ADVANCED RF CAVITY DESIGN FOR COSY SC LINAC

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Abstract

We report the possible improvements of accelerating RF cavities for COSY proton-deuteron SC Linac [1]. The accepted accelerating structures are two-gap half-wave straight coaxial resonators. The terms of improvements are an accelerating field increase and tuning and chemical treatment simplification. Structure's electrodynamics simulations and mechanic analysis have been provided.

1 CROSS-CAVITY INSTALLATION

For the range of particle velocity β=v/c up to 0.2 the most common structure is a quarter-wavelength resonator (QWR) (Fig.1). However, this cavity up to now is used only in the heavy ion accelerators[2]. The existence of the magnetic field on the beam path makes problematic to use QWR for light particle acceleration [3]. That's why a half-wavelength cavity HWR (Fig.2) is more favourable for protons or deuterons.

Figure 1: Quarter Wave-Length Cavity Geometry .

Figure 2: Half Wave-Length Cavity Geometry .

In this cavity type an accelerating field magnitude E_{acc} is limited by peak magnetic field B_{pk} on the surface.

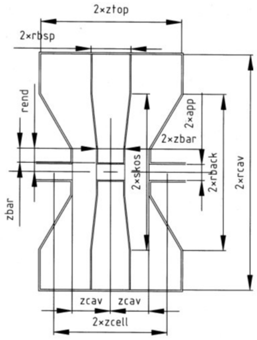

Figure 3: Conical HWR Design.

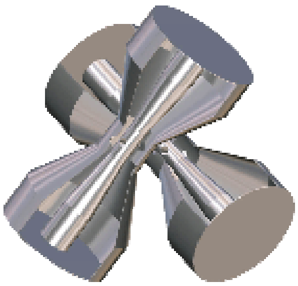

Figure 4: Cross-Cavity Installation.

The most crucial parameter for B_{pk}/E_{acc} minimization is the outer conductor radius "ztop" (Fig.3). On the other hand, its increase makes the whole accelerator length longer that in its turn results in the average acceleration rate decrease. To avoid it we suggest [4] to install the half-wave cavities turned on 90^0 relative to each other and 45^0 to vertical axe (Fig. 4). It gives the possibility to make the outer conductor radius two times bigger. The results of such changes are on Fig.5. With the proper cavity design one can reach two times better parameters (Table 1).

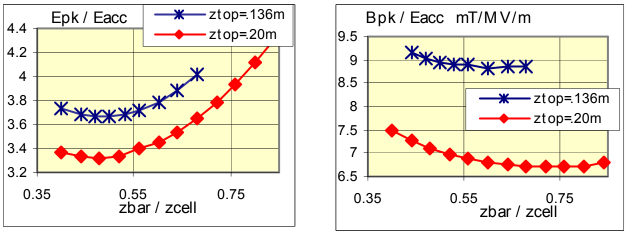

Figure 5: Coaxial HWR parameter optimisations.

Table 1: Some Parameters of Conical HWRs

Frequency	MHz	160	320
β=v/c		0.118	0.224
Z_{top}	cm	20	18
R aperture	cm	1.5	1.5
Z_{cell}=βλ/2	cm	11.06	10.49
R_{cav}	cm	98	46
E_{pk} / E_{acc}		3.65	3.15
B_{pk} / E_{acc}	mT/MV/m	5.3	5.07
B_{pk} / E_{pk}	mT/MV/m	1.45	1.61

2 THREE-QUARTER WAVE-LENGTH CAVITY

The change from QWR to the half-wavelength cavity (HWR) results in the loss of QWR advantages – simple cavity tuning and easy structure inner surface treatment. QWR tuning is made by the bottom plate deformation, which changes capacitance between the inner electrode end and the plate. Usually the tuning plate is made from 1 mm thick Nb sheet and the tuning sensitivity is within 3-5 kHz/mm. The design of such tuning is simple as there is a free access to the plate and the tuning forces are low. In the HWR the known mechanism for the tuning is the deformation of the central part of the cavity around the beam pipe join to the outer conductor wall. This is equivalent to the accelerating gap capacitance change and the sensitivity is defined by the gap size (around 50 kHz/mm). The design of the tune mechanism is complex as there is no much space in this region and forces and stresses are rather high.

Another advantage of QWR before HWR is a good access to the structure volume for the inner cavity surface treatment. In QWR the tuning plate is dismountable because of the low magnetic field value in the region of contact joints. This allows easy surface treatment. In the HWR magnetic field is maximal on top and bottom shortcut plates and they should be welded to the cavity walls before the surface treatment. The possible solution for the HWR can be additional pipes on the shortcuts, which can be used later as vacuum or coupling ports. Taking into account all above discussed we propose the three-quarter wavelength structure 3QWR (Fig.6) that combines advantages of QWR for easy tuning and surface treatment and of HWR for the magnetic field absence on the beam axe [5].

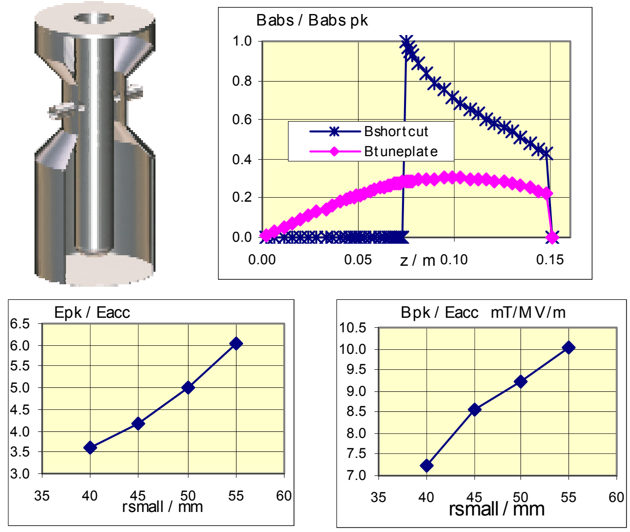

Figure 6: Three-Quarter Wave-Length Cavity.

Fig.6 shows also some structure parameter dependences on inner electrode radius in the central region ("rsmall"), which have been used for cavity geometry optimisation.

3 DISMOUNTABLE TUNING PLATE

The possibility to use the dismountable tuning plate like in QWR is considered.

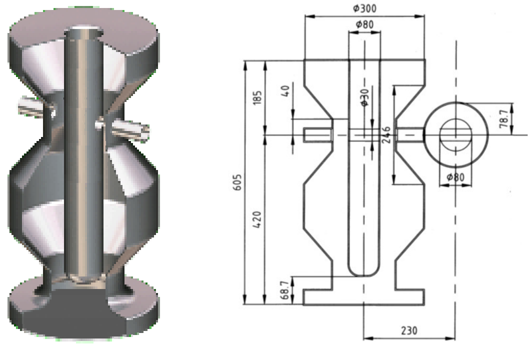

Figure 7: 3QWR with Modified Bottom Capacitance.

One of the most important parameter in 3QWR is the magnetic field value in the region of tuning plate joints (Fig.6) in comparison with B_{pk} on the upper flange. To ease the situation with magnetic field value on contacts a modification of the bottom part of the cavity has been made (Fig.7) – an additional side capacitance minimized the magnetic field penetration in the bottom cavity volume. The bottom capacitance gap is kept the same as the accelerating gap to get the same magnitude of maximal surface electrical field E_{pk}.The parameters of such modified three-quarter wavelength "tower"-cavity are shown in Table 2. For the last cavity option the accelerating field limit at 2 mT contact magnetic field is 10.3 MV/m.

Table 2: Parameters of 3QWR with Modified Bottom Capacitance

Frequency	MHz	323.1
β=v/c		0.2
Z_{top}	cm	15
R_{small}	cm	4
R aperture	cm	1.5
$Z_{cell}=\beta\lambda/2$	cm	93.69
R_{cav}	cm	56
E_{pk} / E_{acc}		4.06
B_{pk} / E_{acc}	mT/MV/m	8.62
B_{pk} / E_{pk}	mT/MV/m	2.13
$B_{contacts}$ / E_{acc}	mT/MV/m	0.195

The possible four "towers" in cross-cavity installation is shown on Fig.8. The well developed elliptic cavity technology may be applied for outer conductor manufacture.

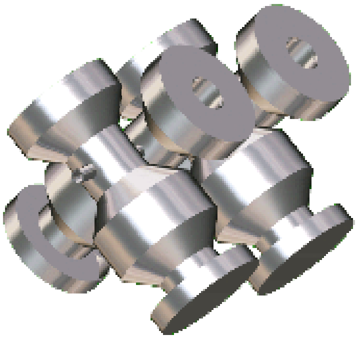

Figure 8: Four "Towers" in Cross-Cavity Installation.

4 REFERENCES

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