The Investigation of Coupler for Linear Collider Accelerating Section

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Abstract

It's considered the questions of electric field overstrength measurement at the most disposed to breakdown surfaces of coupler model. It's shown that the value of the field overstrength coefficient (FOC) on the disk surface and on the inner surface of the coupler with one structure period height is 10% more than FOC for the disk loaded waveguide (DLW). For a coupler with lesser value of coupling coefficient the electric field strength for coupler is lesser than for DLW. Amplitude and phase coupler symmetry has been investigated.

There are specific requirements for the VLEPP type linear collider couplers [1]: the electric field strength at the most disposed to breakdown surface should not exceed that at the waveguide disk aperture surface; electric field amplitude and phase in the coupler beam channel should be symmetric. Furthermore the coupler should be highly matched with DLW at operating frequency as well as in a frequency band (for the VLEPP case the band is±100 MHz around the operating frequency 14 GHz). In the handbook [2] there is information on the preliminary choice of a coupler dimensions, which ensure matching at operating frequency. Also there are constructions which enable to diminish the field asymmetry in the beam channel. We'll consider the coupler in which for the field symmetrization there is cut off waveguide section placed opposite the input waveguide.

Analysis of the DLW and couple electrodynamic characteristics can be carried out on the basis of the coupled resonators model [3] according to which the section normalized input impedance at operating frequency f_0 is equal to unity and its dependance on the frequency f is minimal,if

$$(k_1/k_0)^2=2$$

$$f_1=f_0\sqrt{1+k_0\cos\theta_0}=f_c$$

$$c_1=1+Q_1(f_0/f_1)k_0\sin\theta_0$$

here f_1, Q_1 and k_1 - resonant frequency, Q-factor of a copler and its coupling coefficient with DLW; f_c, k_0 - resonant frequency and coupling coefficient of DLW, β_1- coupling coefficient between the couple and input waveguide, θ_0 - operating mode.

The experiential investigations were carried out on the coupler which had the shape corresponding to that of VLEPP accelerating structure but its dimensions were changed according the operating frequency sealing from 14 GHz to 2919.5 MHz.

The resonance model was used for discovering of maximum electric field strength places in the coupler surface. It consists of the coupler connected with waveguide rectangular section with sliding short-circuit plunger, and a short-circuited DLW section. A section length can be changed with a step of one half-cell. There is a possibility of perturbation bead displacing along surfaces of six former disks including disk at the coupler and its face surface. The perturbation dielectric bead had a rectangular form with sizes 2.3*1.0*0.5 mm^3 and its formfactor was equal k_e=6.11e-21 m^2s/Ω. Formfactor was defined at the ideal resonator considering mirror effect. Measurements of maximum frequency deviation f_{max} was carried out by displacing of perturbation bead along disk surface for DLW using a resonators that consisted of 3,3.5,...,6 cells consistently. If number of DLW cells was changed than short-circuit plunger at the rectangular waveguide had been installed for excitation of the resonator $2\pi/3$ mode at DLG. A normalized value the amplitude of fundamental harmonic of the longitudinal electric components at the structure axis were measured for each DLW cut off section length. The FOC k was defined as

$$k=\xi_{s\,max}/\xi_0$$

$$\xi_{smax}=E_{smax}/\sqrt{PQ}=\sqrt{W_{smax}/(2\,k_e f^2)}$$

Results of measuring by automatic installation [2] for the one DLG period height coupler are shown in the fig.1.

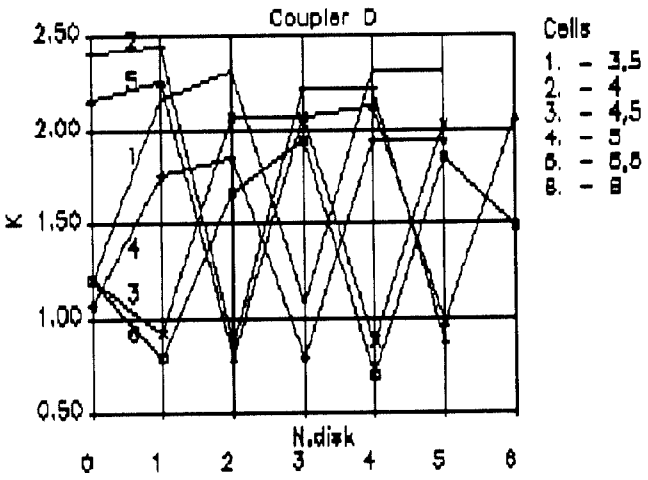

Figure 1. FOC for surfaces of different disks consisting of the resonator ($D=D_0$).

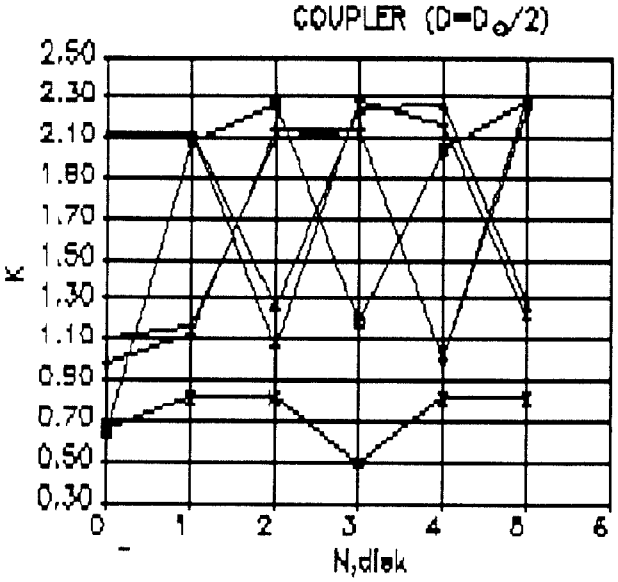

Figure 2. FOC for surfaces of different disks consisting of the resonator ($D=D_0/2$).

The value of FOC is equal 2.25 for considered shape DLG, and values of FOC for first disk (1) and face region (0) are at 10% more. The some measurements for one-half period height coupler has given value of FOC at 10% lesser (fig.2).

For the field symmetrization quality evaluation we introduce the conception of average over copler cavity length longitudinal field amplitude (ΔE) and phase ($\Delta\varphi$) deviations taken at the distance h toward x-axis about the coupler beam channel geometric center, $h/2$ satisfying the condition $h/2—a$ (a - aperture radius at the DLG disk) The field amplitude and phase asymmetry can be described as the relative parameters:

$$\frac{A}{h} = \frac{\partial E_z/\partial x}{E_z} = \frac{2\ (E^+ - E^-)}{h\ (E^+ + E^-)}$$

$$\frac{\varphi}{h} = \frac{2\ (\varphi^+ - \varphi^-)}{h\ (\varphi^+ + \varphi^-)}$$

where E^+ and E^-, φ^+ and φ^- are the electrical field strengths and phases measured along z-axis at the coupler at the coordinates $x= h/2$, $y=0$.

The investigations were carried out on the coupler which had the shape corresponding to that of VLEPP coupler in S-band. The dependance of A/h on the coordinate x for the three values of h is presented in fig 3 and the dependance of φ/h on the coordinate x for values of h equal 7 mm is presented in fig.4.

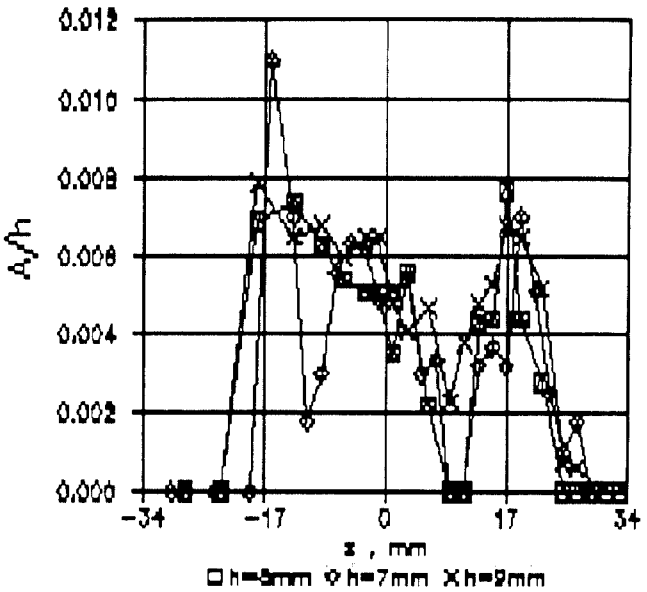

Figure 3. The dependance of A/h on the coordinate x

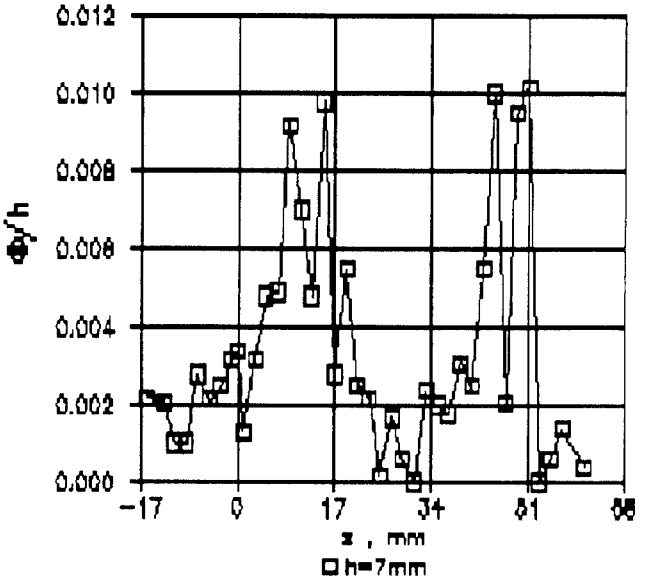

Figure 4. The dependance of φ/h on the coordinate x (h=7mm)

The average values of A/h=0.006 1/mm, φ/h=0.004 1/mm. The results are better for the coupler which has the cut off waveguide dimensions equals the width of input waveguide coupling window.

References

[1] L.N.Arapov, V.E.Balakin, V.R.Fogel, V.I.Fominyh, V.D.Shemelin "The construction of VLEPP accelerating structure", in Partical Accelerating Conference, 1989

[2] O.A. Valdner, N.P.Sobenin, B.V.Zverev et all, Handbook of Disk Loaded Waveguide, Moscow: Energoatomizdat, 1991

[3] N.P.Sobenin, S.V.Ivanov, V.E.Kaljuzhny, S.N.Plotnikov "Calculation and Experimental Study of Circular Disk Loaded Waveguide Impedance Characteristics" in proceeding of this conference