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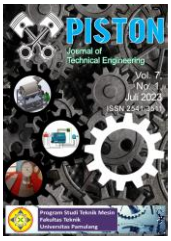

Analysis Crystal Structure and Magnetic Properties of Strontium Ferrite ($SrO6Fe_2O_3$) Made Using Powder Metallurgy

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Abstract: *Strontium ferrite in this study was obtained from a mixture of strontium carbonate and pure iron sand using the metarlurgi powder method. Variation in the composition of the composition of 1: 5 mol, 1: 6 mol, 1: 7 mol with a total mass of 30 grams, both of raw materials were milled by using a rotary ball mill with an additional 125 ml of distilled water for 6 hours. Then dried using the oven to become powder again. After that the sample was calcined by using a furnace at temperatures about 1000 ℃ and hold for 2 hours The sample was measured by using X-Ray Difraction (XRD) test to determine the crystal structure and the Vibrating Sample Magnetometer (VSM) test to determine the magnetic properties. Samples with a stoichiometric composition with mole ratio SrO: Fe_2O_3 = 1: 6 have the highest magnetic properties, namely with a remanence value = 48 emu / g or 0.3 Tesla and a coercivity of 2500 Oe. As well as the crystal structure obtained single phase $SrO6Fe_2O_3$ ($SrFe_{12}O_{19}$).*

Keywords: *Strontium Ferrite, Calcination, Crystal Structure, Remanence, Coercivity*.

Abstrak: Strontium ferrite dalam penelitian ini diperoleh dari campuran strontium karbonat dan pasir besi murni menggunakan metode serbuk metalurgi. Variasi dalam komposisi adalah 1: 5 mol, 1: 6 mol, 1: 7 mol dengan total massa 30 gram, kedua bahan baku digiling dengan menggunakan mesin penggiling bola berputar dengan penambahan 125 ml air suling selama 6 jam. Kemudian dikeringkan menggunakan oven untuk menjadi serbuk kembali. Setelah itu, sampel dikalsinasi dengan menggunakan tungku pada suhu sekitar 1000 ℃ dan dipertahankan selama 2 jam. Sampel diukur dengan menggunakan uji *X-Ray Difraction* (XRD) untuk menentukan struktur kristal dan uji Vibrating Sample Magnetometer (VSM) untuk menentukan sifat-sifat magnetiknya. Sampel dengan komposisi stoikiometrik dengan rasio mol SrO: Fe_2O_3 = 1: 6 memiliki sifat magnetik tertinggi, yaitu dengan nilai remanensi = 48 emu / g atau 0.3 Tesla dan koersivitas sebesar 2500 Oe. Serta struktur kristal yang diperoleh adalah satu fasa tunggal $SrO6Fe_2O_3$ ($SrFe_{12}O_{19}$).

Kata Kunci: Strontium Ferrite, Kalsinasi, Struktur Kristal, Remanensi, Koersivitas.

INTRODUCTION

Ferrite is a ferromagnetic oxides materials and it has a hexagonal crystal structure and these ferromagnetic materials can be easily magnetized along the c-axis [1]. The ferrite material has been developed at the Philips laboratory in 1955. Ferrite materials are still used until now in widely application, for example: as a component of motor, sensors, component speakers, magnetic recording, sealer, microwave absorbers, magneto-optics, and other functional [2], [3]. The ferrite materials are called as hard magnet or soft magnet. Ferrite material has a formula such as $MO.6Fe_2O_3$ (where M: Ba, Sr, Pb) , this type of ferrite is called as hard magnet or permanent magnet [4].

Strontium ferrite with formula $SrO6Fe_2O_3$ is scientifically and technologically very attractive as magnetic materials, because it has relatively high Curie temperature (450ºC), high coercive force and high magnetic anisotropy field, as well as its excellent chemical stability and corrosion resistivity [5]. The properties of the magnetic materials as a permanent magnet are shown in Table 1.

Table 1. Magnetic Properties of Permanen Magnet Materials [6]

Materials	**Magnetic Properties**				
	Br (T)	Hcj (kA/m)	Hcb (kA/m)	(BH)max (kJ/m)	Temperature Curie (°C)
Ba Ferrite	0.38	180	155	27	450
Sr Ferrite	0.40	275	265	30	450
NdFeB	1.43	950	915	398	310

Magnetic properties of Sr ferrite magnets are not very high, but the properties of Sr Ferrite is very stable and good corrosion resistance. The disadvantages of ferrite magnet are brittle and high shrinkage after process sintering [7], [8]. The ferrite magnets can be prepared as isotropic magnet or anisotropic magnet, Permanent magnets of this type are the most popular, mainly due to their low price. Ferrite magnets are still produced and applied up to this point, because raw materials is abundant in nature and cheap.The production route of permanent magnet ferrite consists of several ways such as : sol gel or cooprecipitation method and powder metallurgy method [9].

Powder metallurgy is a common method for producing ferrite magnets, which use raw materials in powder form and this process is cheap also easy and simple [3]. The composition in the manufacture of Sr ferrite can affect the formation of crystal structures and magnetic properties. The theoretical composition of Sr. ferrite is the mole ratio of SrO to Fe_2O_3 about 1: 6. The theoretical composition is called stoichiometric composition [4], [10]. The magnetic properties of sintered Sr-ferrite depend on composition, crystal structure and microstructure (size and shape of the particles). In order to fabricate a sintered magnet with superior properties it is necessary to inhibit the grain growth during sintering and also to keep the microstructure homogeneous. This research was conducted to make Sr Ferrite ($SrO6Fe_2O_3$) powder on stoichiometric and non-stoichiometric compositions and to see its effect on changes in crystal structure and magnetic properties.

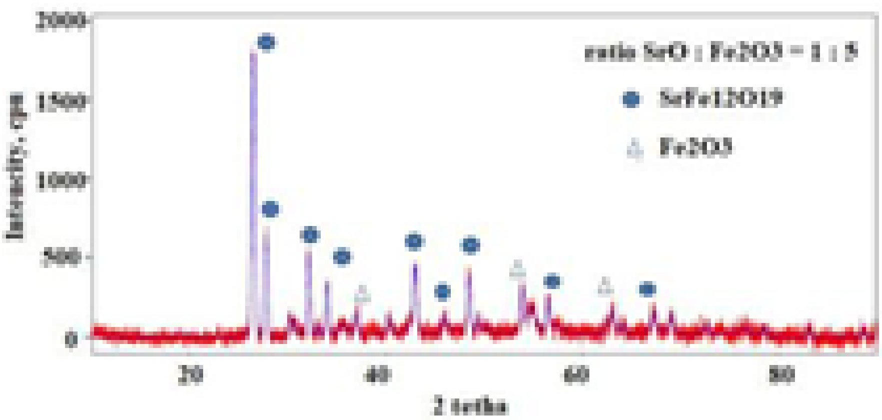
METHODOLOGY

The manufacture of Sr Ferrit ($SrO6Fe_2O_3$) powder used pure raw materials (Pro Analysis), namely $SrCO_3$ pa and Fe_2O_3 pa with variations in the mole ratio SrO: Fe_2O_3 = 1: 6 (stoichiometry), SrO: Fe_2O_3 = 1: 5 (non stoichiometric) and SrO: Fe_2O_3 = 1 : 7 (non-stoichiometric) through powder metallurgy method.

The both of raw materials are weighed according to the composition variation, then put into the ball mill tube and add distilled water and Zirconia ceramic balls. Furthermore, the milling process was carried out using a rotary ball mill machine for 6 hours. Furthermore, the slurry produced from the mixing process with the ball mill is dried using a drying cabinet at a temperature of 110ºC until a dry powder is produced. After that the samples powder ware calcined by using a electrical furnace at temperatures about 1000 °C and hold for 2 hours. The calcined samples ware measured by using X-Ray Difraction (XRD) test to determine the crystal structure and the Vibrating Sample Magnetometer (VSM) test to determine the magnetic properties.

RESULT AND DISCUSSION

The three types of samples with different SrO: Fe_2O_3 mole ratios after combustion or calcination at a temperature of 1000ºC were carried out XRD analysis, the results of the X-ray diffraction patterns of the three types of samples are shown in Figure 1.



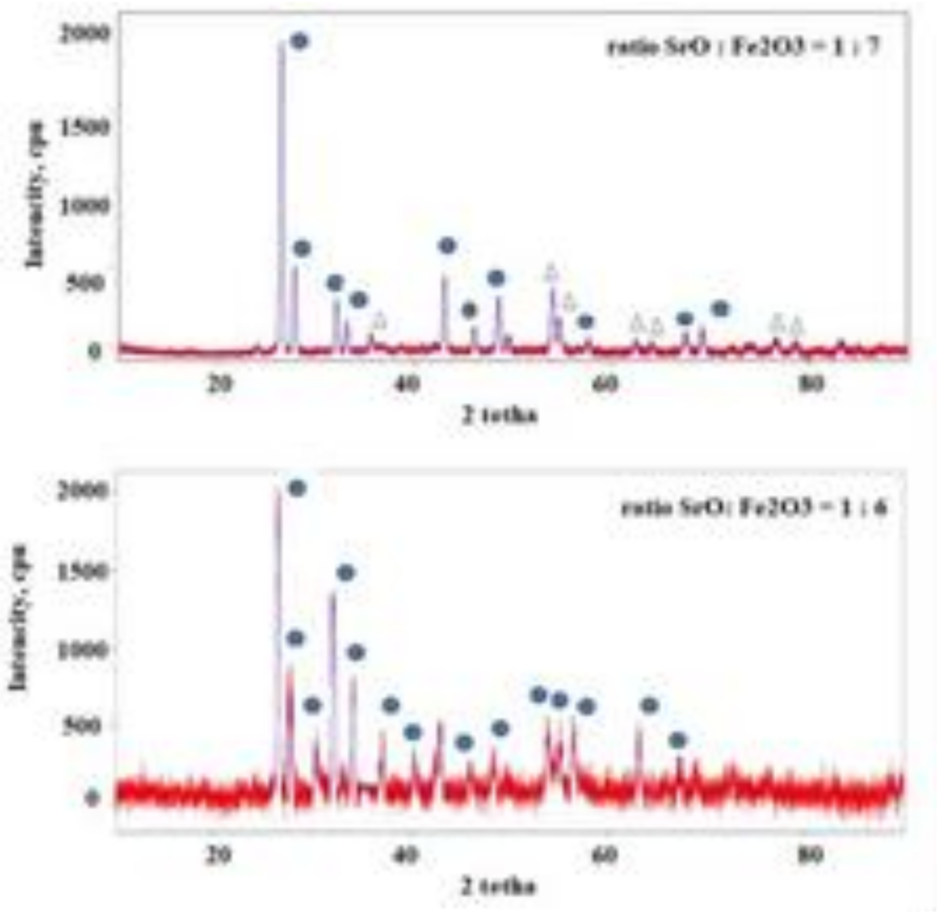


Figure 1. XRD Patterns of Samples After Calcination at 1000°C

Based on Figure 1, it is found that the sample with the mole ratio SrO: Fe_2O_3 = 1: 6 has a single phase $SrFe_{12}O_{19}$, while for the sample with the mole ratio SrO: Fe $_2O_3$ = 1: 7 has two phases, namely the $SrFe_{12}O_{19}$ phase as the dominant phase and the Fe_2O_3 phase as the minor phase. In the sample with the mole ratio SrO: Fe_2O_3= 1: 5, the dominant phase is the $SrFe_{12}O_{19}$ phase and Fe_2O_3 phase as minor phase, but the minor phase is less than the sample with the mole ratio SrO: Fe_2O_3 = 1: 7. Based on the results of XRD analysis, the magnetic phase of $SrFe_{12}O_{19}$ was formed after calcination at a temperature of 1000ºC. The magnetic properties of the three types of powders are measured using a Vibrating Sample Magnetometer. The measurement results in the form of hysteresis curves are shown in Figure 2.

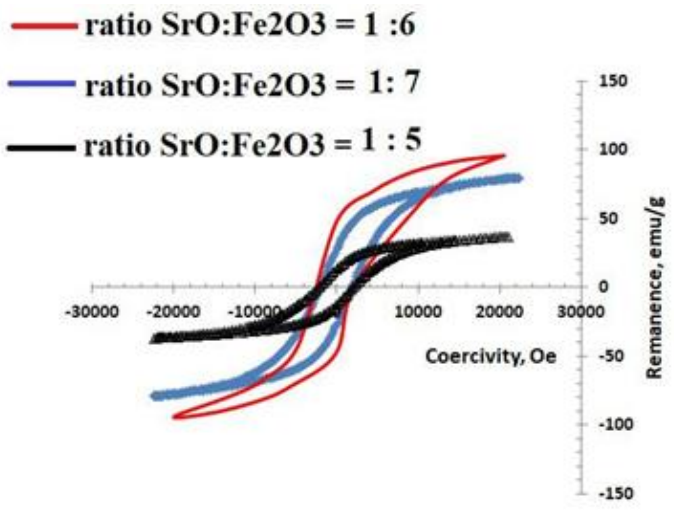


Figure 2. Hyseresis Curve of Samples After Calcination 1000°C

Based on the curve in Fig. 3, it shows that the variation of mole ratio SrO:Fe_2O_3 can affect of hysterisis loop, which has a significant effect on the remanence value , saturation and coercivity value. Based on the hysteresis curve shown in Figure 2, the remanence and coercivity values can be seen by depicting the hysteresis curve in the form of quadrant II curve as shown in Figure 3.

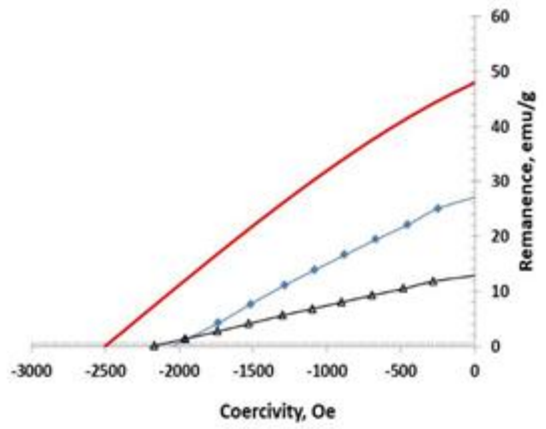


Figure 3. Hyseresis Curve at Quadrant II of Samples After Calcination 1000°C

From the quadrant II curve as shown in Figure 3, it can be seen the remanence value (Mr) and the coercivity value (Hcj) as shown in Table 2.

Table 2. Value of Remanence (r) and Coercivity (Hcj)

Sampel Ratio Mole SrO:Fe_2O_3	Mr, emu/g or [Tesla (T)]	Hcj (Oe)
1:6	48 [0.3]	2500
1:7	27 [0.15]	2200
1:5	13[0.75]	2050

The sample with the mole ratio SrO: Fe_2O_3 = 1: 6 is said to be a stochoimetric composition with the formula SrO6Fe_2O_3 ($SrFe_{12}O_{19}$), has the highest coercivity of 2500 Oe and the highest remanence value is 48 emu/g or 0.3 Tesla. The results obtained in this study These values of remanence and coercivity are still slightly lower with theoretical values, where the theoretical value of remanence is 0.38 Tesla and the theoretical coercivity value is 3000 - 4000 Oe [6]. Meanwhile, samples with non-stoichiometric mole ratios, namely 1: 5 and 1: 7, experienced a decrease in their remanence and coercivity values. This is because in the two samples there is a minor phase Fe_2O_3, so that their magnetic properties decrease. While samples with multiple stoichiometric ratios have only a single magnetic phase, therefore the value of their magnetic properties is higher.

CONCLUSSION

Based on the results of this study it can be concluded that the composition of the mixing of raw materials, especially the mole ratio of SrO: Fe_2O_3 in making SrO6Fe_2O_3 ($SrFe_{12}O_{19}$) permanent magnets can have a significant effect on changes in crystal structure and changes in magnetic properties. Samples with a stoichiometric composition with mole ratio SrO: Fe_2O_3 = 1: 6 have the highest magnetic properties, namely with a remanence value = 48 emu / g or 0.3 Tesla and a coercivity of 2500 Oe. As well as the crystal structure obtained single phase SrO6Fe_2O_3 ($SrFe_{12}O_{19}$).

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