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The effect of the shape of the outer electrode arm on the bipolar lens and the study of its properties

R.Y.J.AL_Salih, Hanaa E. Jasim , Hafsa Y. Ismaeel
Department of physics, College of Science, Tikrit University, Tikrit, Iraq

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Corresponding Author:
Name: R.Y.J.AL_Salih
E-mail:
R.Y.Jasim@tu.edu.iq,
dr.hanaa.e.jasim@tu.edu.iq
hafsa.y.ismaeel.phys515@st.tu.edu.iq
Tel:

ABSTRACT

In this paper, several innovative designs of magnetic lenses were designed, a bipolar lens with different geometries, where the outer pole arm denoted by the symbol (L) was changed. With a current density (6 A / m²) and after its design, the geometric parameters were studied in terms of magnetic properties, then the optical properties were studied in terms of aberrations, i.e. the coefficient of spherical aberration and the coefficient of chromatic aberration. Which led to minor changes in some of them, while others did not make any changes

1. Introduction

Double polepiece magnetic lens: It is a large circular coil surrounded by an iron circle and in its axis are two iron poles of a magnetizing iron material with high magnetic permeability, separated by an air gap of width S in which the magnetic field is concentrated. Surrounding the coil and the electrodes in the iron circuit prevents the magnetic flux from leaking out of the lens. The iron core penetrates an axial bore of diameter d along the axis of the coil to allow the beam of charged particles to pass through it into the air gap. The axial magnetic field generated by the passage of an electric current in the coil is confined within this air gap to form the lens' breaking force for the charged particle beam. If the axial bore diameter is equal at both poles, then the magnetic lens is known as a symmetrical double polepiece lens. If the geometric structure of the lens around the plane of symmetry is the same, the location of the maximum end of the axial magnetic flux density B_{max} will be in the middle of the air gap s.

The optical properties of this type of lens are expressed in terms of the s/d ratio. If the diameter of the axial aperture d for both poles is not equal, that is, $d1 \neq d2$, then the lens is called an asymmetrical double polepiece lens[1].

Aberrations of Magnetic Lenses the importance of aberration depends on the function of the magnetic lens. For example, spherical aberration and chromatic aberration are the two most important defects in objective lenses, because the limits of resolution in electronic optics are determined by the wavelength of electrons and spherical aberration.

Spherical aberration is the most important image defect of the objective lens, which causes every point in the body image to appear as a disk in the image called a disk of confusion. The reason for the appearance of this aberration is due to the difference in the breaking strength of the lens of the electronic beam far from the lens axis from the one close to it as a result of the change in the curvature of the magnetic field lines with the distance from the optical axis of

the lens. This results in an increase in the strength of the lens breaking the electronic beam.
Chromatic aberration it is one of the most important defects of the objective lens, and the effect of this aberration in the case of glass lenses is not the same as in the charged particle. The optimal choice of the type of glass used for the lens can correct this defect to an acceptable extent, while in electronic lenses there is no way to fix this defect, but it can only be reduced. It occurs due to the difference in the speed of the electrons or the change of the magnetic field as a result of the instability of the coil current of the magnetic lenses[2,3].
In 2017, Taleb Mohsen Abbas and Qutaiba Ahmed Sahi presented the characteristics of the proposed lenses in their research. They studied the objective focal characteristics of symmetric magnetic lenses, where the lens was bipolar, using a computer program for the disposal of explosive ordnance [4], Najwan Hussein Noman presented a study in 2018 on Some important geometric properties in lenses, such as bore diameter, air gap length, magnetic flux density, and focusing power. Magnification, spherical aberration, half width and minimum length, which increased the width of the air gap and diameter of the lens, also increased the ampere cycles. Also, a linear increase in magnetic alignment intensity [5]. Marwa Thamer Al-Shamma presented in 2019 two versions of magnetic lens geometry and non-equivalent subject [6].

2. Research objective

In this research, the study aims to study the properties of magnetic lenses and their optical properties of the proposed designs for the purpose of obtaining the best design among the proposed designs in terms of their focal length as well as their optical properties in terms of aberration coefficients, whether they are spherical or chromatic aberration. Innovative aberration lenses.

3. The practical part

In this research, 5 designs of bipolar lenses were designed and the height of the outer pole arm was changed for the purpose of obtaining the best design among those designs in terms of studying the properties of magnetic lenses and their optical properties in terms of aberration coefficients, whether spherical aberration or chromatic aberration, as well as the focal length of innovative lenses.
Where it was studied by using a graphic program to know the optical and magnetic properties of the innovative designs of bipolar lenses with different currents where the first current was (J = 6 A /m^2) where the Electron Optics Design (EOD)[7] and (MELOP)[8] program was used for the purpose of studying the lenses to find out their magnetism In addition to its optical properties in terms of aberration (spherical aberration and chromatic aberration) and focal length.

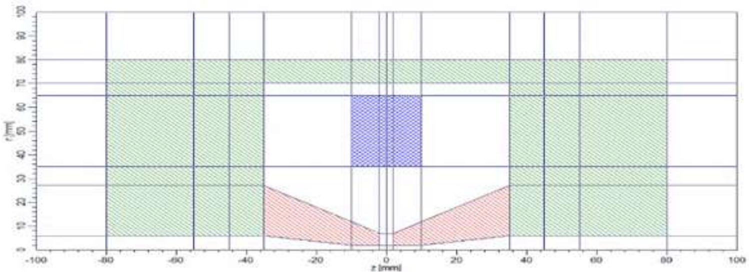

Fig. 1: Cross-section of a magnetic unipolar lens prototype.

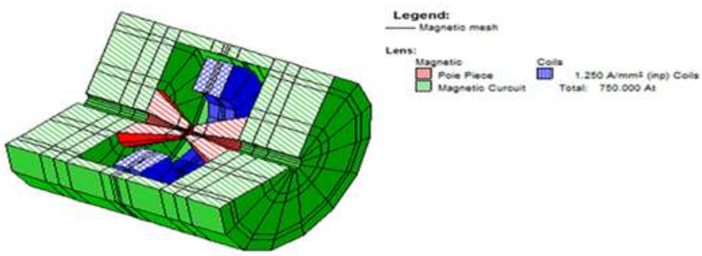

Fig. 2: 3-D of a magnetic unipolar prototype lens

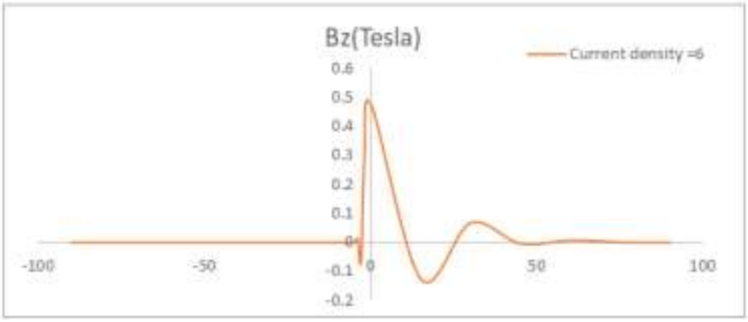

Fig. 3: Distribution of axial magnetic preamble (B_z) as a function of the designed lens at a variable current density (J=6 A/m^2).

Optical Properties

To calculate the optical properties of the proposed designs, where the aberration coefficient of spherical aberration was calculated, as well as the coefficient of chromatic aberration and the focal length as well. The drawings below show the knowledge and study of the optical properties of the proposed lenses, and this was done when using different current densities and (J = 6A / m²) . Figure 4 below shows the relationship between the rectified voltage Vr and the chromatic aberration Cc and its value in the table.

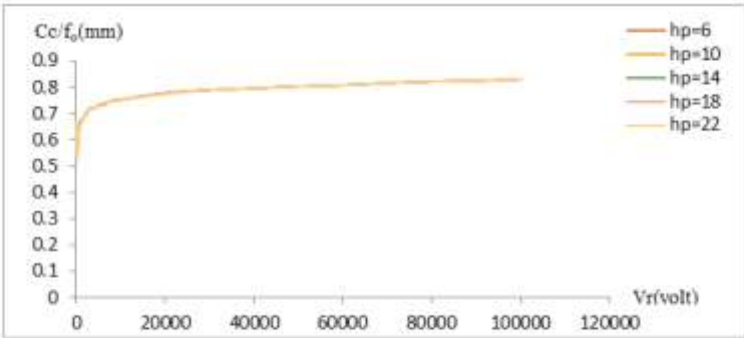

Fig. 4: The relationship between Cc as a function of relatively corrected voltage V_r (volt) which shows the value of chromatic aberration coefficient Cc.

By the observation of Figure 4 as well as the table, it is clear that the relationship between corrected voltage and chromatic aberration is that there are no changes.

Where Figure 5 below shows the relationship between the rectified voltage Vr and the spherical aberration Cs and its value ... at current densities of (J=6A/m^2).

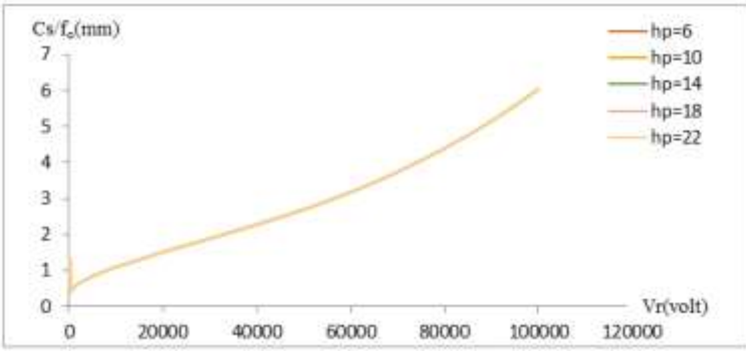

Fig. 5: The relationship between Cs as a function of relatively corrected voltage V_r (volt) which shows the value of spherical aberration coefficient Cs.

Through the observation to Figure 5 as well as the table, it is clear that the relationship between the corrected voltage and spherical aberration is that there are slight changes as shown above, despite these slight changes, they mean a lot, because the spherical aberration has been reduced, and this decrease or decrease in aberration It means a lot, meaning that this change resulted from a decrease in spherical aberration and therefore the lens was improved.

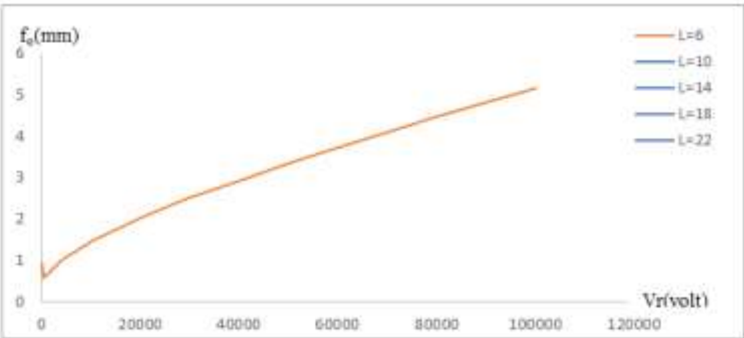

Fig. 6: The relationship between δ as a function of relatively corrected voltage V_r (volt) which shoes the value of the focal length f_o .

By noting Figure 6 as well as the table, it is clear that the relationship between the relatively corrected voltage and the focal length is that there are no changes.

L	Vr(volt)	Cc(J=6A/m^2)	Cs(J=6A/m^2)	f_o(J=6A/m^2)
6	60000	0.807487	3.179144	3.74
	70000	0.815085	3.742092	4.11
	80000	0.821029	4.400447	4.47
	90000	0.824017	5.15735	4.83
	100000	0.830116	6.044402	5.18
10	60000	0.807487	3.179144	3.74
	70000	0.815085	3.742092	4.11
	80000	0.821029	4.39821	4.47
	90000	0.824017	5.15528	4.83
	100000	0.830116	6.042471	5.18
14	60000	0.807487	3.179144	3.74
	70000	0.815085	3.742092	4.11
	80000	0.821029	4.400447	4.47
	90000	0.824017	5.15735	4.83
	100000	0.830116	6.042471	5.18
18	60000	0.807487	3.181818	3.74
	70000	0.815085	3.744526	4.11
	80000	0.821029	4.400447	4.47
	90000	0.824017	5.15942	4.83
	100000	0.830116	6.046332	5.18
22	60000	0.807487	3.181818	3.74
	70000	0.815085	3.744526	4.11
	80000	0.821029	4.402685	4.47
	90000	0.824017	5.161491	4.83
	100000	0.830116	6.048263	5.18

Conclusions

We conclude from this work, by observing the curves shown in the above drawings and the table, that there is no noticeable change in the proposed lens designs in the research when changing by changing the geometry of the outer arm of the bipolar lens pole with density J=6A/m2, but there is a change Very slight is shown in the tables below the illustrations for the purpose of illustrating the changes and this change will be used according to the researcher's needs, purpose and any intensity he needs.

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الملخص

في هذا البحث تم تصميم العديد من التصميمات المبتكرة للعدسات المغناطيسية، وهي عدسة ثنائية القطب ذات أشكال هندسية مختلفة، حيث تم تغيير ذراع القطب الخارجي المشار إليه بالرمز .(L) بكثافة تيار ($J=6A/m^2$) وبعد تصميمها تمت دراسة المتغيرات الهندسية من حيث الخصائص المغناطيسية، ثم تمت دراسة الخواص الضوئية من حيث الانحرافات، أي معامل الانحراف الكروي ومعامل الانحراف اللوني. مما أدى إلى تغييرات طفيفة في بعضها، بينما لم يقم البعض الآخر بأي تغييرات.