DESIGN OF THE DOUBLET MAGNETIC LENS WITH DIFFERENT POLE PIECES

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Abstract :

In this research, A theoretical computational investigation for studying the analysis method for possibility to produce magnetic lens of free from a rotation and distortion. The doublet project magnetic lens with different pole pieces has been designed. The radial and spiral distortions have been corrected by using this lens at low and high magnification regions , after the magnetic field has been computed. Where, a rotation and distortion free images have been obtain by suitable choice of the ratios values of gaps and bores of first lens and second lens.

Key words: Electron Optics, Magnetic Lenses, Optimization , analysis , Aberrations.

الخلاصة :

في هذا البحث تم اجراء دراسة نظرية حاسوبية لدراسة امكانية طريقة التحليل في الحصول على عدسات مغناطيسية عديمة الدوران والتشويه. تم تصميم عدسة مغناطيسية مسقطية مزدوجة ذات اقطاب متنوعة . باستخدام هذه العدسة تم تصحيح التشويهين الشعاعي والحلزوني عند منطقتي اوطأ واعظم تكبير بعد ان حسب المجال المغناطيسي للعدسة .حيث امكن الحصول على صور عديمة الدوران والتشويه باختبار مناسب لقيم النسب بين فجوات وفتحات العدسة الأولى والعدسة الثانية .

Introduction:

In the field of charged particle, The projector magnetic lens in the transmission electron microscope (TEM) is considered an important lens in the imaging system. This lens magnifies the image formed by the objective lens, and projects it on the screen, but it suffers from fundamental defects, the most significant of which are the radial and spiral distortions. Spiral distortion changes in the images formed by magnetic projector electron lenses only and radial distortions changes in the images formed and area by magnetic projector electron lenses **[1].**

In the present work a computational method has been developed to correct the two distortions of projector magnetic lenses with different designs **[2]**.

In magnetic lens the important feature it is the rotation of image about the optical axis as the imaging electron beam passes through the lens magnetic field **[3].**The rotation angle is given by the following equation **[4]**.

……(1) $\Theta = 0.1863 (NI / V_r^{1/2})$

where Vr is the relativistically corrected acceleration voltage and NI is the number of ampere- turns. Equation (1) shows that the direction of rotation depends on the direction of the current in the coil .

The first theoretical and practical study about projector lenses with rotation free image has been investigated by **[5- 8].** The simplest formula of the projector magnetic lens of rotation free is the doublet lens which consists of identical two lenses in design and are working under the condition $(NI)_1 = - (NI)_2$ so that the net rotation of the image zero.

[9] designed the doublet projector Tsuno and Harada magnetic lens. In the first rotation they obtained an image with spiral distortion rate of 0.07% at excitation parameter (NI/SQRT(Vr)) where the radial distortion equal to zero.

Al- Obaidi, **[10]** designed a doublet magnetic lens consists of two lenses, air gap width S_1 of the first lens is different forms of air gap width S_2 for second lens, which earned image of rotation and distortion free in the great magnification.

While Al-saady **[11]** obtained an images of rotation and distortion free in the low and high maximum magnification region using doublet projector magnetic lenses with the cylindrical pole pieces .

Al-Saady **[12]** get an image of free of rotation and distortion in on points of bones first and second magnetic lenses using double projector magnetic lenses but with conical pole.

Lens design:

In the present work , an doublet projector magnetic lens with different pole pieces has been designed , it is consist of two lenses ; the one of these lenses is single cylindrical pole piece **[13]** and the second lens is of a double tapered cylindrical pole piece **[14]**, as shown in Figure (1). In an attempt to obtain free of rotation and distortion in low-lying areas and high magnification for the transmission electron microscopes. The coil is located within the lens and the installation of steel about 3 mm from the face of the pole **[15].**

In order to get an images with a free of rotation in this lens ,must be first equal and opposite to the excitation of the second lens means that 1000A.t., this means that the number of coil laps

the first lens N_1 equals the number of coil laps of second lens N_2, and the current I_1 in a pass-through is equal to the first lens and goes against the current I_2 lens coil in a second.

Several computer programs used in this study such as the **[16]** to calculate the magnetic flux density distribution and use the program **[17]** to calculate the projector focal properties of the doublet lens.

Results and discussion:

Figure (2-a) show as The axial magnetic flux density distribution Bz of the doublet projector lens after being installed to air gap width of the lens when the value S = 4mm, and pivot holes D_1: D_2: D_3 = 2:1.5:1.5 in the first great magnification region. As noted in Figure that the doublet lens field are in a dual lens opposite directions so as to obtain a free of rotation, and the great value of the magnetic flux density B_m of double cylindrical lens is equal to 0.102 Tesla and located 1mm from the face of the lens pole, while the great value of the magnetic flux density B_m of the lens of single tapered cylindrical is equal to 0.373 Tesla and located in the middle of air gap so as to correspond to the magnetic field.

By using the distribution of the axial magnetic flux density shown in figure (2-a) to calculate of the focal properties of the doublet project lens when entering the electron beam on the cylindrical lens double. Where the figure shows (2-b,c,d) change the projector focal length (F_p),radial distortion coefficient(D_r) and the spiral distortion coefficient (D_s) as a function of excitation parameter ($NI/Vr^{1/2}$). Noting that the min value the project focal length (F_p) is equal to 53,32 mm and located at the excitation parameter $NI/Vr^{1/2}$ = 2.9 was found that the values of radial and spiral distortion coefficient become zero at the excitation parameter (3.08). Also to obtain free of rotation and distortion in the second greater magnification at air gap S = 2 mm and the ratio D_1: D_2: D_3 = 2:0.75:0.75, has calculated the distribution of the magnetic field core of this lens, as shown in Figure (3-a) Noting the regions of dual lens to obtain a rotation free, and the great value of the axial magnetic flux density B_m of single tapered cylindrical lens is equal to 0.929 Tesla and located mid-air gap correspond to the magnetic field B_{max} equal to the maximum value of the magnetic flux density B_m of the double cylindrical lens 0.098 Tesla and is located 3 mm from the face of the pole. Use the distribution of the axis magnetic field shown in figure (4) to calculate the projector focal properties of the double projector lens in the greatest magnification in when entering the electron beam on the single

tapered cylindrical lens. As illustrated in Figure (3-b,c,d) change the projector focal length (F_p), radial distortion coefficient (D_r) and spiral distortion coefficient (D_s) as a function of excitation parameter $NI/Vr^{1/2}$, notes that the greeter value of projector focal length (F_p) min is equal to 1.410 mm and located at the excitation parameter (12) , is also noticeable that the values of both D_r and D_s become zero when one excitation parameter (14).

Conclusions:

In the present design for doublet project magnetic lenses with shapes variety pole pieces of images given free of rotation and distortion in the regions of lower and greater magnification.

As well as to obtain free of rotation and free of spiral and radial distortion at one excitation parameter in the first greater magnification point equivalent to those that are smaller then the projector value-focus lens at the first greater magnification point.

As well as to obtain image free of rotation and free of distortion and As to obtain free of spiral and radial distortion at one excitation parameter in the second greater magnification point, and this approach to those that are smaller then the value-focus project lens. In this case, no great loss and the importance of the proposition that the importance of the two distortion . Note that the properties of projector optical lenses belonging to the different behavior in the first rotation than it is in the second rotation in general, particularly in terms of magnification.

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