Optical Performance of the Two Cylindrical Electrostatic Lens of Different Diameter

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Abstract

Two cylindrical electrostatic lenses of different diameters has been designed , of the same length and separate by a distance G=1mm. The axial potential distribution and the focal properties were calculated. It was found that the different diameter of the inner or outer electrode play an important role for the optical performance of the lenses . It was noticed that the lens where D1<D2 (D1 the inner electrode and D2 the outer electrode) has the best optical properties at declerating mode while, the lens at has the best optical properties at decelerating mode when (V2<V1)while, the leans of D2<D1 has the best optical properties at accelerating mode of operation when(V2>V1) .

Key words : Two-cylindrical electrostatic lens, lens properties

Introduction

A lens having two–element allows a conjugate focus condition, and not to keep the image position constant while varying the voltage ratios in two ways, with an accelerating or a decelerating voltage ratio. (M.A.Al-Khashab and A.A.Ahmad,2012) .

Electrostatic lenses are used for the extraction , preparation and first acceleration of electron and ion beams .electrostatic lenses are of great importance in the design of low energy electrostatic accelerators like van de Graff accelerators. In the 1960s, two – element electrostatic lenses have been used in low-energy electron spectrometers to increase sensitivity and resolution . (Kuyatt and Simpson,1967) .

More accurate calculation of the electrostatic lens composed of two cylinders of equal diameter as was given by Read (Read *et at*.,1971). Details of the properties of several types of two–element co axial cylindrical electrostatic lenses were found in many references such as (Sziligyi, 1987) , and (Hawkes and Kasper,1996) .

The most important parameter which evaluating the lens performance are the aberration coefficients, and to reduce these coefficients requires smoothing the potential changes either by using a large number of lens electrodes and applying voltage having a small difference there between the lens electrode (Szilagyi and Szep, 1988) and (A.Hjazie *et al*, 2010) or by using a lens of different diameter (Tahani and Basma , 2009) .

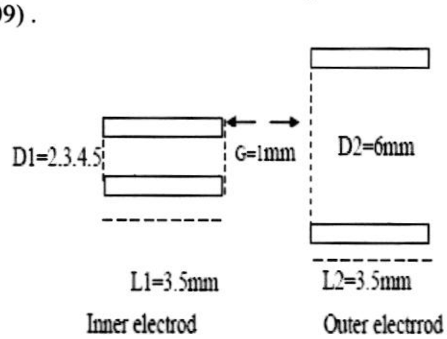

Fig. 1: the cross-section of the asymmetrical two-cylinders electrostatic lenses

Result And Discussion

(1)Calculation of the axial potential distribution

In this paper we shall demonstrate the design of the asymmetrical in equal diameter of the two–cylindrical electrostatic lens and intensive studies were carried out on the effect of the different diameter of the (1st cylinder) inner electrode while the diameter of the outer electrode (2^{nd} cylinder)is constant for two (accelerating and decelerating) modes at zero magnification and inverse.(J. Orloff and L.W. Sanson,1979) .

Experimental Work

Lens geometry

The cross section of two –element electrostatic lens with its geometrical parameters is shown in Fig (1),which consists of two coaxial cylinders of the same length (L1=L2=3.5mm) separated by a distance (G=1mm).The first cylinder called the inner electrode is placed at the voltage (Vo=10V) , while the second cylinder the outer electrode is placed at different voltages range[(VI=(150-450)V] .

The diameters of the inner electrode (D1) and the outer (D2)are in equal .we take two groups :

Group : (1)where D1<D2 i.e. [D1 changes from 2,3,4 and 5 mm while D2 remain constant at 6mm theses denoted by D26,D36 ,D46 and D56 .

Group (2): D2<D1; these lenses denoted by D62,D63, D64and D65.Also we take the case that D1=D2 and this is denoted byD66. Also the same procedure were carried out for by change the outer diameter and studying the inner diameter constant .

The calculation of the properties of any electrostatic lens system requires a knowledge of the axial potential distribution (Vz), along the whole optical axis (Z) .

The values of Vz were computed by the aid of program E11 introduced by Munro in 1975 (Munro, 1975) using the Finite Element Method (FEM) .

Fig . (2) shows the axial potential distribution for the two groups of the electrostatic lenses for accelerating and deaccelerating modes .

(a) accelerating mode

It should be mentioned that the lens will be locally convergent if the curve of Vz against Z is concave up wards and divergent if the curve concave down words (Grivt, 1972) . so, for the region from (z = -5mm to z= 1mm)which shown in the fig (2-a) for the group (1) is called a convergent region. In this region the longitudinal component of the electric (Ez) retards the electrons and making the electrons moving more slowly , and the convergent power increases . while region from (Z=1mm to 5mm)is called a divergent region . In this region the Ez accelerates the electrons and making the electrons moving faster. Thus the diverging power diminishes and the convergent effect always exceeds the divergent effect and the whole lens becomes convergent. It is clear from the above proviso figure that for the group (2) of the lenses where D2<D1 , the gradient of the potential increases gradually, and the curve concave upwards more, this means that the group (2) of lenses are more convergent and having a high convergence power than group (1) at accelerating mode of operation .

(b) declerating mode

It is clear from the fig (2b) that group (1) where (D1<D2) of lenses are more convergent and having a high convergence power , because the curve of Vz a gainst Z is cocave upwords, while group (2) where (D2<D1)of lenses will be locally divergent from (Z=-5 to Z=1mm)and locally convergent from (Z=1mm to Z=5mm)but the convergent effect always exceeds the divergent effect and the whole lens becomes convergent.Thus, the lenses of group (1) having a high convergence power than the group (2) of lenses at decelerating mode of operation .

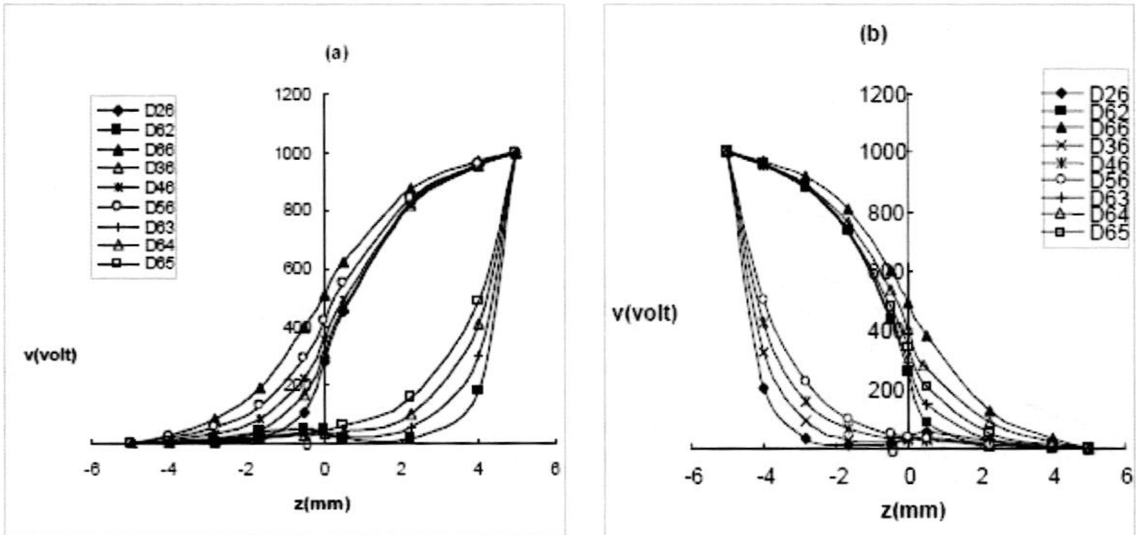

Fig. 2: show the axial potential Vz as a function of z for the two groups of lenses at (a) accelerating (b) decelerating mode of operation.

(2)calculation of the electron optical properties of lenses

The optical properties of the two groups of lenses for accelerating mode where V1=10V and V2= 350Vare shown in Table (1), which , reperesents a coparison between the focal length, the relative spherical aberration coefficients to the focal length (Cs/f) and the relative chromatic aberration coefficient to the focal length (Cc/f). These analyses abviously indicate that the group (2)of lenses has acquired the best values of the optical performance thes the group (1) .

Table 1:A comparison between the focal length ,the relative spherical aberration coefficients to the focal length (Cs/f) and the relative chromatic aberration coefficient to the focal length (Cc/f) for the two groups at accelerating mode

Group1	F(mm)	Cs/f	Cc/f	Group2	F(mm)	Cs/f	Cc/f
D36	6.86	3.45	6.5	D63	5.21	2.3	7.23
D46	9	2.5	6.1	D64	6.18	1.13	3.52
D56	11.25	3.14	5.7	D65	7.69	0.59	3.9

As in the previous table ,The optical properties of the two groupes of lenses for deaccelerating mode where V1=350V and V2=10 V are shown in table (2) .

Table 2: A comparison between the focal length , the relative spherical aberration coefficients to the focal length (Cs/f) and the relative chromatic aberration coefficient to the focal length (Cc/f) for the two groups at deaccelerating mode

Group1	F(mm)	Cs/f	Cc/f	Group2	F(mm)	Cs/f	Cc/f
D36	0.68	0.95	0.88	D63	0.72	1.22	0.37
D46	1.01	0.25	0.32	D64	1.16	1.28	0.37
D56	1.29	0.31	3.9	D65	1.55	1.45	0.4

and Cc/f) of the two groups of lenses as a function of voltage ratio V2/V1 under zero magnification for acclerating Mode of operation .This figure shows that the lower values of Cs/f and Cc/f are obtainal for the lens D65 at low valus of voltage ratio V_2/V_1 . for acclerating mode of operation .

These analyses obviously indicate that the group (1) of lenses has acquired the best values of the optical performance than the group (2) .The choice of a favorable lens largely depends on its focal properties . Fig. 3 (a,d)represents the comparion of the relative pherical and chromatic aberation coefficients (Cs/f

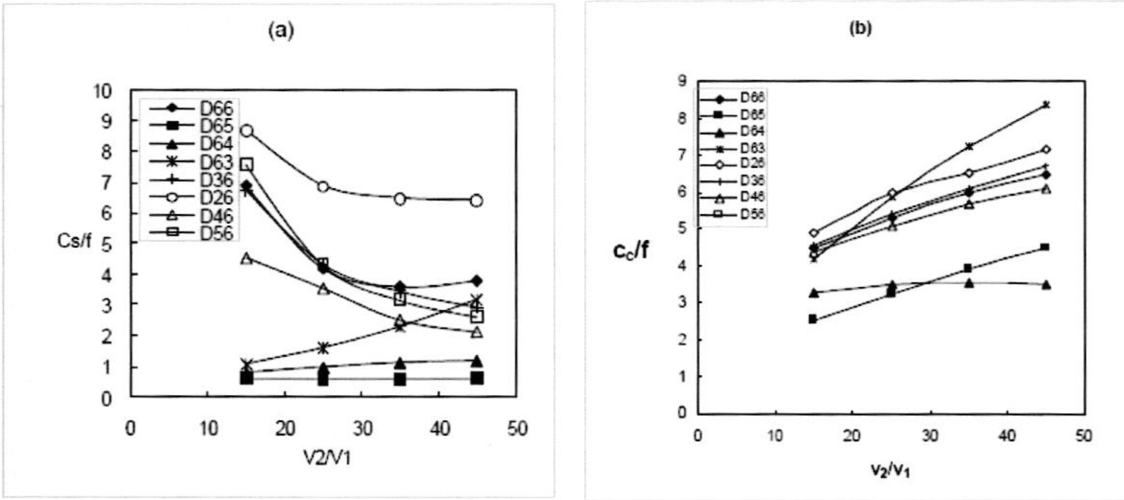

Fig. 3 :(a) The spherical and (b) chromatic aberration coefficients Cs/f and Cc/f as afunction of voltage ratio V2/V1 under zero magnification condition for acceleratingmode

Fig 4(a,b) shows that lens D46 has alower values of Cs/f and Cc/f for declerating mode of operation .
The above results indicated that the best optical properties acquired group (2) of lenses at acc. mode and group (1) at decleraty mode of opertion .

Fig.4 (a,b) represents the comparion of the comparion of the relative spherical and chromatic aberration coefficients (Cs/f and Cc/f) of the two groups of lenses as a function of voltage ratio V2/V1 under zero magnification for acclerating mode of operation .

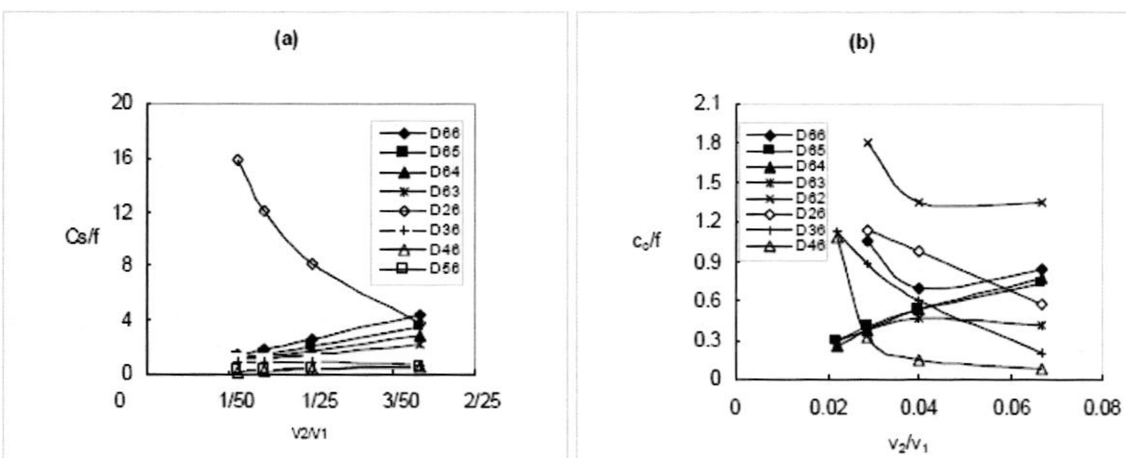

Fig. 4 :(a) The spherical and (b) the chromatic aberration coefficients Cs/f and Cc/f as afunctionof voltage ratioV2/V1 under zero magnification condition for daccelerating

The optical properties of the special case where D1=D2=6mm this lens denoted by D66 Fig. 5, shows the axial potential distribution of This lenses for two mode of operation. It is clear from this Figure that the lens D66 hase the same axial potential distribution of the lense of group (1)at acclerating mode and the same distribution of axial potential for the group (2)at deacclerating mode This mean that lens of equal diameter D66 is not prefered to use as electrostatic lens for two mode of operation as show in Table 3 .

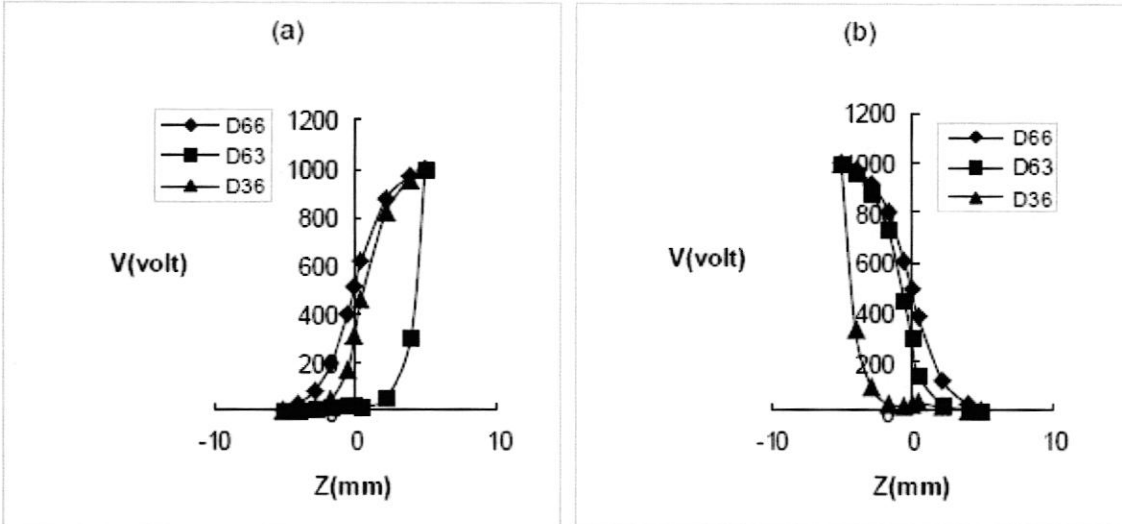

Fig. 5: Show the axial potential Vz as a function of z of the above mentioned lenses(D66,D63,D36) for accelerating and deaccelerating mode

Table 3:The optical properties of equal diameter electrostatic lens D66 compaired with D63 and D36 lenses

Lens	Accelerating			Deaccelerating		
	F(mm)	Cs/f	Cc/f	F(mm)	Cs/f	Cc/f
D66	13.10	3.6	5.98	2.23	1.84	1.06
D63	5.21	2.3	7.23	0.72	1.22	0.37
D36	6.86	3.45	6.5	0.68	0.95	0.88

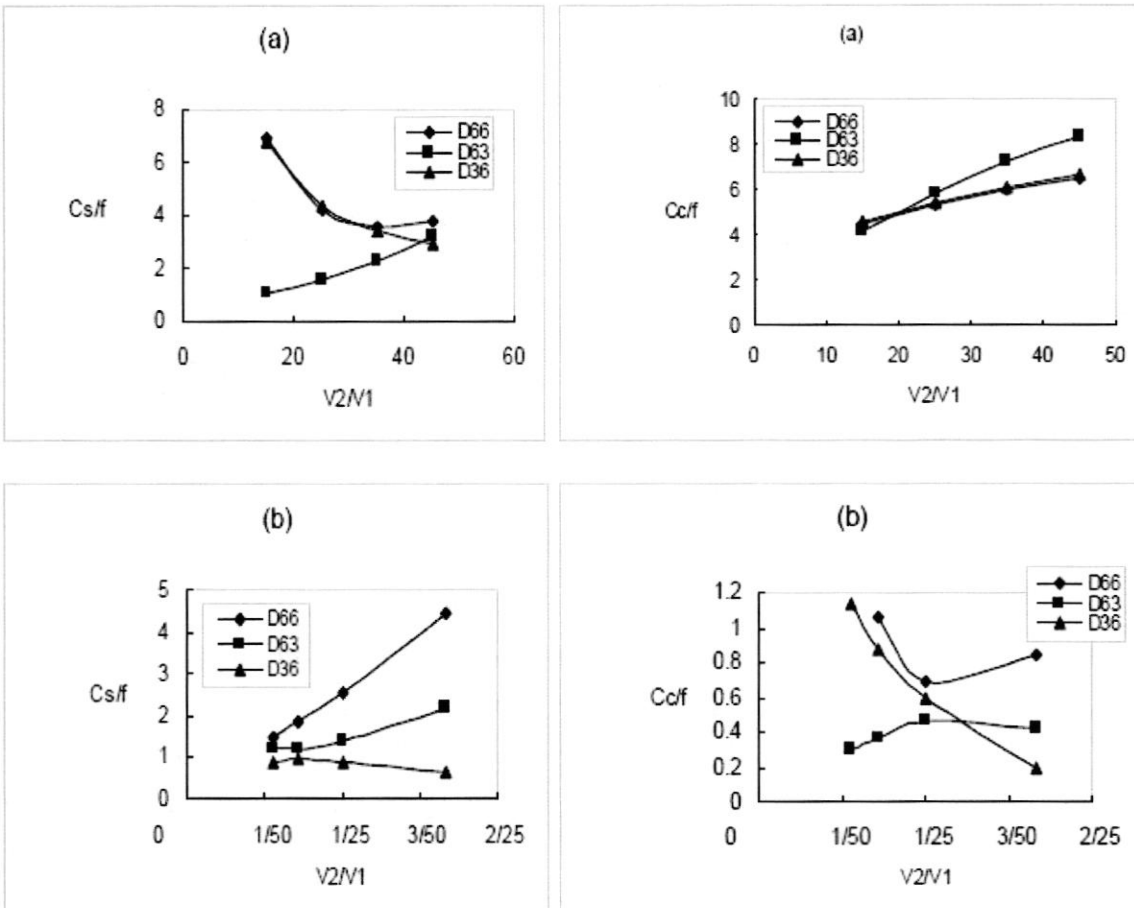

Fig. 6:The spherical and chromatic aberration coefficients Cs/f andCc/f as afunction of voltage ratio V2/V1 under zero magnification condition (a) deaccelerating and (b) daccelerating in(D66,D63,D36)

Conclution

It appears from the present investigation that the inner and the outer diameter of the two – cylindrical electrostatic lens have agreat effect on the performance of this lenses .It has been found that :

1- The lenses of group (1) (i.e $D_1<D_2$) (D1 the dimeters of the inner electrode and D2 the outer) having a high convergence power this group (2) (i.e$D_2<D_1$)at deacceleraty mode while group (2) having high convergen power than group (1) at accelerating mode of operation .

2- From the results it has been that the best optical properties acquireal group (2) of lenses at accelerating mode and group (1) at deaccelerating mode of operation .

3- It has been found that lenses of equal diameter is not preferable to use in both modes of operation .

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الأداء البصري للعدسة الكهروستاتيكية الثنائية الأقطاب الاسطوانية ذات الأقطار المختلفة

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الملخص

تم تصميم عدسات كهروستاتيكية ثنائية الأقطاب الاسطوانية بأقطار مختلفة ذات الأطوال المتساوية والمسافة بين القطبين (1 ملم) . وتم حساب توزيع الجهد المحوري والخواص البصرية لهذه العدسات ، وقد وجد بان اختلاف القطر القطب الداخلي أو الخارجي للعدسة يلعب دورا مهما على الأداء البصري لهذه العدسات . وقد لوحظ بأن العدسات التي لها D1<D2 (D1 هو القطر الداخل وD2 هو القطر الخارج) تمتلك خواص بصرية جيدة عند نمط التشغيل المبطئ عندما(V2<V1) في حين العدسات التي لها D2<D1 تمتلك خواص بصرية أفضل عند نمط التشغيل المسرع عندما (V2>V1) .

الكلمات المفتاحية : عدسة كهروستاتيكية ثنائية الأقطاب الاسطوانية ، خواص العدسة .