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Influence of Particle Sizes on Mechanical and Magnetic Properties of Magnet Composite Fe3O4

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ABSTRACT:In the current research to investigate, the effect of size Fe3O4 granules on mechanical and magnetic properties magnet composite material with Fe3O4 filler. The Fe3O4 composite magnetic binder uses a Polyvinil Alcohol (PVA) matrix. The manufacturing process using the vacuum infusion (MIV) method. The variations in the size of the Fe3O4 grains used are 200, 225, 250, 300 mesh. And the weight fraction (% Wt) of PVA and Fe3O4 particles is 40% : 60% of the specimen weight of 10 grams. Testing of mechanical properties in the form of testing bulk density and compressive strength, testing of magnetic properties in the form of testing remanent induction values (magnetic remanence (Mr), coercivity (Hc), and maximum product energy (BHmax).The results of testing remanent induction values (Mr) ,Hc, BHmax and total calculations confirm the hypothesis that the 225 mesh sample (largest grain size) has better magnetic properties than the other samples.
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KEYWORDS: Magnet composites, Mechanical properties, Magnetic properties, Fe3O4 filler, PVA matrix

I. INTRODUCTION

Iron sand is a mineral which is a potential natural resource owned by the Indonesian state. Lombok Island has a coastline with a length of 2,333 km. Of course, there are many natural iron sands that have the potential to be developed and cultivated, including in the Pohgading area, Telindung Beach, Mudung hamlet, Anggaraksa village, Pringgabaya sub-district, East Lombok district, West Nusa Tenggara province[1][2].Iron sands generally have the main composition, namely iron oxide (Fe2O3 and Fe3O4), silicon oxide (SiO2) and other compounds, such as Fe, Ni, and Zn with smaller levels [3][4]. The iron (Fe) content in iron sand is widely used as a raw material for making steel, cement, etc., where the oxide and Fe content of iron sand can be distinguished physically or chemically[5][6].

Fe3O4 particles have magnetic properties whose magnetic properties depend on the grain size. The small particle size makes the material very reactive to external magnetic fields, but if the magnetic field is removed, the properties of the material itself will be very similar to paramagnetic materials[7][8].Fe3O4 particles from local iron sands which have ferrimagnetic properties have the opportunity to be applied as filler for composite magnetic materials. Composite magnetic materials are indispensable to meet industrial raw materials and in the electronics field, where the development and needs are increasing. Examples of applications in the industrial sector are: ceramics industry, catalysts, energy storage, magnetic data storage, ferrofluids, absorbents and in medical diagnosis[9][10].

From the results of the study above, there are very few studies on the effect of the grain size of Fe3O4 filler on the mechanical and magnetic characteristics of composite magnetic materials with PVA matrix. As a result, the use of iron sand, especially Fe3O4 has not been maximized, only as a building material whose value is much lower than the price of composite magnetic material which is indispensable in the industry. Thus, there is a need for a better understanding of the effect of Fe3O4 filler grain size on the mechanical and magnetic properties of a composite magnetic material.

This study aims to determine the characteristics of the mechanical properties and magnetic properties of the composite magnetic material, with Fe3O4 filler and polyvinyl alcohol (PVA) binding matrix.

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II. EXPERIMENTATION

The Fe_3O_4 filler used in this study came from iron sand in Pohgading Village, East Lombok Regency, West Nusa Tenggara Province, Indonesia. Fe_3O_4 was synthesized from iron sand by the coprecipitation synthesis method

Coprecipitation method is one type of wet chemical method used to synthesize Fe_3O_4. In the synthesis process, precursors in the form of anhydrous metal salts are used as a source of metal ions and basic hydroxide compounds such as NaOH and KOH act as coprecipitant.

Iron sand and filler Fe3)4

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Polyvinil matrix material magnet composite

Coprecipitation method is a synthesis method which has the simplest synthesis step and does not require high temperature treatment ($T < 120\ ^0C$) for the synthesis of Fe_3O_4 samples. There are 3 main stages of the coprecipitation synthesis method. First, the preparation of the precursor metal salt solution. If the source of Fe ions is iron sand, the anhydrous precursors $FeCl_3.6H_2O$ and $FeCl_2.4H_2O$ are not used. Making a solution of Fe^{2+}/Fe^{3+} from iron sand is by dissolving iron sand with 12M HCl at a temperature of $\pm 70\ ^0$ C. Second, the reaction for the formation of Fe_3O_4 through an alkaline reaction. The Fe solution was dropped into the coprecipitant solution while being stirred at a T-synthesis temperature $< 120\ ^0$ C. Third, the process of washing Fe_3O_4 nanoparticle slurry and then oven at 90 ^{0} C for 4 hourse.The control carried out on the synthesis parameters, such as synthesis temperature, stirring rate, and coprecipitant concentration, will affect the particle size of Fe_3O_4. In general, the mass of Fe_3O_4 nanoparticles produced is the largest compared to other synthesis methods. The weakness of the coprecipitation method is that the grain size distribution of the nanoparticles tends to be large and the polydisversivity of the particles is small. Nanoparticles easily agglomerate. The solution is to functionalize the surface of the nanoparticles by adding a capping agent in the form of oleic acid.

The manufacturing process using the vacuum infusion (MIV) method. The variations in the size of

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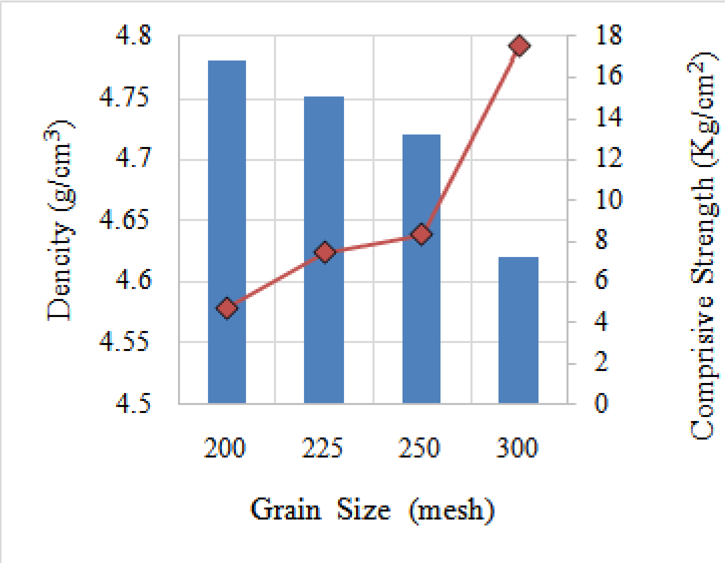
the Fe3O4 grains used are 200, 225, 250, 300 mesh. And the weight fraction (% Wt) of PVA and Fe3O4 particles is 40% : 60% of the specimen weight of 10 grams

III. OBESERVATIONS MECHANICAL AND MAGNETIC PROPERTIESOF MAGNET COMPOSITEFE3O4

This discussion focuses on the effect of the grain size of the Fe3O4 filler on the mechanical and magnetic characteristics of the specimen. Based on the results of scanning electron microscope observations with a scale of 500 times Figure... Polyvinyl Alcohol (PVA) matrix is indicated with a white particulate image, a solid black color indicates a surface cavity and the color between the two is a Fe3O4. composite magnetic filler material.In the f igurethe distribution of the PVA matrix is more and more evenly distributed throughout the Fe3O4 filler from the largest to the smallest size (200 mesh to 300mesh). This fact indicates that the PVA matrix begins to work optimally as a composite magnetic binder. The surface appears to have started to shrink from 200 mesh to 300 mesh due to the smaller size of the composite caviyfiller material and the more even distribution of the PVA matrix.



Mechanical properties of magnet composite with matrix PVA and filler Fe3O4

As can be seen in the figure, the grain size of the Fe3O4 filler affects the density and compressive strength of the composite magnet. The larger grain size of Fe3O4 in magnet composite materials, the density increases and the compressive strength decreases. The increase in the density, respectively, 4.62, 4.72, 4.75, 4.78 g/cm^3 and thedecrease in compressive strength of 17.5, 8.3, 7.4, 4.7 Kg/cm^2 correspond to the increase in the grain size of the Fe3O4 filler, 300, 250, 225, 200 mesh (the smaller the mesh, the larger the grain size). The larger thegrain size of the Fe3O4 filler, the magnetic density of the composite increases because the density of Fe3O4 is greater than that of the PVA matrix. On the other hand, the smaller the grain size of the Fe3O4 filler, the compressive strength of the composite magnet increases, because the volume fraction of the PVA matrix increases. The PVA matrix functions tohold and transmit the forces/loads acting on the composite magnetic material

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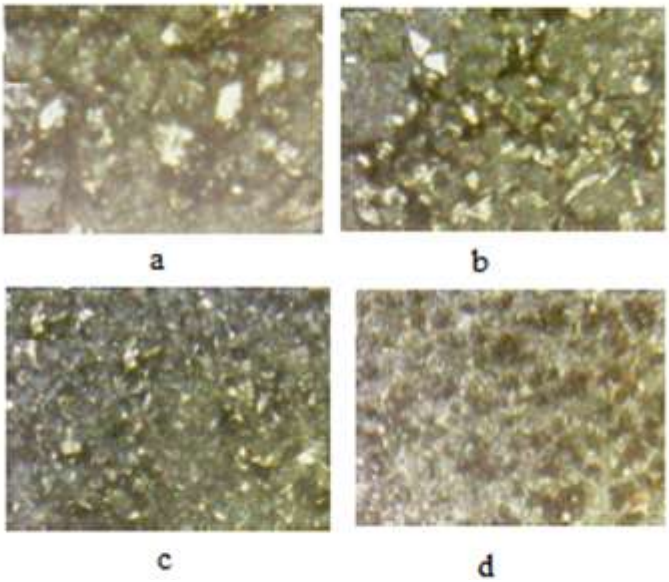
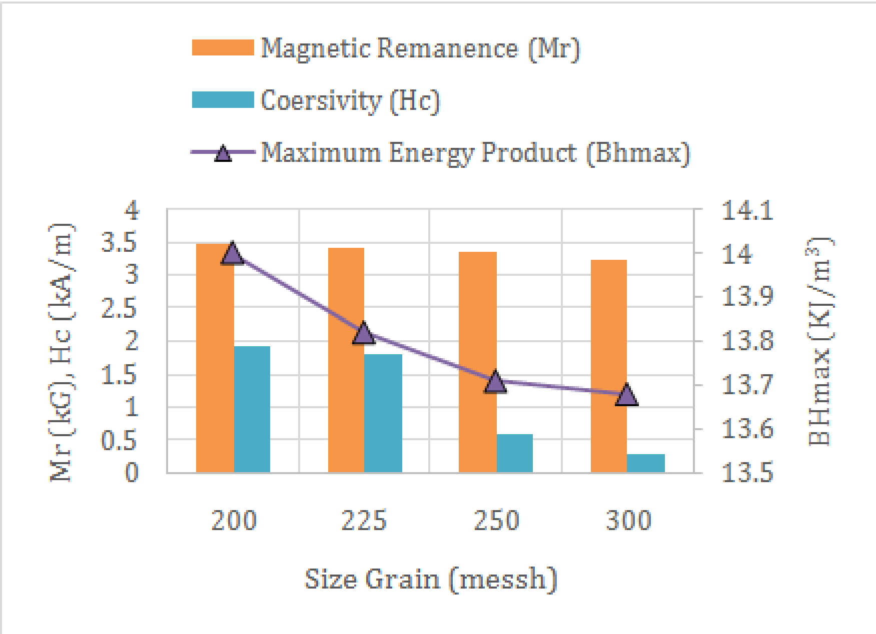


Microstructure of magnet composite with filler
Fe3O4. a. 200 mesh b. 225 mesh c. 250 mesh d. 300 mesh



Magnetic properties of magnet composite with matrix PVA and filler Fe3O4

The magnetic properties of the specimen are also influenced by the grain size of the Fe3O4 filler. In general, the smaller the grain size (magnetic remanence (Mr), coercivity (Hc), and maximum product energy (BHmax) decrease. The values (magnetic remanence (Mr) respectively are : 3.47, 3.41, 3.35, 3.25 kG, coercivity (Hc) are : 1.92, 1.81,0.57, 0.29 kA/m, and maximum product energy (BHmax) is : 14, 13.82 , 13.71, 13.68 KJ/m^3 corresponds to a decrease in the grain size of the Fe3O4 filler (200, 225, 250, 300 mesh).

Hysteresis curve magnetization

A more complete characterization of the magnetic properties of composite magnetic materials was obtained by using a permagraphproduces a magnetizing hysteresis curve as shown Figure of Hysteresis curve magnetization Plotted data is the

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result of measurementsdirectly without being processed so that the shape of the curve is notsmooth (smooth). However, the hysteresis form can
still be clearly observed and analyzed. Some parameters of magnetization hysteresis that can beseen. Magnet remanence (Mr), coercivity (Hc), and maximum energy of induction product (HBmax)

IV. CONCLUSION

The Based on the results of the analysis, the characterization of the mechanical and magnetic properties is influenced by the grain size of the Fe3O4 filler. The larger the grain size, the higher the density, remanence (Mr), coercivity (Hc), and the decrease in maximum product energy (BHmax). However, the compressive strength tends to decrease. So, samples with large grain size of Fe3O4 filler still have competitive advantages in terms of density and magnetic properties compared to other samples which have relatively smaller grain sizes. However, in large grains the PVA matrix has not formed optimal bonds as shown in the photo from the SEM test, as a result, the larger the grain size of the Fe3O4 filler, the compressive strength tends to decrease. The decrease in compressive strength is 17.5, 8.3, 7.4, 4.7 Kg/cm^{2}corresponds to the increase in the grain size of the Fe3O4 filler, 300, 250, 225, 200 mesh.

SOME OF THE ADVANAGES FROM THE ABOVE RESULTS

The Material magnet compositewith filler Fe3O4 and PVA matrix, have good density and magnetic properties.The highest density is4.78 g/cm^3, magnetic remanence (Mr) is 3.47 kG, coercivity (Hc) is : 1.92kA/m, and maximum product energy (BHmax) is : 14 KJ/m^{3}in the magnet composite with the largest Fe3O4 filler size, which is 200 mesh.

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