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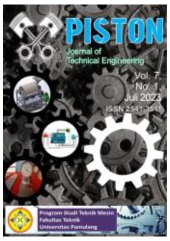

Analysis of Mechanical and Magnetic Properties of Rubber Magnet Composite Made From NdFeB Magnetic Particlesand Silicon Rubber

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Abstract: *This study conducted the manufacture of permanent magnet composite based on NdFeB magnetic powder and polymer adhesives, the purpose of this study was to determine the effect of the composition of the mixing of raw materials on mechanical properties and magnetic properties. Neodymium Iron Boron (NdFeB) composite was made by mixing of NdFeB magnetic powder and binder of silicon rubber (SR) in form liquid. The percentage of silicon rubber was varried of 5 %, 10%, 20 % and 30% by volume. Both raw materials were mixed until homogeneous and poured into the mold and allowed to dry at room temperature.The formed samples were characterized which includes the measurement of tensile strength and magnetic properties . The characterization results show that the sample with 20 % and 30 % SR has good flexibilty and other samples are rigid or not flexible. The variation in the composition of silicon rubber has a significant effect on mechanical properties and magnetic properties, especially remanence. The characteristic of flexible rubber magnet with a composition of 20% and 30% silicon rubber is that it has a tensile strength of 9.31 - 11.46 N / mm2 with an elongation of 17.55-26.74% and a hardness of 38-42 HA. While the magnetic properties achieved are magnetic field strength = 430-500 Gauss, remanence = 30-35 emu / g and coercivity of 2000 Oe.*

Keywords: *Magnet Permanent, NdFeB, Silicon Rubber, Ultimate Tensile Strength, Magnetic Properties.*

Abstrak: Studi ini melakukan pembuatan komposit magnet permanen berbasis serbuk magnet NdFeB dan bahan perekat polimer. Tujuan dari studi ini adalah untuk menentukan pengaruh komposisi campuran bahan baku terhadap sifat mekanik dan sifat magnetik. Komposit Neodymium Iron Boron (NdFeB) dibuat dengan mencampur serbuk magnet NdFeB dan bahan perekat karet silikon (SR) dalam bentuk cair. Persentase karet silikon divariasikan antara 5%, 10%, 20%, dan 30% berdasarkan volume. Kedua bahan baku tersebut dicampur hingga homogen dan dituangkan ke dalam cetakan, lalu dibiarkan mengering pada suhu ruangan. Sampel yang terbentuk kemudian dicirikan yang meliputi pengukuran kekuatan tarik dan sifat magnetik. Hasil karakterisasi menunjukkan bahwa sampel dengan 20% dan 30% SR memiliki fleksibilitas yang baik, sementara sampel lainnya kaku atau tidak fleksibel. Variasi dalam komposisi karet silikon memiliki pengaruh signifikan pada sifat mekanik dan sifat magnetik, terutama remanensi. Karakteristik magnet karet fleksibel dengan komposisi 20% dan 30% karet silikon adalah memiliki kekuatan tarik 9,31 - 11,46 N / mm2 dengan pemanjangan 17,55-26,74% dan kekerasan 38-42 HA. Sementara sifat magnetik yang dicapai adalah kekuatan medan magnet = 430-500 Gauss, remanensi = 30-35 emu/g, dan koersivitas sebesar 2000 Oe.

Kata Kunci: Magnet Permanen, NdFeB, Karet Silikon, Kekuatan Tarik Maksimal, Sifat Magnetik.

INTRODUCTION

Rubber magnets are also an advanced group of materials consisting of magnetically polarized particles embedded in a soft rubber matrix, rubber magnets are classified as composite materials that use a filler in the form of magnetic particles and as a matrix are a rubber-like polymer [1], [2]. Rubber magnets are magnetic materials that are flexible and have good flexibility. There are several types of polymer rubber used, including: natural rubber or latex and synthetic rubber such as nitrile rubber, silicon rubber and other types of elastomers. Rubber magnets are widely used as components in doors or windows as locks and sealers, or as an adhesive material between two components, and are used for DC motor components, light-controlled actuation and interfaces [3].

Rubber magnets have not been produced domestically, almost 100% are still imported. Meanwhile, the raw materials for the manufacture of rubber magnets are quite widely available in the country, such as natural rubber polymer produced by rubber plantations in the country, as well as magnetic materials as magnetic particles can be made using domestic raw materials such as for example as a source of iron and Nd can be obtained natural resources. To meet the demand for rubber magnets in the future, it is necessary to carry out research and development in the manufacturing sector, so that rubber magnet manufacturing technology can be mastered, so it is hoped that in the future a rubber magnet industry will emerge in Indonesia.

There are several kinds of magnetic particles used for the manufacture of permanent rubber magnets, for example: ferrite-based, NdFeB magnets, AlNiCo and SmCo magnets. Of the three types of magnets, NdFeB magnets are classified as the strongest magnets that have a magnetic remanence that can reach 10 kGauss or 1 Tersla. But this magnet has the disadvantage of being unstable at room temperature, because Nd is easily oxidized [4]. Therefore NdFeB-based magnets are made into composites, with polymer adhesives, where the polymer material will protect the surface of the NdFeB particles, so that the NdFeB composite magnets will be stable. The polymer materials used for the manufacture of NdFeB magnetic composites include: resin, poly Vynil Acrylate, synthetic rubber, natural rubber, bakelite [5], [6].

The manufacture of magnetic composites is strongly influenced by several factors, namely: the composition of magnetic particles and the composition of polymer materials, because polymer materials are non-magnetic materials, so it is necessary to use polymer concentrations according to the desired magnetic strength level. Ramlan et al reported that increasing the composition of Poly Vynil Alcohol from 5% -7.5% in the manufacture of NdFeB bonded magnets can reduce the magnetic remanence from 0.5 T to 0.4 T, but can increase its mechanical strength [7].

R. Setnescu reported that the manufacture of a flexible magnet based on micro-crystaline NdFeB grinded powder and a polymeric matrix (EPD] shown high magnetic properties due to magnetic microcrystaline powder and good flexibility due to elastomer matrix [8]. This study conducted the manufacture of permanent magnet composite based on NdFeB magnetic powder and polymer adhesives (silicon rubber), the purpose of this study was to determine the effect of the composition of the mixing of raw materials on mechanical properties and magnetic properties.

METHODOLOGY

A rubber magnet NdFeB is magnetic material made from a mixture of magnetic powder NdFeB from magnet quenh as a magnetic filler and the polymer silicon rubber as a matrix material to bind the magnetic particles. The raw material used to manufacture rubber magnet are NdFeB powder from magnet quench (commercial) and silicon rubber. There are four composition that have been made with a variety of silicon rubber. The compositions of silicon rubber are 5 %, 10%, 20 %, 30% and 40% by volume. Both raw materials were mixed manually by using glass spatula until homogen then poured into the mold, then dried for 6 hours at room temperature (30^{o}C). The characterizations were done such as : measurement of tensile strength, shore hardness, magnetic properties and microstructure. The tensile test was performed according to ASTM D412-2000 standard using a universal testing machine and the hardness (shore A, ASTM D2240-86) was measured by a Durometer tester. The magnetic properties were measured by using Gaussmeter and Vibrating Sample Magnetometer (VSM).

RESULT AND DISCUSSION

The rubber magnet samples were measured the tensile strength using UTM machine to know the value the tensile strength and the elongation at break of the rubber magnet NdfeB. The result is shown in Figure 1. The value of tensile strength and elongation tends to increase with increasing of SR It means that the samples with high content of SR (20 % and 30 %) become soft and flexible because the magnetic particles within the composite are bonded to each other by the SR polymer, if the SR content increases, the sample tends to soft.

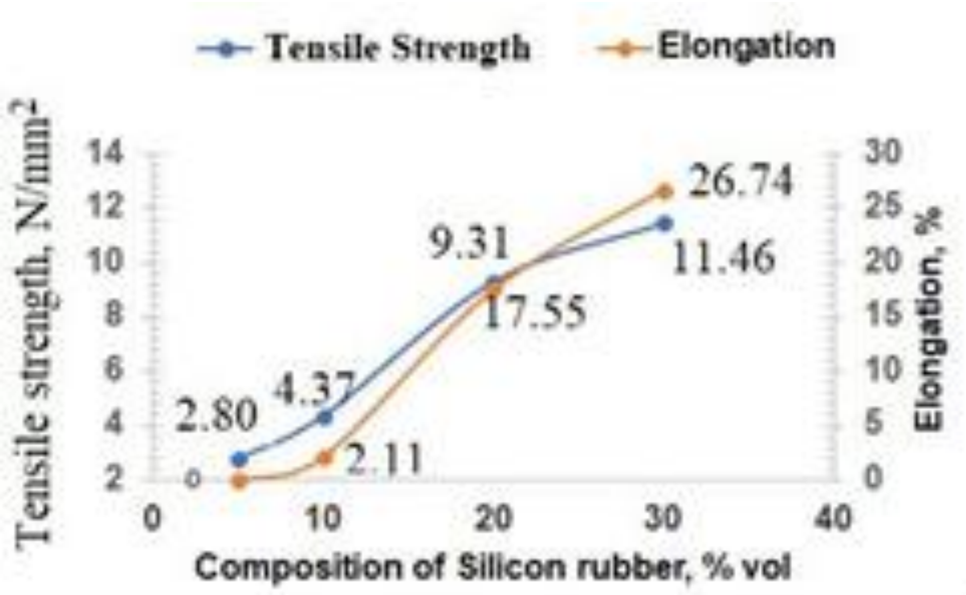

Figure 1. Relationship curve beetwen tensile strngth and elongation of rubber magnet NdFeB with the percentage of silicon rubber (SR)

The sample with the highest tensile strength was obtained about 11.46 N / mm^2 with elongation of 26, 74% in the sample with a composition of 30% SR. Under the composition of 20% SR, the elongation value decreases and the tensile strength value is getting smaller, because in samples with 5% to 10% SR become rigid, it shows that the sample conditions tend to be rigid (rigid) and more than 10 % SR, the sample has high or still flexible properties. The result of measurement shore hardness A is shown at Figure.2, the value of shore hardness A tends to decrease with increasing of SR content, because the sample becomes soft and flexible.

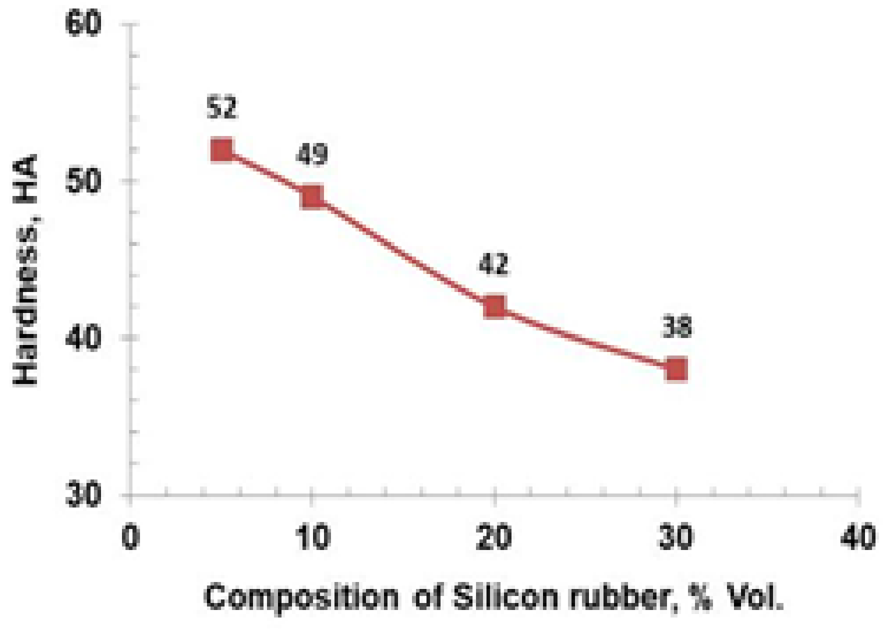

Figure 2. Relationship curve beetwen hardness value of rubber magnet NdFeB with the percentage of silicon rubber (SR)

Based on the hardness measurement curve (Figure.2) shows that the sample rubber magnet composite has a shore hardness value of around 38-52 HA. The sample with more SR composition, the sample hardness tends to decrease, because the sample becomes softer and more flexible. The results of measuring the magnetic field strength on the sample surface were carried out using a Gaussmeter, the measurement results are shown in Figure 3.

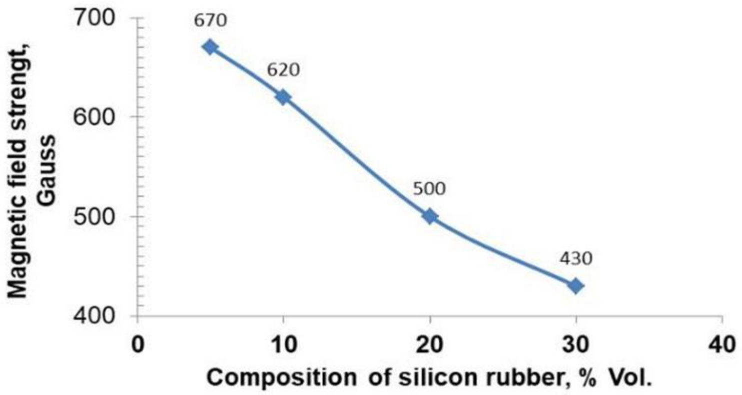

Figure 3. Relationship curve of Magnetic field strength of rubber magnet NdFeB with composition of silicon rubber

The results of measuring the magnetic field strength values in Figure.3 show that the magnetic field strength values reach a maximum point with a value of 670 Gauss on a 5 % silicon rubber and the lowest magnetic flux value is 430 Gauss at 30 % silicon rubber (SR). Based on Fig. 3, the increasing levels of SR, the value of the magnetic field strength decreases or gets smaller. Because the adhesive from SR is a nonmagnetic polymer material, so if it is added to NdFeB the magnetic field strength will decrease. This result is also confirmed by Djuhana (2018) [9]. The results of measurements of magnetic properties carried out using VSM from all samples are shown in the form of a hysteresis curve as shown in Figure 4.Based on the hysteresis curve, it can be seen that variations in the composition of SR have a significant effect on the remanence value, namely the greater the remanence value tends to decrease, because SR is non-magnetic. has an influence on the value of magnetic remanence. But the composition of the SR has no effect on the coercivity value, because coercivity is only affected by the magnitude of the magnetic particle domain.

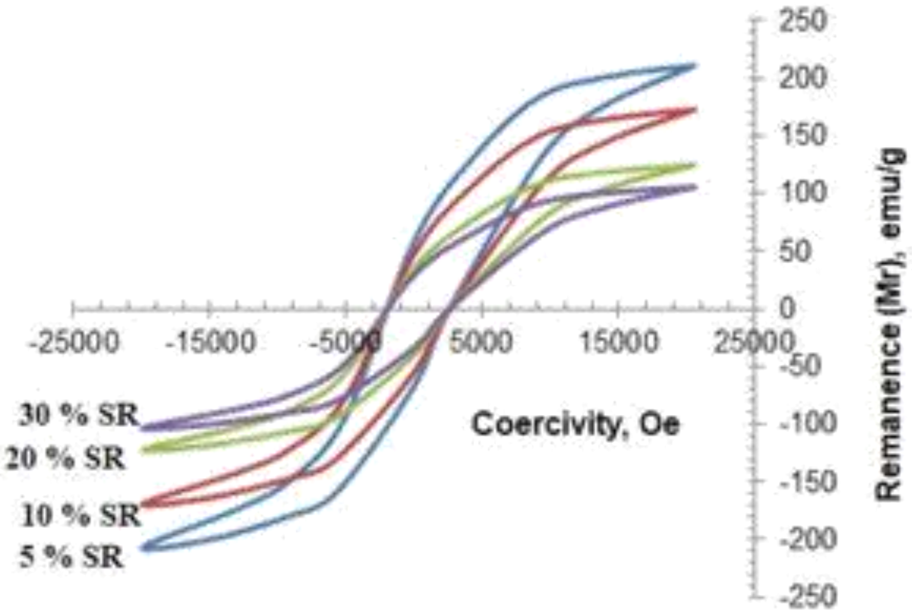

Figure 4. Hysteresis curve of the NdFeB rubber magnet with variations in the composition of the SR

From the hysteresis curve of the NdFeB rubber magnet, it can be seen that the value of remanence and coercivity with variations in the SR composition through the hysteresis curve in quadrant II as show in Figure 5.

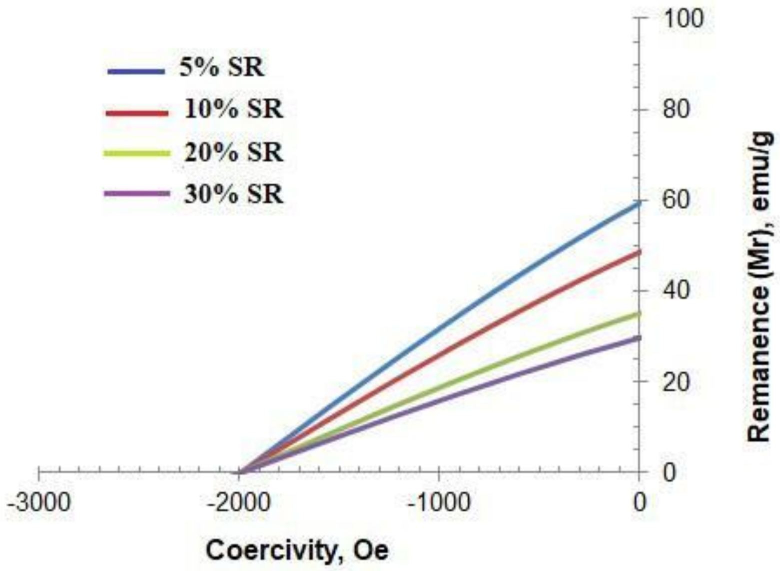

Figure 5. NdFeB rubber magnet hysteresis curve in quadrant II

Based on the quadrant II hysteresis curve, it shows that the highest remanence value is achieved at 59.80 emu / g in a sample with 5% SR, while a smapel with 10% SR has a remanence of 49 emu / g, while a sample with 20% SR has a remanence of 35 emu / g, for a sample with 30% SR has a remanence of 30 emu / g. While the coercivity value for all samples is a constant of 2000 Oe.

CONCLUSSION

A flexible NdFeB rubber magnet with a silicon rubber composition of 20% and 30% by volume has been successfully developed. The variation in the composition of silicon rubber has a significant effect on mechanical properties and magnetic properties, especially remanence. The characteristic of flexible rubber magnet with a composition of 20% and 30% silicon rubber is that it has a tensile strength of 9.31 - 11.46 N / mm2 with an elongation of 17.55-26.74% and a hardness of 38-42 HA. While the magnetic properties achieved are magnetic field strength = 430-500 Gauss, remanence = 30-35 emu/g and coercivity of 2000 Oe.

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