H-CAVITY BASED ACCELERATING STRUCTURE FOR PROTON ACCELERATOR

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Abstract

Nowadays there is a growing interest in high intensive proton sources for different types of applications: neutron sources, Accelerator-Driven Subcritical Reactors (ADSR), nuclear waste transmutation, neutron factory, etc. Different types of accelerating structures for different beam energies are developed in leading centers all over the word [2]. This paper presents the results of numerical modeling accelerating structure for low (0.01-0.04) beta range. Two operating frequencies 144 MHz and 433 MHz were analyzed in detail. The influence of geometrical sizes to the main electrodynamic characteristics was investigated to find out the optimal configuration.

CAVITY DESIGN

Today there are many projects of high current accelerator complexes one of which is BWLAP (Backward Wave Linear Accelerator of Particles). The R&D work was dedicated to the front-end part of this complex. For this purposes inter-digital H - mode (IH) resonators (see Fig. 1) consist of drift tubes, stems and pilons were chosen [3].

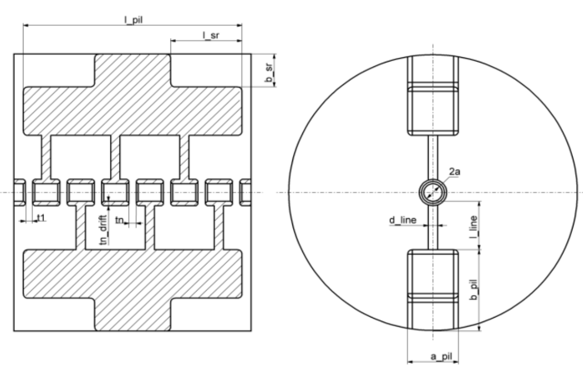

Figure 1. IH - Tank layout.

Period D of the structure is constant and it is equal to:

$$D = \frac{\beta\lambda}{2} \tag{1}$$

as for all IH-structures working in π - mode regime.

Operating frequencies (144 MHz and 433 MHz) of front - end part were chosen according to the frequency of the main accelerator (1300 MHz). It is third (433 MHz) and ninth (144 MHz) harmonics.

Simulation Process

Since the IH - structure is periodical the first step of research process was performed on one geometric period (see Fig.2) which includes two electric periods.

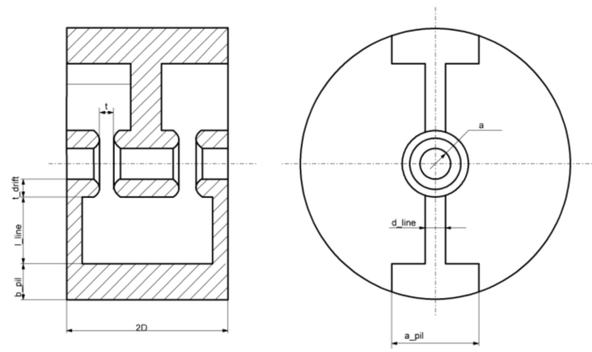

Figure 2. One period layout.

Two magnetic boundary planes were used at the opposite sides of the model to create correct field distribution. In such type of cavities electric field concentrates between drift tubes in opposite directions in neighboring gaps. Magnetic field also directed along the beam axis but it is suited at the opposite sides of the stems.

At the center of drift tubes there is a lack of electric field and presence of the longitudinal component of magnetic field. It would be the best place to locate magnetic boundary plane. Also one magnetic symmetry plane (belonging to the axis of the stems) was used to increase the accuracy.

At this stage IH - resonator demonstrated high values of shunt impedance: from 300 MOhm/m to 800 MOhm/m for different frequencies, aperture radii, accelerating gaps and geometric sizes of the stems and pilons. It should be noted that for this beam velocity range better to use lower frequency since it's got higher wavelength and higher period value. For example in case of the 433 MHz and $\beta = 0.01$ period D is equal to 3.5 mm. Such design couldn't be practically realized and they were not taken into further consideration.

Full Structure Modelling

After structure adjusting at one geometric period full tank (see fig.1) was simulated. But the field inside whole resonator isn't the same as inside one period. There is a difference of the magnetic field distribution at the central part of the resonator and at the end part of resonator. At the central part magnetic field has longitudinal component as in case with one period. At the end parts magnetic field turns around the pilon. It leads to the different field

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distribution, different working frequency of the end circuits (comparing to the central part of the structure). As a result we have irregular electric field distribution along the beam axis and low efficiency of the resonator. At this stage optimizing of the electric field distribution was our main goal. To characterize the irregularity special coefficient was introduced:

$$K_{ir} = \frac{E_{\max} - E_{\min}}{E_{\min}} \cdot 100\% \tag{2}$$

The models with 7, 8 and 9 electric periods were simulated. At first all researches were performed with operating frequency equal to 352MHz. Such structures have higher period value (comparing to the 433MHz version) and lower geometric sizes (comparing to the 144MHz version). For initial investigations it was best choice between simulation time and possibility of changing geometry of the structure.

At the beginning there was not any pilon recess in the model (as one can see on fig.1). There were only gaps between end wall of resonator and pilons to make a closed flux of magnetic field around pilon. As one can see in the Table 1 structure without pilon recess has worst irregularity. But using the pilon recess didn't improve the irregularity significantly.

Table 1: Influence of the pilon geometry.

Type of modifications	K_{ir},%
Without modifications	63
Changing the gap between pilon and end wall	60
Using rectangular pilon recess	53

The next step of optimization was modification of the end cell geometry. Firstly the thickness of the end cells lying on the end wall of the resonator was changed. The irregularity became better: 39 %. Secondly the thickness of the two nearest end cells and the gap between them was changed. Employment these methods decrease the irregularity till 11%. Our main goal was noticeable field increasing at the end accelerating gaps and soft increasing at neighbor gaps. It was realized using end cells geometry described at the fig.3.

As a result irregularity is equal to 5 % with the field distribution showed at the fig.4.

All of these techniques make irregularity better but they have a negative influence on the shunt impedance value: without modifications it was equal to 250 MOhm/m; after using all this techniques it became 130 MOhm/m. But it should be noticed that increasing the amount of periods inside the tank makes the value of shunt impedance (reduced) higher.

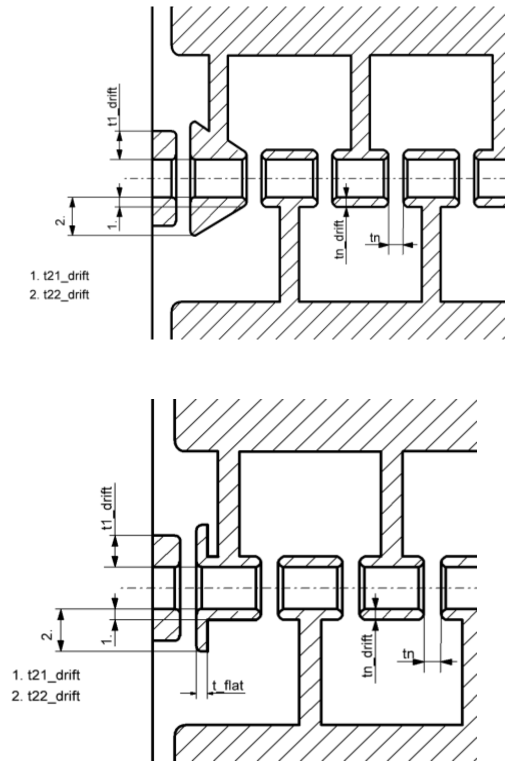

Figure 3. Different types of end cells modifications.

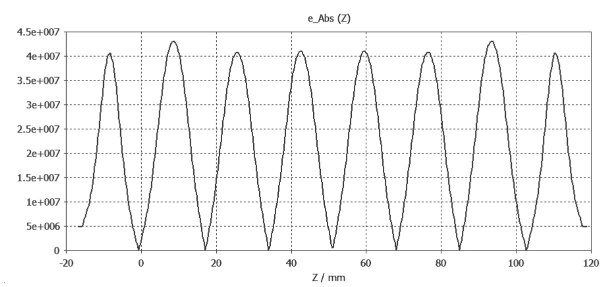

Figure 4. Field distribution after end cell modifications.

CONCLUSION

In this article the adjustment of IH-structure for low beta acceleration was presented. Two operating frequencies were considered: 144 MHz and 433 MHz. Full tank containing 7, 8 and 9 periods was modeled. Best results were obtained in the case with working frequency 144 MHz: good field flatness (better than 98%) with best values of shunt impedance for different aperture radii.

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