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ELECTRICAL PROPERTIES & SURFACE MORPHOLOGY STUDY ON MAGNETIC COMPOSITE FOR ROTATION COIL SENSOR APPLICATION

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Abstract

Magnetic composite is widely used in technology now. Among the technology involves sensors and one of the many type of sensors is rotating coil sensors. On the other hand, the research on characterization of magnetic composite used is rotating coil sensors is lack of information. The research is done using three main method to obtain data. First is sample preparation. The sample is clean, cold mounting then grind. Next, the samples characterize using Scanning Electron Microscope (SEM), Energy-Dispersive X-Ray Spectroscopy (EDX) and ImageJ software. Then, the electrical properties of the sample. All the data is to determine the optimum parameter of the magnetic composite. The research conclude that as the number of porous count increases, the value of current flow also increases.

Keywords: Scanning Electron Microscope (SEM), Energy-Dispersive X-Ray Spectroscopy (EDX), ImageJ , Porous

1.0 INTRODUCTION

The existing magnet naturally has a strong magnetic element but today's technology industrial required much stronger magnetic bond. So, many type of magnet are produced by mixing the iron and steel element alloy to stronger the bond. The force generate by the interaction of atoms crate a much stronger magnetic fields depend on the magnetic force. When the electricity runs thought the coil wire, it will produce magnetic field.

Magnet is a piece of iron or materials that has atom components in it in order to exhibits materials properties that is magnetism. Each atoms has electron particles to carry the electric charges. The movement of components inside the magnets generates the electric current and the microscopic magnet is occur cause by each electron act. Each magnet has north and south poles that magnetized when the magnetic substance enter the magnetic field

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Even though, the magnetic composite rotating coil sensor is regularly used but the electron bond in magnet is changing to make is much stronger bond. Most of the research focused in fabricating method of the magnet and the design of the coil sensor however, they did not highlight on characterization of the magnet structure. Due to this matter, further research is done to identify the significant relationship between electrical properties and surface morphology of porous many type of magnetic composite with the rotating coil sensor.

The findings of this study will be as a guideline to determine the electrical properties and surface morphology on magnetic composite magnets for rotation coil sensor application. It also enhanced better understanding about the many type of magnetic composite for future used. Furthermore, the research can be used as a source of knowledge for fabrication of photodetector based of the porous for the comparison of magnetic composite for researcher interested in this field of study.

2.0 EXPERIMENTAL

This research is conducted to study the surface morphology and electrical properties of the magnetic composite. There are three major component in obtaining the data. There are sample preparation, sample characterize and electrical properties determination.

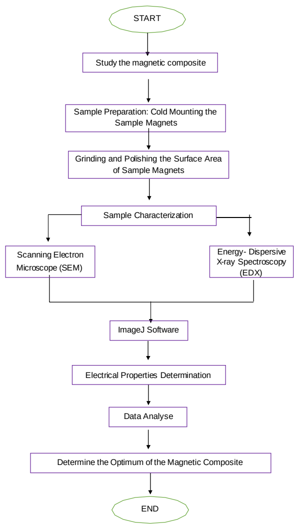


Figure 1: Flow Chart of the Research

ii. Sample Preparation

The samples are measured and cleaned and the actual size is 2 cm. the sample used are five Somaloy 700 and one Conventional magnet. Then, the samples undergo cold mounting process to case of handling during grinding and polishing process.

The solutions use are Epoxy and Hardener with the ratio of 1:10, 1 Epoxy equal to 10 Hardener needto be used in the mixture. Next, the mixture is mixed and stirred slowly homogeneously by using woodenstick as shown in Figure 2.

The samples are placed right in the middle of the mould with the surface that need to grind face down. The solution will solidify in about 4 days. Whenthe solution is harden, the outside of mould need the knock using a small hammer to release it.

Figure 2: The Mixture Is Pour into Mould

Lastly, the samples are grind and polish. The dark surface area of the sample need to be grind into mirror like surface finish. This is essential in order to analyse the sample easily using SEM.

A grind machine and in total of five different type of sandpapers are used in this process. The lower the grit number results in a coarser abrasive that will remove material much faster.

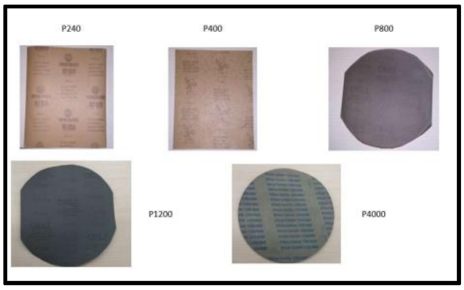


Figure 3: The sandpaper used in the experiment

Begin with the rougher surface sandpaper which is P240, P400 and P800 to remove the dark material on surface of the sample. Then, for the shinning process, use the P1200 and P4000, the smoother surface sandpaper as state in Figure 3. It take about three hours to grind all six samples into mirrored surface area as shown in Figure 4.

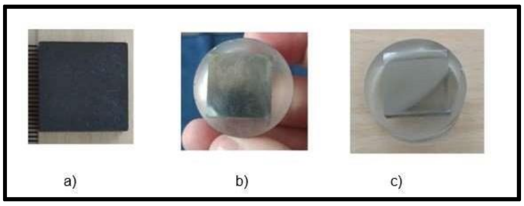


Figure 4: The sample a) before mount b) after mount c)after grind

ii. Sample Characterization

The Scanning Microscopy Electron (SEM) will analyse the surface morphology of the magnetic composite is fabricated by electrolyte etching technique to gain the structural properties of the samples. Then the characterized process will be measured using the Energy- Dispersive X-ray Spectroscopy (EDX). Lastly the percentage of porosity on the surface is identified and measured by the ImageJ Software.

A. Scanning Electron Microscope (SEM)

The scanning electron microscope (SEM) is a process that scans a sample with an electron beam produce a magnified image for analysis. It is uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens.

B. Energy- Dispersive X-ray Spectroscopy (EDX)

Energy Dispersive X-Ray Spectroscopy (EDX) is a chemical microanalysis technique used in conjunction with scanning electron microscopy (SEM). EDX functions with a series of three major parts: an emitter, a collector, and an analyser. This steps will identify either the samples is porous and non-porous.

C. ImageJ Software

ImageJ Software is an image processing software that capable to display, analyse, measure and calculate the images obtain into small units. The image structural properties of the sample obtain by the SEM is analyse by the software. The porous surface plot, the porous count, the average size of the porous and the area of porous is measure and calculate using this software.

The total of five sample of Somaloy 700 magnetic composite are analyse. For the Conventional magnetic composite, the sample is divide into five different surface area on the same sample because of the limited quantity of the sample

iii. Electrical Properties Determination

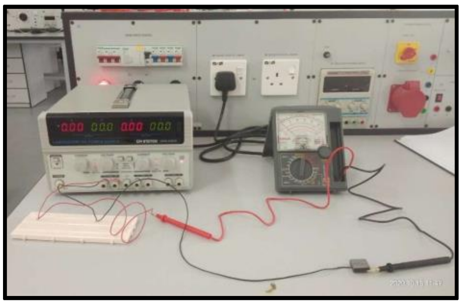


Figure 5: The experimental set up for I-V characteristics identification

To determine the electrical properties of the magnetic composite based on it porous, the I-V characteristic must be measured using the power supply and analog multimeter.

3.0 RESULT AND DISCUSSION

The results are discussed which align to the objective of the research. The discussion for this section is about the micro structure and the electrical properties of the Somaloy 700 magnetic composite magnet and the conventional magnetic composite magnets. The surface structure, the element composition and the electrical properties were studied to obtain the outcome indicates from the experimental research that has been done.

Scanning Electron Microscopy (SEM) Analysis

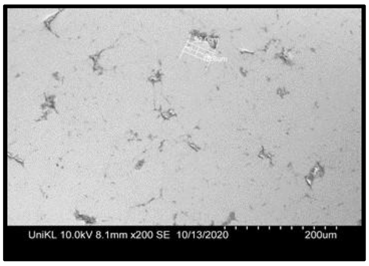


Figure 6: The sample Somaloy 700 surface morphology for porous structure of samples using SEM

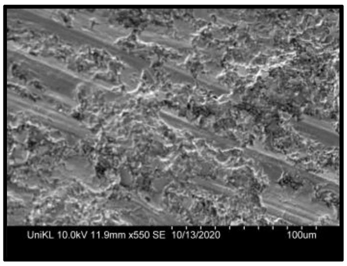


Figure 7: The sample Conventional magnet surface morphology for porous structure of samples using SEM

After the grinding process of the surface of the samples, it has to be characterized using the SEM machine to observe the surface structure on the surface area. The indicators that develop from electron-sample contacts expose the data about the samples such as surface structure, size of particles and chemical composition.

The porosity count and area that have been capture using the SEM. The size for the Somaloy 700 magnetic; Figure 6 is visible but not for the Convectional magnet; Figure 7. Figure 6 also give the size of the largest porous found on the surface is measure using SEM which is 18.6 µm width and 52.0 µm height.

ImageJ Analysis

The further analysis of the porosity formed are characterized by using the ImageJ software. The porosity of each samples count and the total area with the average size are records. Table 1is for the Somaloy 700 magnetic composite while Table 2 is the surface of 5 different surface area on the same conventional magnetic composite.

Table 1: The image analysis of Somaloy 700 magnetic composite

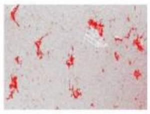
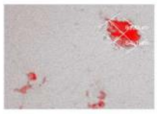
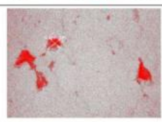
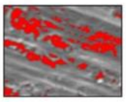
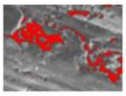
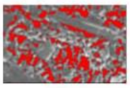
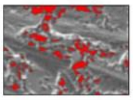
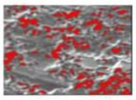
SAMPLE	IMAGEJ ANALYSIS	POROUS COUNT	TOTAL AREA (μm^2)	AVERAGE SIZE (µm)
1		17	14.33	1.864
2		4	6.12	0.752
3		9	12.25	1.284
4		3	4.47	0.423
5		5	10.73	0.864

Table 2: The image analysis of conventional magnetic composite

SURFACE	IMAGEJ ANALYSIS	POROUS COUNT	TOTAL AREA (μm^2)	AVERAGE SIZE (µm)
A		18	3.41	2.41
B		11	2.55	1.58
C		33	9.67	3.913
D		21	6.42	2.431
E		27	5.26	3.654

From Table 1, show that Sample 1 of Somaloy700 magnetic composite has the highest number of porous with 17, total area of porous; 14.33 µm2, and the average of porous size of 1.864 µm. Meanwhile Table 2 show that the Surface C of conventional magnetic composite with the 33 porous count, 9.67 µm2 total area of porous and 3.913 µm average size of porous is the highest among the other surface on Conventional magnet.

After that the surface plot of the samples is construct. Figure 8 and Figure 9 show the one example of each samples. The surface plot is smooth is indicate that there is not many porous on the surface area of the sample and vice versa. For porous samples, it show a very different surface plot due to different number of porous and porous size. The more the number of porous, the more the peak formed on the surface showed by the surface plot.

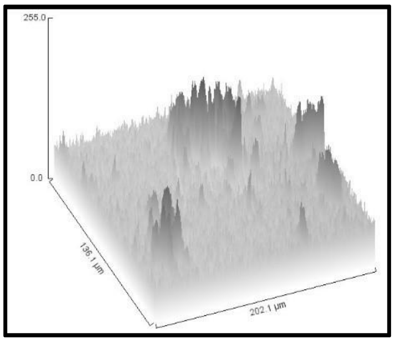


Figure 8: The Surface Plot of Somaloy 700 magnetic composite

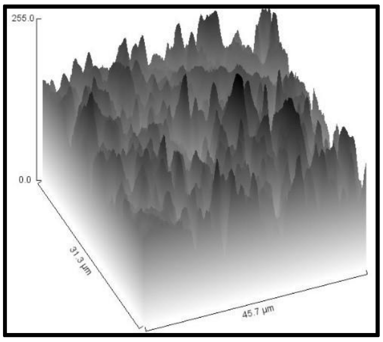
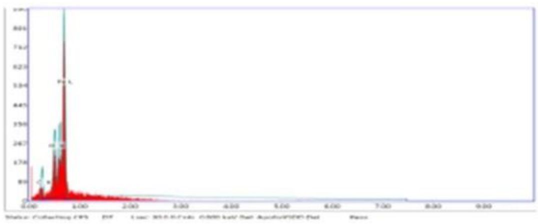


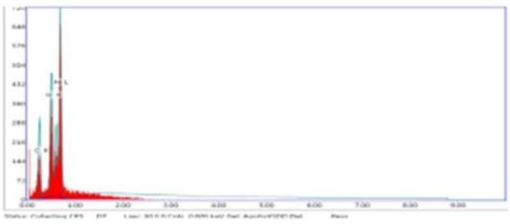
Figure 9: The surface plot of conventional magnetic composite

Energy Dispersive X-ray Spectroscopy (EDX)

The Figure 10 is the Energy Dispersive X-ray Spectrometry (EDX) analysis for the non-porous and porous structure. The porous structure percentage of Iron; 75.06%, Oxygen; 11.21% and Carbon; 12.72%. By contrast, the percentage for non-porous structure are Iron; 61.6%, Oxygen; 16.51% and Carbon; 21.89%.



a)



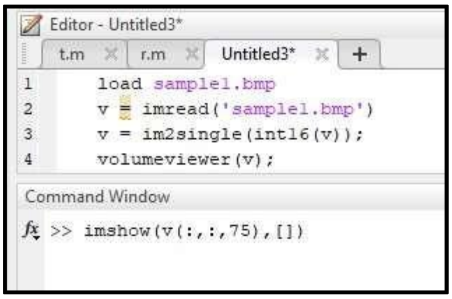
b)

Figure 10: The percentage of Somaloy 700 by using EDXfor a) porous and b) non-porous

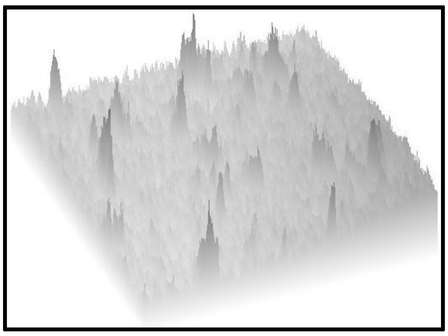
MATLAB

From the SEM of Somaloy 700 and conventional magnetic composite, the images are integrate with the Volume Viewer by MATLAB. The Volume Viewer app lets view 3-D volumetric data and 3-D labelled volumetric data. Using this app, it can view the dataas a volume or as plane slices.

The data is display in 3D Volume Viewer so thatall the pixels in the data has the same X Y and Z dimension and easier to understand the porous in the surface of the sample.



a)



b)

Figure 11: The a) coding and b) the 3D of the Volume Viewer

Current-Voltage Characteristic

The voltage used are 0 V-8 V. Unfortunately duringthe experiment, the conventional magnet result came out as not an electrical conductor, so for thecurrent flow is 0 mA. Therefore, the conventionalmagnet is a type ferrite magnet that cannot conduct electricity

Table 3: Data of Current Flow

Voltage(V)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Conventional Magnet
	Current (mA)					
0	0	0	0	0	0	0
0.5	0.22	0.13	0.17	0.08	0.15	0
1	0.38	0.19	0.31	0.16	0.25	0
1.5	1.24	0.91	1.13	0.87	1.08	0
2	1.43	1.22	1.36	1.17	1.29	0
2.5	2.27	1.97	2.04	1.96	2.03	0
3	2.45	2.28	2.37	2.26	2.33	0
3.5	3.27	2.74	2.94	2.84	2.95	0
4	3.38	3.18	3.22	3.31	3.47	0
4.5	4.27	4.17	4.24	4.18	4.21	0
5	5.86	5.41	5.89	5.31	5.90	0
5.5	6.76	6.45	6.63	6.27	6.71	0
6	7.44	6.88	7.29	6.82	6.91	0
6.5	7.93	7.39	7.72	7.31	7.49	0
7	8.86	8.51	8.79	8.37	8.66	0
7.5	9.64	8.77	9.27	8.63	8.86	0
8	10	8.94	9.21	8.73	9.17	0

From the table above, it reveal that sample 4of Somaloy 700 is 8.73 mA which is the lowest value of correct flow meantime the highest current flow is 10 mA is sample 1. It also show that the Somaloy 700 is suitable for low voltage used because the maximum voltage is 8 V and less.

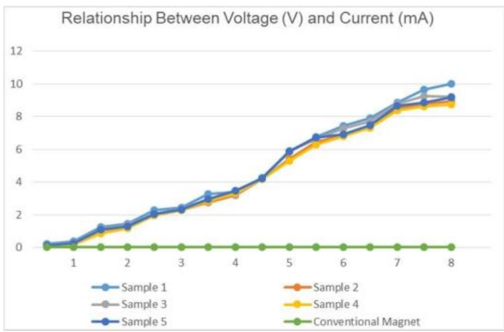


Figure 12: The Relationship between Voltage (V) and Current (mA)

The Figure 12 reveal that the maximum current flow for sample 1; 10 mA, sample 2; 8.94 mA, sample 3; 9.21 mA, sample 4; 8.73 mA and sample 5; 9.17mA. It is measure using 0 V to 5 V voltage.

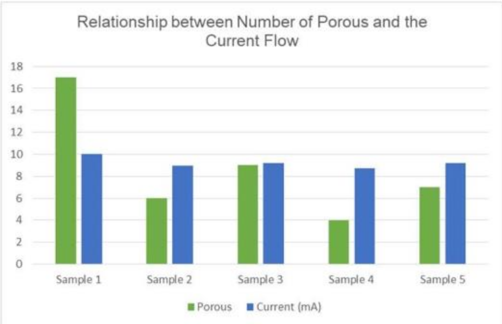


Figure 13: The Relationship between number of porousand Current (mA)

From Figure 13, we can conclude that as the number of porous count increases, the value of current flow also increases. From the Figure 13 show Sample 1 has the highest number of porous count and highest value of current flow and Sample 4 has the lowest of porous count and current flow. Taking into consideration the main two factors which are highest number of porous count and highest value of current flow, Sample 1 shows the best sample of porous of Somaloy 700 Magnetic Composite for rotation sensor.

4.0 CONCLUSION

In this study, the two main factor are to study the surface morphology and the electrical properties of the sample of Somaloy 700 magnetic composite for the used in rotation coil sensor. It can be conclude that the higher the number of porous count, the value of current flow also higher. With the data obtain, the researcher has determine that the Sample 1 of Somaloy 700 magnetic composite is best sample to use and from the electrical properties determination bar graph show that the highest current flow is 10 mA with the number of porous is about 17.

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