

# HIGH-CURRENT ION LINAC CALCULATION

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The research on multibeam ion accelerators has been carried. Full analysis of the oscillating system on example of a HCIL cell containing a pair of conducting rings (CR) with drift tubes (DT) and a central drift channel was carried out. High-current electronic beam is used as an electromagnetic power supply, which not exclude an external power source. Interaction factor of an electronic beam with a field of about 100%, kiloampere currents and megawatt power levels allows to produce a compact electron-beam pumping system with drift tubes shorter then wavelength.

*PACS number: 29.17.+w*

## 1 INTRODUCTION

In earlier works [1, 2] the research on the multibeam cavity of HCIL was performed according to analytical calculations of Boyd [3] and Andreev [5]. However, previous calculation does not permit to investigate fully the structure geometry dimensions.

In this research presented is a full analysis of the oscillating system. The equivalent Prieszhev's method replaces Boyd's method [4].

## 2 MULTIBEAM CAVITY ANALYSIS

It is obvious, that effective interaction between multibeam ion jets and the field could be achieved only at a resonance frequency when the base mode prevails. So the ultimate aim of this research was to determine the structure geometry. Examining a single cavity cell containing a pair of conducting rings (CR) with drift tubes (DT) and central drift channel (CDC), assumed that the resonance frequency of a cell equivalent to the eigenfrequency of the cavity, on conditions that a phase difference between single cells by the cavity length is zero, and identifying the structure with a Boyd type cavity, we could write down a dispersion equation based on the circuit theory. It allows connecting phase shift on an azimuthal period with a resonance frequency:

$$\cos \varphi = \cos \theta_0 - 0.4(\theta_0 \sin \theta_0) / F^2, \quad (1)$$

where  $F^2 = 1 - (\lambda_{dt} / \lambda_{kr})^2$ ,  $\theta_0 = (2\pi / \lambda_{dt}) DF$ ,  $\lambda_{dt}$  – cell wavelength,  $D$  – azimuthal period,  $\varphi$  – phase shift between azimuthal parallel channels.

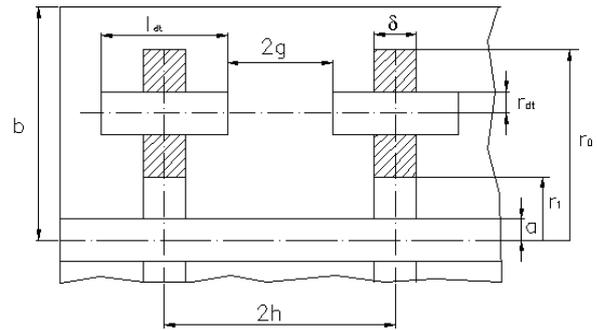
$\lambda_{kr}$  is a parameter defining the geometry structure:

$$\lambda_{kr} \cong \pi \sqrt{2 \frac{(\eta - d_{dt})}{\zeta}}, \quad (2)$$

where  $\zeta = \frac{2g}{2h}$ ;  $\eta = b - a$ ,  $2g$  – distance between DT.

All dimensions are shown in Fig. 1.  $2h$  is a period along the cavity. The equation  $2h = \beta \lambda_0$  defines zero wave mode in the structure, where  $\lambda_0$  is a cell wavelength without loading DT. The value of  $\lambda_0$  could be obtained from the partial areas method [2].

Thus, set of equations (1), (2) allows to solve the problem put by.



*Fig. 1. Single cell geometry.*

## 3 CALCULATION RESULTS

The multibeam cavity calculation was carried out using the methods described in part 2. The equation (1) was replaced by the simplified version:

$$\cos \theta_0 = 1 + 0.4(\theta_0 \sin \theta_0) / F^2, \quad (3)$$

where  $\varphi = 0$  because of identical conditions of accelerating ions by azimuthal channels.

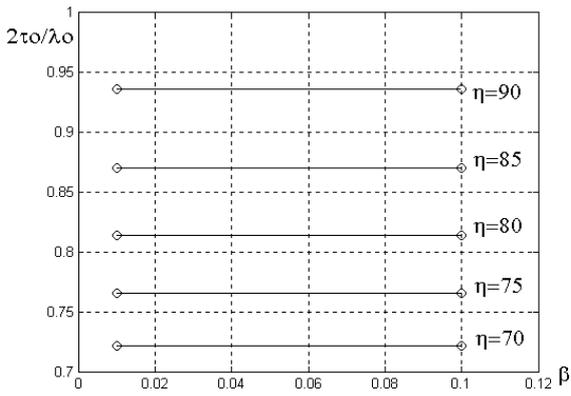


Fig. 2. Unloaded cell geometry versus wavelength.

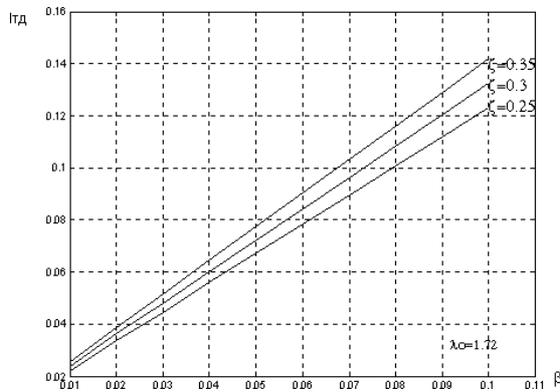
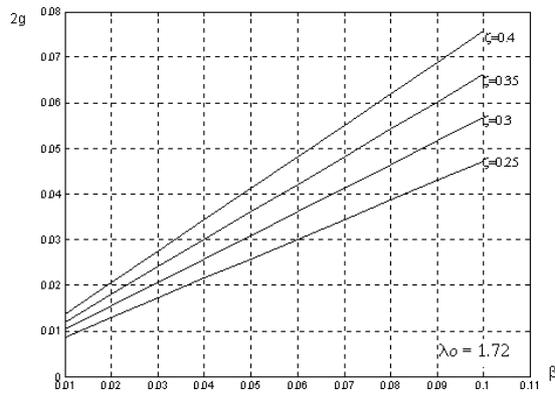


Fig. 3. General geometry parameters of HCIL.

Fig. 2 shows the dependence  $2r_0/\lambda_0(\beta)$  with various  $\eta$  for an unloaded cell. As graph shows,  $\lambda_0$  is weakly depended from dimensions of CR that is explained by features of zero wave modes, i.e. by the absence of field variations along the structure. The graph obtained specifies initial conditions for calculations.

Then from Fig. 2 we choose values of  $\eta$ ,  $\lambda_0$ ,  $r_0$

and  $N$  – number of DT by azimuth (in our case  $N = 20$ ). From Eq. (3) we could find out the resonance wavelength as a function of  $\zeta$  with various  $\eta$ .

Fig. 3 shows the graphs determining DT dimensions from equations:

$$\begin{cases} 2g = \zeta\lambda_0\beta \\ \lambda_{dt} = \beta\lambda_0(1-\zeta) \end{cases} \quad (4)$$

For all graphs:  $\beta \in (0.01 - 0.1)$ ,  $d = 10$  cm,  $a = 5$  cm,  $r_1 = 10$  cm,  $\alpha = 0.9$ .

## 4 CONCLUSION

As a result it became possible to calculate the multi-beam cavity for a specified mode. Also, presented graphs could be used in construction of an experimental model.

Note that the structures with such a complicated configuration should be calculated in programs like MAPHIA, which are expensive and give miscalculation in determining the resonance frequency for sophisticated structures about 20-30%. It is obvious, that if the method presented also would give miscalculation about 30%, it must be preferred. In any case it determines all general parameters of the model, which may be later adjusted in experiment.

The way of using graphs is following (Fig. 2-3). For the calculation one should assign values of  $d_{dt}$ ,  $a$ ,  $r_1$ ,  $\alpha$ ,  $\eta$  then define  $\lambda_0$  with a fixed  $r_0$  (Fig. 2), after this  $\zeta$  should be selected and  $\lambda_{dt}$  calculated ( $\lambda_{dt}$  in different cells should be constant). Fig. 3 defines general geometry parameters.

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