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THE CHARACTERISATION OF MAGNETIC MATERIALS EXTRACTED FROM THE ACEH IRON SAND Muhammad Sayuti,*_Reza Putra2, Muhammad Yusuf2 1Department of Industrial Engineering, Faculty of Engineering Universitas Malikussaleh, 24351 Aceh Indonesia. 2Department of Mechanical Engineering, Faculty of Engineering Universitas Malikussaleh, 24351 Aceh Indonesia

Abstract – This study aims to identify the content and particle shape and to determine the type of iron oxide in the magnetic material from Aceh Iron Sand.

The magnetic materials are separated from the iron sand using an external magnet, washed out with distilled water and dried at 80 °C. The materials were characterized by XRD and SEM. The results show that the magnetic materials sampled from the Aceh iron sand contain 88.93%, 96.3%, 92% and 85% of Fe, respectively.

The iron oxide found in Aceh iron sand wasdominantly magnetite (Fe_3O_4) or ilmenite $(Fe,Ti_3)O_4$, however, there are also other oxide impurities, such as silica and chromium oxides. The identified minerals were classified as lithogeneous sedimentary volcanic minerals, which have blackcolour and spherical shape. Related to that, the sampling locations of these minerals were the type of volcanic minerals and lithogenous sediments since the position of the coast locations is adjacent to the Burni Telong vulcano, Peut Sago volcano, Seulawah volcano, and the minerals are carried by currents to beach through the river flow, which further supports the assumption of its volcanic origin.

Keywords: Iron sand, Magnetic materials, Iron oxide, Aceh

Introduction Along with the development of technology, magnetic materials are currently used not only as raw materials for steel making, but also in various fields such as electrochemical, catalytic and medical science [1,2]. The development of the magnet industry critically depends on the use of magnetic materials components[3].The currently used magnetic materials include iron oxide materials, such as hematite (a-Fe_2O_3), maghemite (?-Fe_2O_3), ilmenite (Fe,Ti3)O3), and magnetite (Fe_3O_4), sulfide iron materials such as pyrrhotite (Fe_7S_8) and greigite Fe_3S_4[4].The research on the use of iron oxide materials has been carried out in various fields [5].

Maghemite iron oxide is used as a super capacitor material electrode while magnetites are widely used as drug delivery agents to transport drugs to certain parts of the human body and as contrast agents in magnetic resonance imaging (MRI)[6]. The magnetic nano particle materials modified with polymers were used to adsorb metal ions such as Cd (II), Zn (II), Pb (II) and Cu (II) [3].

These three magnetic materials are usually synthesised in the laboratory using the co-precipitation method [7]. The precursors in the synthesis of magnetic materials used are usually FeCl36·H2O, FeCl24·H2O,FeSO47·H2O or Fe(NO3)39·H2O[8-10]. However, these precursors are relatively expensive and produce new waste.

Therefore, a more effective, efficient, and environment-friendly source of magnetic materials is required to replace these precursors. The source of magnetic materials can be replaced with magnetic materials derived from the natural iron sand. Iron sand is generally composed of iron oxide, namely magnetite (Fe_3O_4), hematite (a-Fe_2O_3), and maghemite (?-Fe_2O_3), and several other oxide compounds such as Al_2O_3, MgO, and SiO_2 [11].

Iron sand in Indonesia is found mostly on coastal locations, such as the coast of West Sumatra, the southern coast of Kebumen, and the north coast of Java Island. Aceh has several regions with excellent potential minerals, such as Monklayu, Mantak Tari, Lam Panah and the Syiah Kuala coast. Potential minerals found in the area include magnesite, chromite, iron, quartz, limestone, sandstone and clay stone[12].

Therefore, it is necessary to identify iron sand materials from different areas, especially the province of Aceh, and to determine its iron content. An iron ore obtained from an iron sand is usually mixed with soil, so an appropriate method is required to purify the iron sand. On a laboratory scale, the iron sand magnetic material is prepared manually using an external magnet [13], but it still contains several impurities [10].

The sand can be classified by its physical properties or by the constituent mineral content. The classification based on the physical properties of the sand can be distinguished based on the shape, size, colourand density of the sand. A researcher used three sub-quantities, where each quantity describes the shape but at different scales [14]. These terms are morphology/form, roundness and surface[15].

In Figure 1 is shown how the scale terms are defined. A graphic scale to illustrate the quantitative measure (Figure 2)[16]. It is important to highlight that any comparing chart that describes particle properties has a high degree of subjectivity. The classification can also be done by looking at the differences of the chemical constituents of the sand.

One method used to analyse mineral content in the sand is X-ray diffraction (XRD), whichs calculates the mineral percentages in the specific sample [17]. Fig. 1. Fig.2 Therefore, the magnetic material has to be purified to remove impurities that cannot be pulled out by external magnets. In this study, the separation of the magnetic material from the iron sand was performed using external magnets; the magnetic material was prepared by washing out with distilled water before the further characterization, identification of magnetic material content, and determination of iron oxide types in the magnetic material of the Aceh iron sand. This research can provide an alternative use of iron sand as a support for the national steel industry.

Experimental The samples of the iron sand originating from the coasts of Mon Klayu, Mantak Tari, Lam Panah and Syiah Kuala Beach were used for the preparation of magnetic materials. 100 g of the iron sand was separatedby an external magnet and afterwards washed with distilled water. The washing procedure was repeated three times. The magnetic solidswere dried in an oven with a temperature of 70 ° C for 24 h.

The obtained iron sand powder was characterized by X-ray diffractometry (XRD) and scanningelectronmicroscopy (SEM) in the laboratory of the National Nuclear Energy Agency of Indonesia (BATAN). The additional characteristic observation of the sand shape was conducted using an optical microscope. The shape of each sample was then compared with the image of the sand form in Figure 2.

Results And Discussion The Mineral Content Figure 3 shows the grayish black colourof the iron sand of Mon Klayu (MK) beach, Mantak Tari (MT), Lam Panah (LP) and Syiah Kuala (SK) before magnetic separation. After the magnetic separation, the black magnetic concentratewas obtained, as shown in Figure 3 (b). The black colour visually implies that iron oxide in the magnetic material is dominantly composed of the magnetite type [18].

However, further characterization is needed to support the identification of iron oxide types and the content of the iron sand magnetic material. The content of the iron sand magnetic material and the amount of impurities that cannot be separated from the external magnet were determined by SEM. The results of the characterization of iron sand magnetic materials using SEM are shown in Table 1. Fig. 3 Table 1.

Based on Table 1, it is known that the magnetic materials sampled out at Mon Klayu, Mantak Tari, Lam Panah and Syiah Kuala locations contain Fe as a major element with the average levels above 90%, and also other minor elements. The high level of Fe is caused by the preparation procedure, which was carried out using external magnets and the geographical conditions of the area from where the samples were taken. SEM results show that the levels of elements C, Mg, Si, Ti, Al, V, S, Na, Cr in the investigated magnetic materials are quite large.

The iron oxide from Aceh iron sand is dominantly composed of magnetite (Fe_3O_4) or ilmenite $(Fe,Ti)_3O_4)$ (Figure 4). The levels of these oxides are quite large since they also have magnetic properties. Therefore, when the magnetic material of iron sand is pulled out by an external magnet, the oxide is also attracted to an external magnet.

In addition, the Aceh sampling area is also a region producing chrome mineral resources. The obtained magnetic material still contains these elements in sufficient quantities. The constituent elements of the magnetic material do not exist as chemical elements but rather in the form of oxides.

Therefore, magnetic material needs to be further characterized to find out the oxide phases present in the magnetic material. The mineral content affects the colour of the iron sand [18]. The iron sand appears as black because of the dominant presence of cromite with a heterogeneouscolour layer structure: the layer contains a mixture of red, brown, white and solid black. This colour identification can be seen in the Table 2.

The iron sand content is very dependent on the source of the local stone and environmental conditions. The bright white sand found on the beach is limestone or silica and some sands are rich in dark magmatic material so that the black appearance comes from volcanoes and oxides. In the black sand, the dominant minerals are magnetite (Fe_3O_4), ilmenite $(Fe,Ti_3)O_3)$, diamond (C), or chromite [$(Mg,Fe)\ Cr_2O_4$].

The darker is the colour of the sand, the higher is the concentration of Fe phases or chromite. Table 2. Based on the mineral content, the particle size of iron sand can be classified as of fine grade. Arstrong suggested that high levels of SiO_2 and Ca-oxide can be found in medium-sized sand, while in a fine sand, the mineral content found is generally composed of ironsand (Fe), Al_2O_3 and Ti [19].Related to this, it is suggested that these minerals belong to the type of volcanic minerals and lithogenous sediments because the position of four beaches is adjacent to the Burni Telong vulcano, Peut Sago volcano and Seulawah volcano, and the minerals are carried by currents to the coast by the river flow[20].

Particle shape It can be seen in Figure 5 that the grain shape of the sand hasan irregular form,The sphericity is a measure that describes the tendency of a grain shape towards a spherical shape[21].The high roundness value or the round shape of the grains of sand indicates that the grain has undergone a further transport process resulting in the fine sand grains.

The sand or the particle/grain is shaped by abrasion during transportation, where collisions between particles or with bedrock exist, so that the shape changes from angled/pointed to rounded. The longer the distance traveled, the more complex and the more rounded the particle form [22]. Based on the analysis of the sediment fraction, the average particle size of sand is 0.14 mm, which means that Aceh beach sand can be categorized as fine.

The visual inspection of the sample shows that the sand sample is in the coral form. The size of the sediment granules in the study location is inseparable from the surrounding environmental conditions that help the sediment formation. One of these conditions is the source of sedimentary components from the land, such as the process of abrasion or erosion, which are then carried by the river.

The factor that influences the size of the sedimentation grain is the sediment material transport mechanism. This will determine the depositional variation that occurs, so the coarser particles are easier to be deposited than finer ones, since it is affected by hydro-oceanographic factors, such as water flow and tides[18]. Fig.4 Fig.

5 Conclusion Depending on the locations, the extracted magnetic materials have different amounts of Fe-mineral: 88.93% (Mon Klayu), 96.3% (Mantak Tari), 92% (Lam Panah) and 85% of Fe (Syiah Kuala), as well as C, Mg, Si, Ti, Al, V, S, Na, Cr and other minor elements. Iron oxide in the Aceh iron sand is dominantly in magnetite (Fe_3O_4) or ilmenite (Fe,Ti3)O4) form.

The results of characterization show that the magnetic materials of the iron sand still contain oxide impurities, such as silica oxide and chromium oxide. The types of minerals identified were classified into volcanic mineral types from lithogeneous sedimentary types, black in colour and rounded in shape.This corroborates well with the position of the Monklayu, Mantak Tari, Lam Panah and Syiah Kuala beach is adjacent to the Burni

Telong vulcano, Peut Sago volcano, and Seulawah volcano, and the minerals are carried by currents to the beach by the river flow.

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Figure captions Fig. 1. The shape-describing sub-quantities. Fig. 2 Aroundness qualitative scale [16]. Fig. 3 The iron sand before, and after separating (concentrate); a) Mon Klayu, b) Mantak Tari, c) Lam Panah and d) Syiah Kuala. Fig.

4 XRD patterns and related compositions of the ironsands a) Mon Klayu and b) Mantak Tari, and the corresponding concentrates c) Mon Klayu and d) Mantak Tari. Fig. 5 The particle shape of different iron sands: a) Mon Klayu, b) Mantak Tari, c) Lam Panah and d) Syiah Kuala.

Table 1. The elemental composition of the magneticmaterials determined by SEM.

AREA	Composition (%)									
	Fe	C	Mg	Si	Ti	Al	V	S	Na	Cr
MK	88.93		0.93	1.39	6.65	2.09				
MT	96.3			1.67	0.54	1.22	0.27			
LP	92	2.7	0.54	2.5	0.74	0.94	0.2	0.13		0.12
SK	85	0.67	1.09	1.64	7.93	1.49			1.65	

Table 2. The identification of the minerals according to the colour.

Colour _Type of Mineral/Compound/Element _ _Red _Hematite (Fe2O3), Cuprite (CuO2), or Pyrope (Mg,Al2SiO12) _ _Yellow _Marcasite (FeS), Sulfur (S), Chalcopyrite (CuFeS2) or Vanadium (V) _ _Black _Magnetite (Fe3O4), Ilmenite (Fe,Ti3)O3), Diamond (C), or Chromite [(Mg,Fe)Cr2O4] _ _Brown _TiO2compound or Spinel (MgAl2O4) _ _White _SiO2compound or Orthoclase (KalSi3O8) _ _Light green _Uvarovite (Ca3Cr2Si3O12) or olivine [(Mg,Fe)2SiO4], _ _Orange _Spessartine (Mn3Al2Si3O12) _ _ _ Figure 1

_ Figure 2

_ Figure 3

_ Figure 4

_ Figure 5

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