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Characterization of Sawang River Sand for Foundry Application

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ABSTRACT

The study investigated characteristic of Sawang river sand in Aceh Indonesia for its possible use in foundry application. Experimental techniques which included determination of moisture content, clay content, Grain Fineness Number, and grain shape of river sand were conducted to measure foundry properties of the sand. Tests are carried out following the standards and procedures defined by the American Foundrymen's Society (AFS). Results obtained revealed that the river sand has moisture content of 5.81 % and clay content of 13.66%. The value of the Grain Fineness Number (GFN) obtained is 49.9, which is still within the acceptable range of mold sand and suitable for metal casting. The sand has angular grain shape, slightly rounded mixed with angular and slightly rounded. Sawang river sand will be suitable for casting of casting of light steel, grey iron, and non-ferrous metals, with the addition of binding agent in suitable proportion. However, further study is recommended on the sand test for casting to assess the quality.

Keywords: sawang river sand, properties, molding, foundry

1. Introduction

The metal casting process involves the pouring of molten metal into a mold. Therefore, the mold material and molding method must be selected with care [1, 2]. Most of castings are made in sand molds because metallic molds wear out too quickly to be economical for ferrous metals production [3, 4, 5]. Selection of the molding material depends on the type of metal being poured, the type of casting being made, the availability of molding aggregates, the mold and core making equipment owned by the foundry, and the quality requirements of the customer. Sand is a common material used in the sand mold of metal casting and its characteristics give a great deal of influence to the mold properties. Sand for molding is generally classified into three groups that are natural sand, silica sand and special sand. The silica sand such as mountain sand, sea sand, beach sand, river sand and lake sand. Both natural and silica sand are composed of silica (SiO_2). Zircon, olivine and chromite sand are classified as special sand which is expensive.

The shape, size, composition, and purity of the sand are important factors to the success of the mold making operation [6, 7]. The size distribution of the sand affects the quality of the castings. Coarse grained sand allows metal penetration into the molds giving poor surface finish to the castings. Fine grained sands generate better surface finish but need higher binder content and the low permeability may cause gas defects in castings. Most mold sands should fall within 50-60 grain fineness number (GFN) or 220-250 microns average grain. Grain shape is defined in terms of angularity and sphericity. Sand grains vary from well-rounded to rounded, sub-rounded, sub-angular, angular and very

angular. Within each angularity band, grains may have high, medium or low sphericity The best mold sands have grains which are rounded with medium to high sphericity giving good flowability and permeability with high strength at low binder additions. More angular and lower sphericity sands require higher binder additions, have lower packing density and poorer flowability [7].

The objective of this study is to investigate the potential of Sawang river sand as a molding material for metal casting process.

2. Methods

The sand investigated for this study was collected from S river Aceh Indonesia. Its coordinates are 5°14'22"N and 96°56.56"E. The sand properties was investigated to determine its possible use in the metal casting. Properties of the sand investigated are, moisture content, clay content, grain size and distribution, and grain shape. The investigations were carried out according to American Foundrymen Standard (AFS) procedure.

2.1 Moisture Content (MC)

Fifty (50) grams of sand sample was weighed with the digital balance and dried in oven at 110°C for 20 minute. The ratio of loss of weight for each sand sample on heating and that of the sample before heating, expressed in percentage [8]. Moisture content is expressed mathematically as:

$$MC\ (\%) = \frac{W_1 - W_2}{W_1}\ x\ 100 \quad (1)$$

Where W_1 is the weight of moist sample, and W_2 is the weight of the dried sand.

2.2 Clay content

The clay content was determined using glass bottle and solution of salt water (NaCl). Fifty (50) grams of dried sample was placed into the glass bottle followed by 475 ml of water and twenty (20) grams of NaCl, the glass bottle was set on rotating sand washer. Sand sample was washed until clear solution was obtained. The sand had been dried in the oven and the remaining sand was weighed. The ratio of the loss of weight in the sand sample on heating and that of the washed sand sample, expressed in percentage, gives the clay content [9].

$$Clay\ content\ (\%) = \frac{W_a - W_b}{W_a}\ x\ 100 \quad (2)$$

Where Wa is the initial weight of dried sample before washing, and Wb is the remaining weight of dried sample after washing.

2.3 Grain size and distribution

The sand grain size and distribution was determined using sieve analysis, and mechanical sieve shaker was employed for the experiment. The sieve shaker was arranged from the sieve with the highest mesh opening to the lowest mesh opening in descending order on the mechanical sieve shaker. Fifty (50) grams of clay-free sand samples were sifted through standard set of sieves for 15 minutes and the weight of sand in every sieve was weighed using electronic balance. The percentages of the sand passed through the sieves and retained in the sieves were recorded [7]. The grain distribution for each samples were obtained and the Grain Fineness Number (GFN) was calculated using the equation:

$$GFN = \frac{\sum(Wn\ x\ Sn)}{\sum Wn} \quad (3)$$

Where Wn is the weight of sand collected on each sieve and Sn is grain fineness coefficient.

2.4 Grain Shape

The angularity of sand was estimated using the Olympus BX51M microscope with the digital

camera to determine the shape of the sand grains.

3. Result and Discussions

The moisture content is the amount of water present in the sand. The river sand has the average moisture content of 5.81 %, as shwon in Table 1. This falls in the range of 4 – 8% which are within the satisfactory AFS molding sand moisture content for casting of light steel, heavy grey steel and medium grey iron [10, 11].

The average clay content of the river sand was found to be 13.66%, the results of the various tests are presented in Table 2. From the standard requirement for casting, these values are above the recommended standard values of 4% - 12% for ferrous metals, while that of non-ferrous metals of 12% - 18% [6, 8, 10, 12,13].

The grain sand distributions from sieve analysis of the sand sample are as shown in Table 3. By using Eq.3, GFN was calculated and established that 49.9. This number classifies it under coarse grain size, which is still within the acceptable range of mold sand and suitable for metal casting application [7, 10, 14,15]. This type of sand possesses high permeability and refractoriness. Variation in percentage of sand retained with sieve and grain distribution for the sand sample is presented in Figure1.

Tabel 1 The Moisture Content of River Sand

No. Test	W_1 (gram)	W_2 (gram)	MC (%)
1	50	47.05	5.90
2	50	47.05	5.90
3	50	47.15	5.70
4	50	47.16	5.68
5	50	47.05	5.90
Average			5.81

Tabel 2 The Clay Content of River Sand

No. Test	W_a (gram)	W_b (gram)	Content (%)
1	50	43.05	13.90
2	50	44.30	11.40
3	50	43.40	13.20
4	50	42.85	14.30
5	50	42.25	15.50
Average			13.66

Tabel 3 Sieve Analysis of River Sand

Sieve No	Wn (gram)	Sn	Wn x Sn
20	3.45	12	41.4
40	10.19	20	203.8
60	12.42	40	496.8
80	12.48	60	748.8
100	5.65	80	452
Pan	5.25	100	525
Total	49.44		2467.8

Figure 1 Graph of river sand grain size distribution

The shape of sand also influences the packing density and sand surface area and the consumption of binder is proportionate to the sand surface area. The best foundry sand is generally rounded with medium to high sphericity grains [7, 16, 17, 18]. The river sand has angular grains, low sphericity mixed with angular grains, medium sphericity as shown in Figure 2.

Figure 2 Sand grain shape classification

4. Conclussion

The characteristic of Sawang river sand has been investigated in this study and the following conclusions are made:

1) Moisture content of river sand has of 5.81%, which is falls in the range the recommended standard values of 4% - 8% for casting of light steel, heavy grey steel, and medium grey iron.
2) Clay content of the sand was found to be 13.66%, which is above the recommended standard values of 4% - 12% for ferrous metals, while that of non-ferrous metals of 12% - 18%.
3) The grain fineness numbers of the sample show a coarse aggregate with a value of GFN 49.9, which is still within the acceptable range of mold sand and suitable for metal casting.
4) The river sand has angular grains, low sphericity mixed with angular grains, medium sphericity.

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