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Grain Size Analysis of Biliri and Damaturu Moulding Sands for Foundry Application

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Abstract
Moulding sand is one of the key factors that directly affect the production rate and product quality in metal casting. Natural moulding sands utilized in many parts of north-eastern Nigeria have not been scientifically investigated to know their suitability for foundry applications. Thus castings being produced have lots of defects which lead to waste thus hampering the productivity of indigenous foundries in the zone. This work compares the grain sizes of Billiri and Damaturu natural moulding sands with a view of determining their suitability for foundry applications. Samples were collected at three different depths from Billiri and Damaturu and subjected to sieve analysis techniques. The results of the grain fineness numbers for the two deposits were determined to be 162.35, 148.42 & 99.30AFS and 133.21, 88.05 & 125.99AFS for samples collected at the depths of 0.5m, 1.0m and 1.5m from Billiri and Damaturu deposits respectively. On the hand, the shapes of the sand grains were sub angular for both deposits while the color of the samples from the two deposits were brown and dark- brown respectively. Based on the results obtained, natural moulding sand from deposits are appropriate for casting of nonferrous metals as well as malleable iron.

Keywords: Green sand moulding, foundry, Grain fineness number, Sieve analysis, Natural moulding sand

1.0 Introduction

Green sand moulding process has been traditionally used for a very long time because of its numerous advantages that include ease of processing and assessment. When investigated on Stress strain curve, behavior of sample indicates that sample from naturally bonded sand has highest tensile strength with superior ductility, has good surface finish than cement mould and Impact strength is high when compared to cement and CO_2 mould. For these reasons, natural moulding sand was selected for this study (Ademoh and Abdullahi, 2009). A foundry is a commercial establishment for founding or producing casting. It is also a shape forming process whereby molten metal is poured into a prepared mould and allowed to solidify such that the shape of the solidified object is determined by the shape of the mould cavity (Ibhadode, 1997). The process of casting has two distinct subdivisions: expendable and non-expendable mould casting (Beeley,2001) while according to the different binders, foundry sand used for moulding can be divided into green sand, water glass sand and resin sand (Ihom, *et a*l. 2009). One of the common clays normally used to aid binding in green sand molds are bentonites, which are forms of montmorillonite or hydrated aluminium silicate. Montmorillonite is built up of alternating tetrahedral of silicon atoms surrounded by oxygen atoms, and aluminum atoms surrounded by oxygen atoms. It is in a form of layered structure, and it produces clay particles that are flat plates. Water is absorbed on the surfaces of these plates, and this causes bentonite to expand in the presence of water and to contract when dried (Missouri, 2013). Casting involve molten metal being poured into the mould at a right temperature and is given time to solidify in the mould This process is followed by fettling which is the removal of gates and risers from the casting and the removal of parting fins, and other foreign material that is not needed in the casting. The items produced in this foundries are household and machine parts (cooking pots, dishes, spoons, aluminum gates decoration, machine belt pulleys, fans etc) in production capacity of 200 tons of nonferrous metal per month (Umar and Samaila, 2014). A study carried out by Aji *et al.* (2014), shows that Moduganari silica clay sand deposit in Maiduguri metropolis of Borno state, Nigeria is suitable for local foundry practice because of its higher value of bonding strength, fine sand and good refractoriness. Walter (1990) highlighted that natural sand is largely formed from the denudation of land from the decomposition of massive quartz based rock. This produces siliceous sand grain used for synthetic sand. Furthermore, in looking for good molding sand, high alumina content provide the necessary refractoriness needed by core (Brown, 1994).

Sieve analysis is a procedure to quantify the sizes and types of particles present in a particular sand sample as well as their relative frequency of occurrence. The analysis can be performed on inorganic materials. The sample is sifted through a series of sieves, beginning with a sieve with large apertures, through successively smaller sieves. The results of a sieve analysis can tell foundry men and engineers much about the composition of a sample and how particular sand will behave in a sand casting foundry. The objective of this work is to analyze and compare the two natural moulding sand deposits of Billiri and Damaturu with a view to determining their suitability for use in foundry applications.

2.0 Materials and Method

2.1 Materials

The natural moulding sand used for this study was obtained from Billiri and Damaturu sand Deposits in Gombe and Yobe states, Nigeria. Nest of sieve (11 of them stacked together), sieve shaker, clay washer, electronic digital balance, Pickstone oven-made by Ridsdale and Co. Ltd Middlesbrough- England were used for the experiment.

2.2 Methodology

Particle Size Analysis

The particle size analysis was carried out to measure the grain fineness of the sand using American Foundry Society (AFS) Grain Fineness Number (GFN). GFN is a measure of the average size of the particles (or grains) in a sand sample. The test was carried out in power-driven shaker consisting of number of sieves fitted one over the other. In this case, 400 g of the natural sand was weighed and dried to a constant weight using an electric oven; 100 g of the natural sand was weighed and introduced into the top- most sieve of the nest of sieves arranged from the largest aperture to the smallest (1400μ - 63μ). The sieves had the largest aperture of 1400 microns and the smallest with an aperture of 63 microns. Another 100g was weighed and introduced into a nest of sieves, which had the largest sieve with an aperture of 710 microns and the smallest with an aperture of 63 microns. The nest of sieves was mounted on the sieve shaker and used in calculating the average grain size of the natural sand (Budanov, 2010).

The samples tested were determined by finding the product of the weight retained and the multiplier factor from each of the apertures. Subsequently, grain fineness number was determined by taken the ratio of the sum of the product in the apertures used to the sum of weight percentage retained in the aperture used. This experiment was done on 3 different samples collected at different depths of 0.5m, 1.0m and 1.5m for each of the two deposits.

3.0 Results and Discussion

Table 1 presents the result of mechanical sieve analyses for Billiri and Damaturu natural moulding sands at varying depth.

Table 1: Sieve Analysis and Colour and Shape of Billiri and Damaturu Natural Moulding Sand

Source	Depth (m)	GFN (AFS)	Color	Grain Shape
Billiri	0.5	162.35	Brown	Sub-angular
Billiri	1.0	148.42	Brown	Sub-angular
Billiri	1.5	99.30	Brown	Sub-angular
Damaturu	0.5	133.21	Dark-Brown	Sub-angular
Damaturu	1.0	88.05	Dark-Brown	Sub-angular
Damaturu	1.5	125.99	Dark-Brown	Sub-angular

Laboratory examination shows that the color of sand from Billiri is brown at all depths and that of Damaturu portrays dark-brown coloration. The natural moulding sand for both deposits have sub-angular shape. The sand screened were reasonably distributed which gave rise to good permeability and compressive strength (Rundman, 2000). The results further showed that at the depth of 0.5 m with GFN of 162.5AFS and 133.21AFS, for Billiri and Damaturu deposits respectively. High grain fineness number leads to reduced porosity due the presence of organic matter and hence not suitable for use in foundry application. Samples obtained at 1.5 m from Billiri with GFN of 99.30 AFS and 1.0 m in the case of Damaturu deposit with GFN of 88.05AFS will give rise to good permeability and compressive strength with. Products produced using such samples will have good mechanical properties and therefore better resistance to fracture during production and subsequent use of the cast products. Furthermore, when the GFN of the two deposits (see Table 1) are compared with foundry standard specification, they both fall within requirement for appropriate use in foundries especially for the casting of nonferrous metals.

4.0 Conclusion

Natural moulding sand samples collected from Billiri and Damaturu deposits showed variation in grain fineness number with change in depth of collection. The two deposits of natural moulding sand have acceptable grain size for use in foundry practices. Billiri and Damaturu deposits at a depth of 1.5 m and 1 m with GFN of 99.30 and 88.05AFS respectively will provide adequate permeability and good compressive strength compared to samples collected at other depths. These samples can be utilized effectively in casting of malleable iron and non-ferrous metals. Hybridization of the sand samples from these two depths will further enhance the mechanical and physical property of the natural moulding sand for better foundry applications.

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