The Effect of Cross-Section Area of Electron Beam on the Aberration of Einzel Electrostatic Lens

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Abstract: *A theoretical study by using computer model is presented by fitting an axial electrostatic potential distribution to polynomial function of fourth order from which the paraxial –ray equation is solved to obtain the trajectory of particle that satisfy the suggested potential function. The distribution of the axial potential up or on the lens of length (22mm) has been carried out using Laplace equation by using Finite element method., the results are obtained for Cs and Cc normalized in terms of the results showed low value of spherical and chromatic aberration comparing with other searches about(2.42) for spherical aberration and(0.03) of chromatic aberration, of this study showed small values of spherical and chromatic aberration, with values of area of which considered as(3mm^2).*

Keywords: Electron Optics, Einzel Lens, Electrostatic Lens, spherical aberrations, chromatic aberrations .

1. Introduction

The most commonly used einzel lens have two electrodes to the relationships between their electrode. The distinctive feature of einzel lens is that the has the same constant potential at both the object and image sides that's mean the charged partial energy remains unchanged [1]. The present work has been mainly concentrated on the design of two electrode type electrostatic electron lenses, the trajectory of electron beam through an axially symmetric electrostatic lens[2]. Progress in the calculation of electron optical properties in recent years have been reviewed by [3] and [4].

2. Theory

The trajectory of charge particles through an axially symmetric electrostatic lens field,in terms of the axial potential field V(z) and its first and second derivatives V(z) and V(z) respectively, is given by the following equation[5]

$$\nabla^2 V(z) = 0 \quad \text{--------------------(1)}$$

where r is the radial displacement of the beam from the optical axis z, and the primes denoted a derivate with respect to z, The spherical and chromatic aberrations are dominant in an electrostatic lens [6]. The spherical aberration and chromatic coefficients Cso and Cco respectively at the object plane have been computed with aid of the two following formulae [7].

$$Cs_O = \frac{V^{-1/2}(z_o)}{16 r_o'^4} \int_{zo}^{zi} \left\{ \left[\frac{5}{4}\left(\frac{V''(z)}{V(Z)}\right)^2 + \frac{5}{24}\left(\frac{V'(Z)}{V(z)}\right)^4 \right] r^4(z) + \frac{14}{3}\left(\frac{V'(Z)}{V(z)}\right)^3 r'(z) r^3(z) - \frac{3}{2}\left(\frac{V'(z)}{V(Z)}\right)^2 r'^2(z) r^2(z) \right\} V^{1/2}(z)\, dz \text{----------------(3)}$$

$$Cc_O = \frac{V^{1/2}(z_o)}{r_o'^2} \int_{zo}^{zi} \left[\frac{1}{2}\frac{V'(Z)}{V(z)} r'(z) r(z) + \frac{V''(Z)}{4V(z)} r^2 \right] V^{-1/2}(z)\, dz \text{---------(4)}$$

In the image space, the spherical aberration coefficient **Csi** and chromatic aberration coefficient Cci is expressed in a similar form of equations (3) and (4).

3. Results and Discussion

The axial potential obtained from the solution of the paraxial ray equation are plotted in figure (1). F igure (2) represent the trajectory of the charge particle (3) and (4) shows the relative spherical and chromatic aberration as function of the area, Figure (5), (6) shows the relative spherical and chromatic aberration as function of the voltage ratio(V1/V2), this figure indicates that the relative aberration coefficients decrease with increasing and the voltage ratio. The axial field distribution V(z) given in equation (1) for an einzel lens, Table (1) shows properties the electrostatic einzel lens operated under different aberration coefficient,, Table (2) shows spherical and chromatic aberration comparing with other searches.

Table 1: Shows the optical properties the electrostatic einzel lens

$S(mm^2)$	Cs/F	Cc/F
0.5	2.79	0.1
0.7	2.7	0.06
0.8	2.65	0.05
1.2	2.55	0.035
2	2.45	0.033
2.5	2.43	0.032
3	2.42	0.03

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Table 2: Shows the cooperation between searcher the electrostatic einzel lens

Vi/Vo	Cs/f	Cc/f	searcher
10	2.43	0.032	Present study
10	3.6	0.60	(Al-Meshhdany,2002)[9]
10	3.16	0.57	(Al- Khashab 2009)[10]

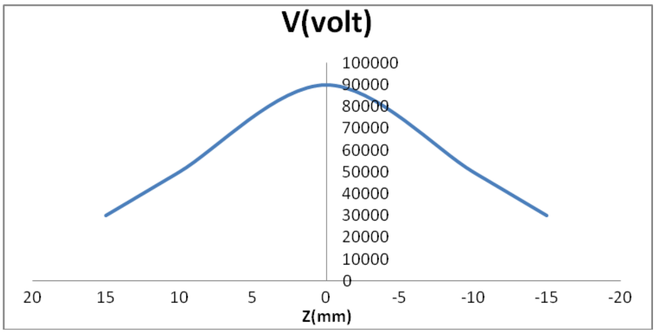

Figure 1: The axial potential distribution V(z)of einzel lens

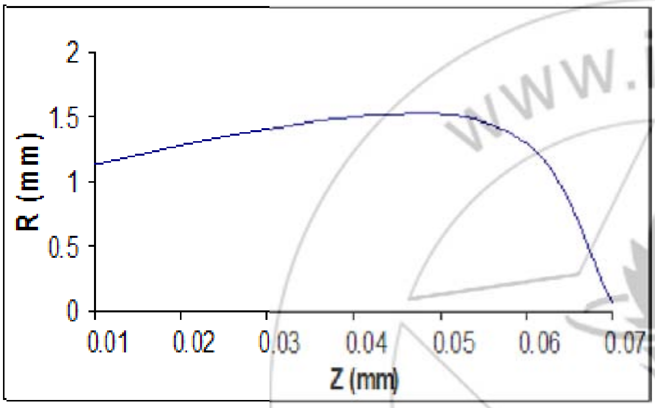

Figure 2: Trajectory of charge particles in the electrostatic einzl lens

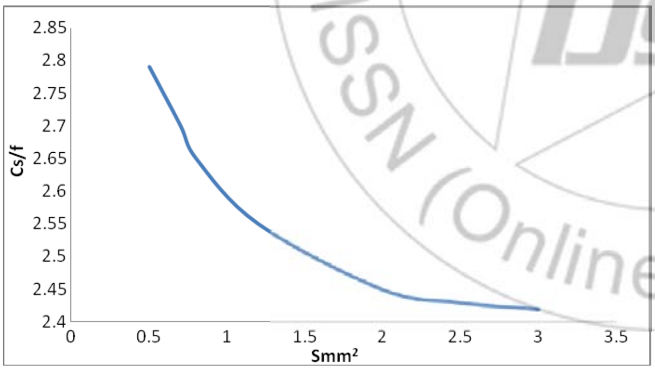

Figure 3: The relative spherical aberration coefficient Cs/f as function of area S mm^2

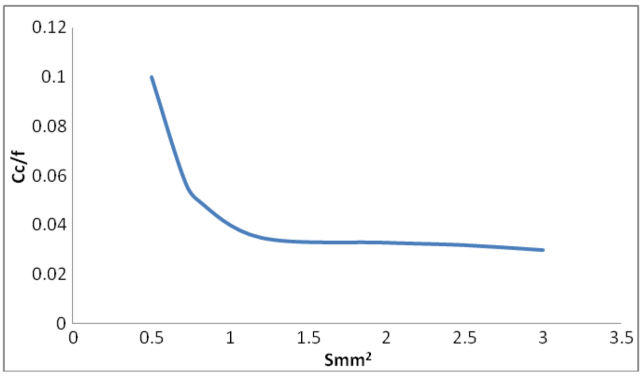

Figure 3: The relative spherical aberration coefficient Cc/f as function of area S mm^2

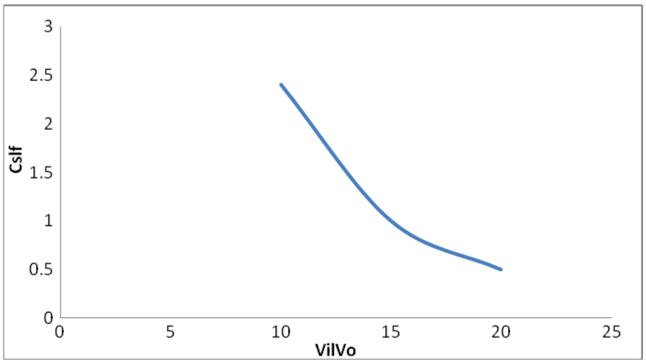

Figure 5: The relative spherical aberration coefficient Csi/f as function of voltage Vi/Vo

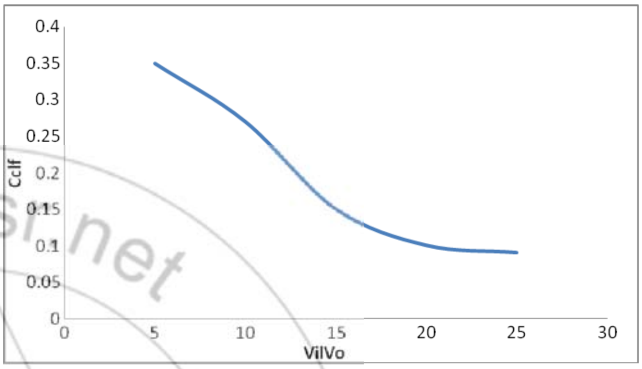

Figure 6: The relative spherical aberration coefficient Csi/f as function of voltage Vi/Vo

4. Conclusion

1) The potential evaluated by the simple inverse method for einzel lens and optical properties are also evaluated.
2) It has been found that it is possible to design an einzel lens with small aberration.
3) From the result it has been found that the aberration coefficient decreases .
4) It appears that the proposed analytic function of the axial potential field for an einzel lens offers considerable advantage with regard to the relative spherical aberration coefficient.

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