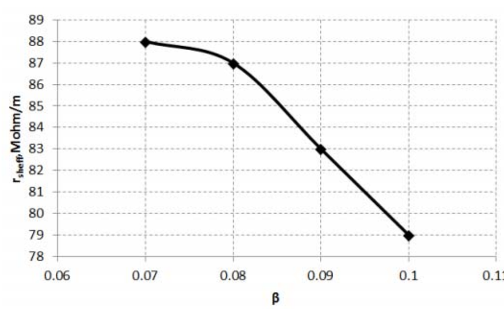

Figure 4:Dependence of effective shunt impedance vs. particle velocity.

The dependence of effective shunt impedance vs. aperture diameter D_a is presented in figure 5. Results were obtained for 7 gap cavities and two different particle velocities β. To optimize field flatness in case D_a=30mm correct rounding of the drift tube outer wall was used.

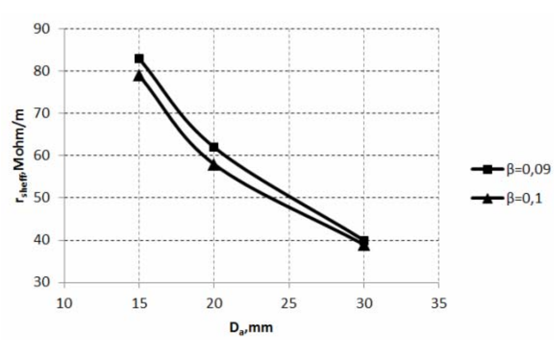

Figure 5: Dependence of effective shunt impedance vs. aperture diameter.

The uniform field distribution was also reached for the cavities with different number of accelerating gaps.

The results of optimization are presented in Fig.6 for two different particle velocities β.

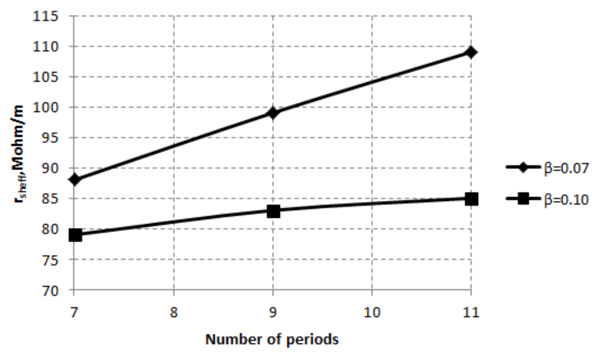

Figure 6: Dependence of effective shunt impedance vs. number of periods.

The flat field distribution could be obtained for different holding vanes geometries (see Fig.1.). The dependence of main electrodynamic characteristics from the vane geometry and tuning hole dimension is presented at the table 2:

Table 2: Dependence of the main eletrodynamic characteristics from the vane geometry.

Parameter	Value			
b_{pil}, mm	87.5	91	94.5	98
b_{hole}, mm	45	50	60	65
r_{sheff}, MOhm/m	63	67	74	77
T	0.841	0.840	0.840	0.840
Q – factor	11680	12150	13000	13400
Field flatness, %	4.6	3.7	3.3	3.2

CONCLUSION

Field flatness tuning technique for CH cavities development is employed. This method allows one to find right cavity dimensions resulting cavity with flat field distribution and good elecrodynamic characteristics. Application to the multigap CH-resonators with EDCs obtained using computer simulation are presented.

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