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Numerical analysis to verifying the performance of condenser magnetic lens in the scanning electron microscope.

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Abstract

The research aims to analysis of condenser magnetic lens in the scanning electron microscope using numerical analysis software and geometrical optics to know the behavior and characteristics of the electron beam and ability to focus it to decrease magnitude of aberrations which contribute decrease in a clear image and estimate the beam spot size that incident on the specimen surface by changing the distance between the magnetic poles down to the model that gives the best focal properties.

Keywords: scanning electron microscope, magnetic lens, optical column, Ray tracing

1. Introduction

For measuring devices and small-sized instrument must use nano-technology, which precise down to the nanometer scale, or micrometer, Khursheed, (2000) Due to the development of modern electronic microscopes industry, which events jump quality and important in biology research and the discovery of compositions and nanostructures of cells and tissues.

In general, there are two main types of electronic microscopes is the first scanning electron microscope and the other is a transmission electron microscope, Le Poole (1979) A third type is a relatively recent combines between the advantages of each of the two major types so there is no represented a separated type , a scanning transmission electron microscope, each of these types gives us a limited analysis, Egerton (2005) All of these types have the same basic components.

the scanning electron microscope of the most commonly instrument to measure and analyze the nanostructures and obtaining an image for surfaces models for many important applications in the field of materials science and medical science, Oatley (1972), Sihilia (1988) Uses the electron gun as a source of electron beam short wavelength less than 1nm. Goldstein et l. (1981) Figure (1) shows the basic components of the scanning electron microscope, Goldstein et, al. (2003).

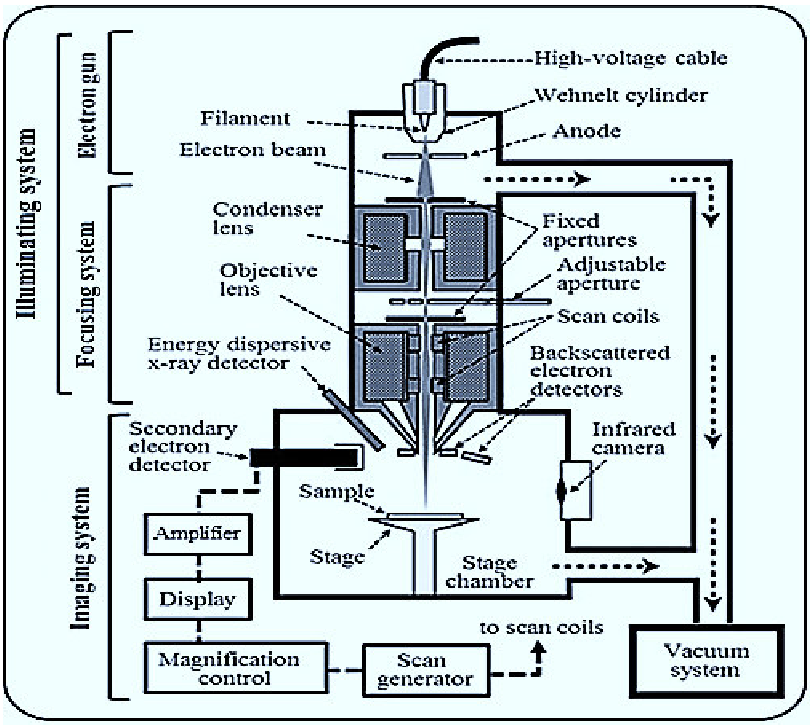

Figure 1. shows the basic components of the scanning electronic microscope

2. Theoretical details

In general when dealing with the electronic lens take us into consideration that we are dealing with the geometric shape of the poles and the gap between them filled by a magnetic field cannot change its shape, but changed the shape of the gap, Hawkes (1972). Whatever be the shape of the lens, there will remain relatively large aberrations, sometimes called defects. For this reason, it is often designed the electron lenses with small gaps between the magnetic poles in order to limit the electrons in the central space. But these defects to this day continue to limit the ability of the analysis in the electron microscopes.

Three models of condenser magnetic lenses equal designed in geometrical dimensions and shape of the poles and different in the length of the distance between the poles to see the impact on the optical performance of the lens. Figure (2) illustrates the three designs for condenser magnetic lenses. To find out the extent of the condenser magnetic lens quality in terms of leakage magnetic flux in its composition and study the distribution of the magnetic flux lines inside it using Flux program where these lines on a regular basis in parallel on the optical axis and fall vertically on the pole surface and take the geometrical shape of the proposed lenses, and are close in regions that possess high flux density and far in the regions has low density. Figure (3) illustrates the path of magnetic flux lines within three lenses.

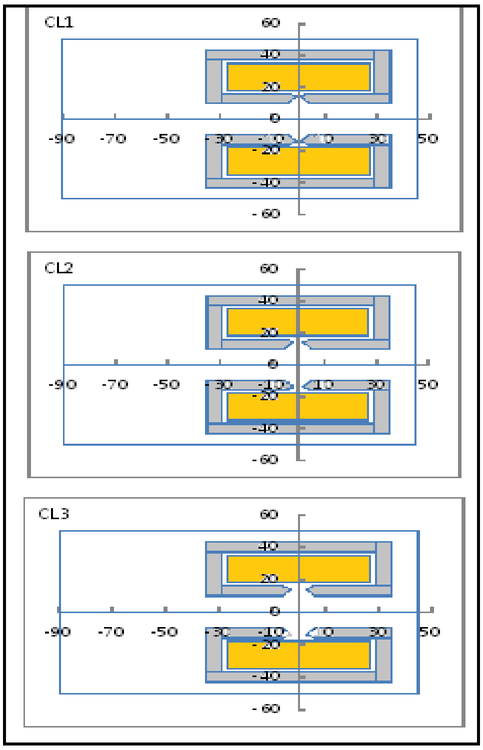

Figure 2. illustrates the three designs

for condenser magnetic lenses.

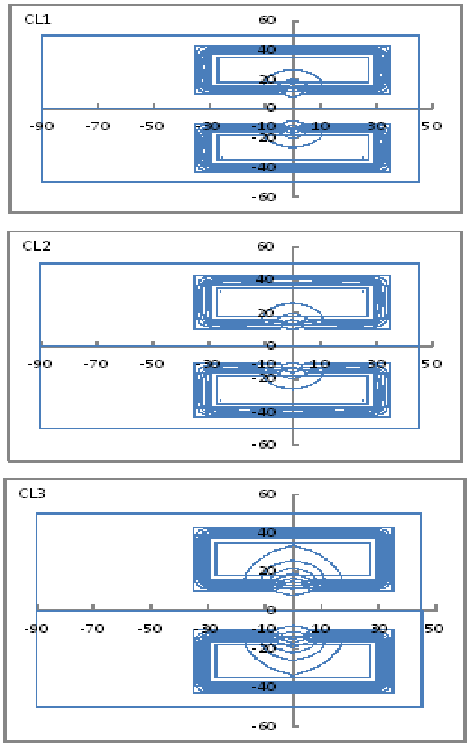

Figure 3. illustrates the path of magnetic

flux lines within three lenses.

Calculating The distribution of axial magnetic flux density Bz for three condenser magnetic lenses at excitation (NI = 1000A.t) to see the focal properties through the use of AMAG program, Lencovà (1986). Figure(4) shows the distribution of magnetic flux density Bz as a function of the optical axis Z, note from the figure that the magnetic flux has a maximum value Bmax at the region between the poles, Table (1) shows the detailed results of the maximum values of magnetic flux density Bz and the location of the refraction of the beam Zp and location of the intersection with the optical axis Zi and the amount of the focal length f of the three condenser magnetic lens at excitation (NI = 1000A.t) and an accelerated voltage (Vr = 8kV).

Table 1. shows the detailed results of the maximum values of magnetic flux density Bz and the location of the refraction of the beam Zp and location of the intersection with the optical axis Zi and the amount of the focal length f of the three condenser magnetic lens at excitation (NI = 1000A.t), accelerated voltage (Vr = 8kV).

Sample	location of the refraction of the beam Zp(mm)	location of the intersection Zi(mm)	focal length f(mm)	maximum values of magnetic flux Bmax(T) density
CL1	-1.91	7.583	8.5	0.085404
CL2	-2.01	7.626	8.66	0.083838
Cl3	-2.15	7.941	8.97	0.080418

Using the M21 program prepared by Munro in 1975 and its operation in the low magnification was calculated electron beam path inside the three condenser magnetic lenses and find the image position configured from the intersection point of the electron gun at (Z = -80mm) to the position of image level Zi at excitation and voltage accelerate (Vr = 8kV , NI = 1000A.t). By solving the axial ray equation by method (Rung-Kutta) .figure(5) shows the path of the electron beam within the condenser magnetic lenses designed at excitation and accelerating voltage (Vr = 8kV, NI = 1000A.t).

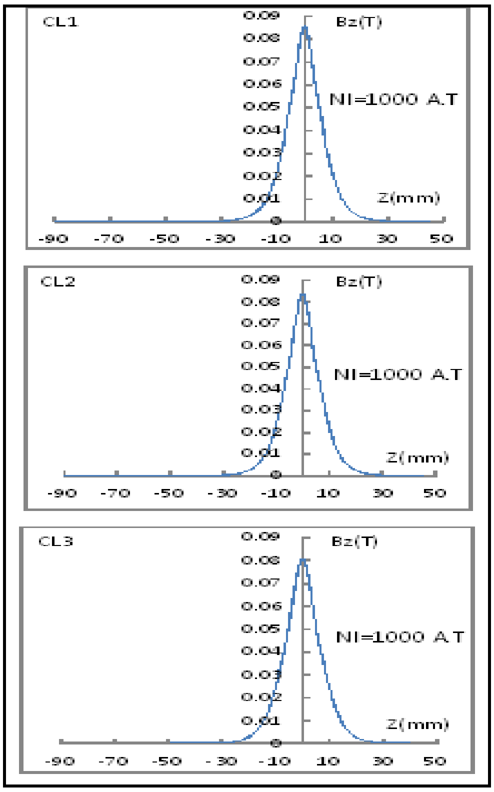

Figure 4: shows the distribution of magnetic flux density Bz as a function of Magnetic lenses designed.

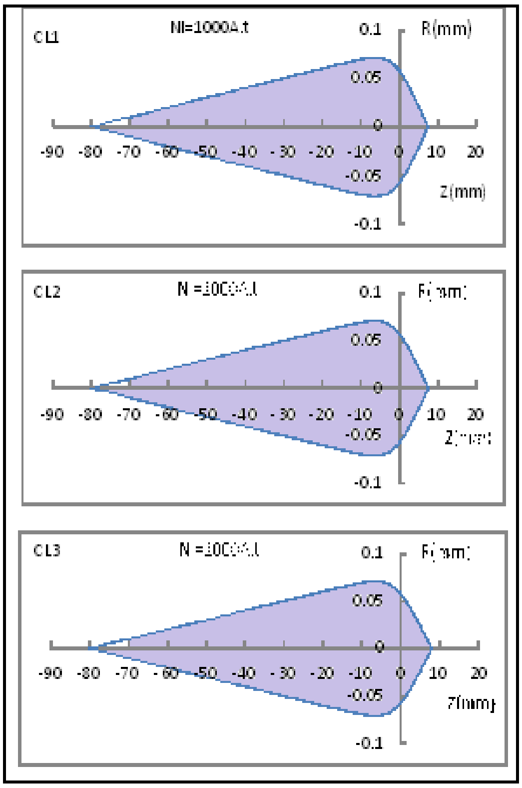

Figure 5: shows the path of the electron beam within the condenser the optical axis Z .

3.Results and discussion

Study of the relationship between the Spherical aberration Cs and chromatic aberration Cc as a function of the acceleration voltage at a constant excitation (NI = 1000A.t), was found when increasing the voltage accelerated increases the amount of aberrations (Figure 6),(7) illustrate the relationship between the Spherical aberration Cs and chromatography Cc as a function of acceleration voltage .

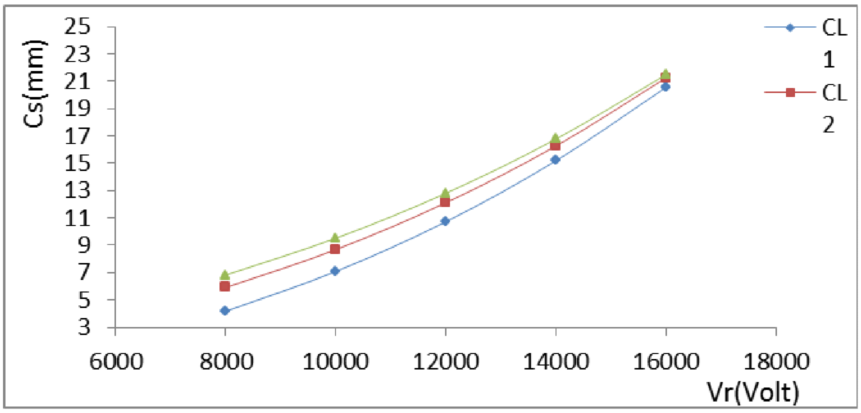

Figure 6. illustrate the Spherical aberration Cs as a function of acceleration voltage at an excitation (NI=1000A.t)

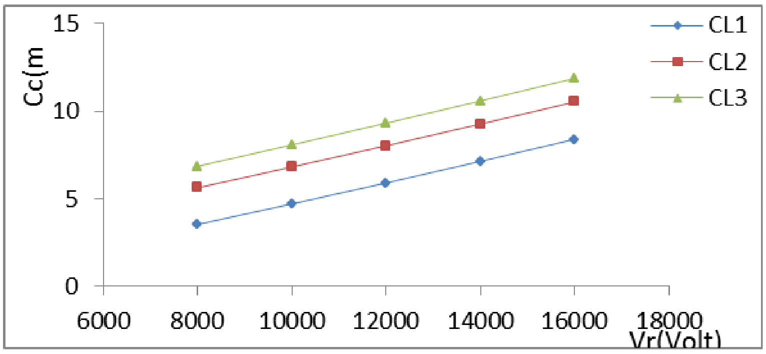

Figure 7. illustrate the chromatic aberration Cc as a function of acceleration voltage at an excitation (NI=1000A.t)

Study of the relationship between the focal length f as a function of the acceleration voltage Vr .found that the focal length increases with increasing the accelerated voltage at constant excitation of the condenser magnetic lenses designed at (NI = 1000A.t) leading to increasing of electron beam diameter as a result of concentrated under the level of the sample Figure (8) shows the relationship between the focal length f as a function of the acceleration voltage Vr at constant excitation (NI = 1000A.t).

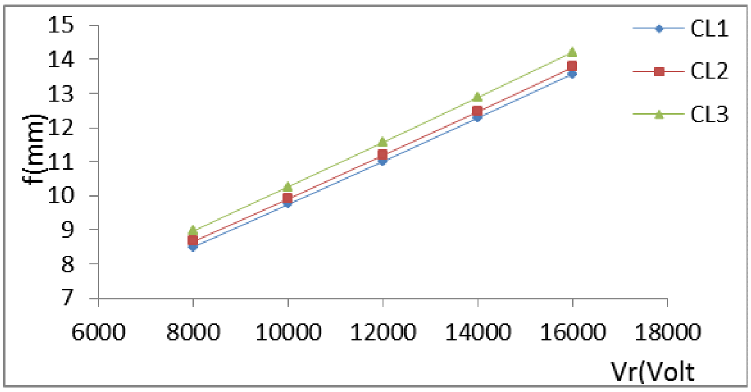

Figure 8. illustrate the focal length f as a function of the acceleration voltage Vr at an excitation (NI = 1000A.t).

As for the amount of demagnification dM in three condenser magnetic lenses , found that decreasing due to increasing of acceleration voltage Vr .figure(9) shows the relationship between the amount of demagnification dM as a function of the acceleration voltage Vr at constant excitation (NI = 1000A.t).

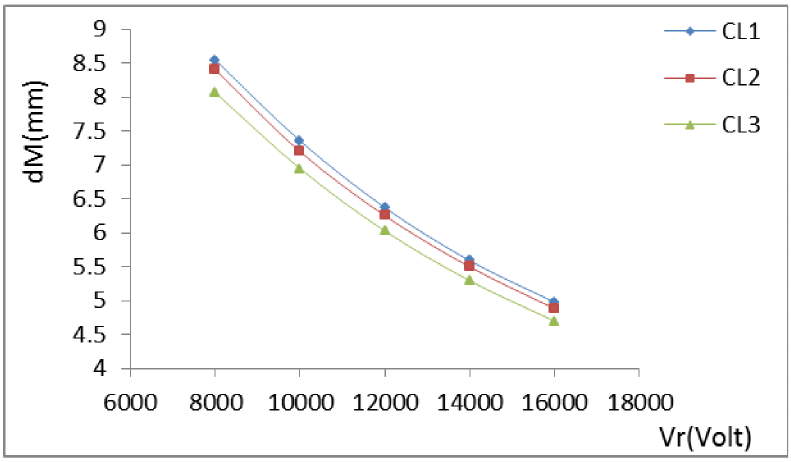

Figure 9. illustrate the amount of demagnification dM as a function of the acceleration voltage Vr at an excitation (NI = 1000A.t)

Finally, studying the relationship between the electron beam diameter d as a function of the acceleration voltage Vr found when increase the acceleration voltage electron beam diameter has increases due to increased focal length and thus, the number of electrons that pass through the constant diameter be relatively large, which makes the electron beam current great. Figure (10) shows the relationship between the electron beam diameter d and acceleration voltage Vr at a constant excitation (NI = 1000A.t).

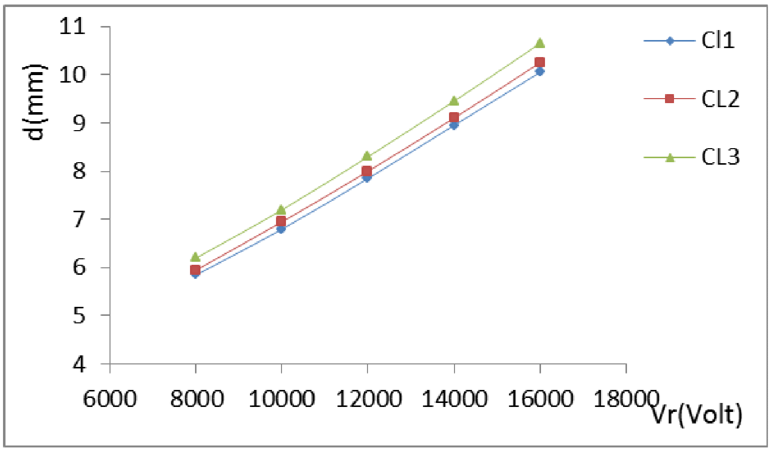

Figure 10. illustrate the electron beam diameter d and acceleration voltage Vr at an excitation (NI = 1000A.t).

4. Conclusions

Numerical analysis of the three condenser magnetism lenses and study of their focal properties represented by focal length f, Spherical aberration Cs, chromatic aberration Cc, as well as the number of times of demagnification dM in electron beam diameter .proved that the distance between the magnetic poles play an important role in the efficiency of condenser magnetic lenses, it is found the model that has less distance between the poles, which CL1 achieved the best results, obtained on less values of spherical and chromatic aberration and the highest amount to demagnification in electron beam diameter. Increase the acceleration voltage at constant excitation affect adversely on the focal properties of the lenses and the number of times of demagnification in electron beam diameter, leading to increased electron beam diameter and thus obtaining on low-resolution image.

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