European Journal of Mechanical Engineering Research
Vol. 9, Issue 1, pp.12-20, 2022
Print ISSN: ISSN 2055-6551(Print)
Online ISSN: ISSN 2055-656X(Online)

Suitability of North Northeast (Nigeria) Moulding Sands for Foundry Use – A Review

U. A Saeed [1], I. A Muhammad [2], M. M Dukku [3], Garba Elhusein [4]
Abubakar Tafawa Balewa University Bauchi [1]
Abubakar Tatari Ali Polytechnic Bauchi [2]
Nigerian Army Universty Biu, Borno [3]
Federal University of Technology Yola [4]
Department of Mechanical Engineering [1234]

ABSTRACT: - *This paper would discuss appropriately on the suitability of northeast sand for small and medium casting industries. Many researches had been carried out using different sand. Most of these materials have not been explored in this part of the country. This justified the need for the search of a more suitable, available material. The material(sand) obtained from various places had been analyzed based on their properties such as shape and distribution of sand grains, permeability, strength, refractoriness, thermal stability, moisture content, bulk density, sieve analysis, moisture content, Clay content, permeability, shatter index, flowability, thermal stability, collapsibility, heat conductivity, reusability, hardness, shattered index, casting finish, dry compressive strength and green compressive strength from relevant literatures. The procedure for the whole experiment must go with a known standard.*

KEY WORD: Mouldability, Sand grains, Shatter index, Binder, Dry compressive strength.

INTRODUCTION

Foundry sand is made up of silica groups. The mineral silica is one of the major ingredients in moulding sand apart from clay and water because it imparts refractoriness, chemical resistivity, bonding strength, high hardness and permeability to the sand. It is characterized with a high melting point of about 1710^0C – 1713^0C (Agbo et al., 2018). The properties of good moulding sand include permeability, plasticity, refractoriness, chemical stability, cohesiveness, dry compressive strength and green compressive strength (Shuaibu-Babata and Olumodeji 2014). There are two types of foundry sand- Natural moulding sand and synthetic (Garba Elhusien, 2018). Metal casting is 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. The process of casting has two distinct subdivisions: Expendable and non-expendable mould casting. The object obtained from the metal casting is called a *casting*, while the phenomenon is called *founding* (Garba elhusien, 2018). Foundry, on the other hand, is a commercial

establishment for founding (Ibhadode, 2001). Proper control of the properties of moulding materials is pertinent for the consistent production of high quality casting at low cost (Yusuf & Shuaib, 2014). Using foundry techniques it is easy to produce devices and equipment that are very difficult to produce by other engineering processes. In castings, products with either regular or irregular shapes in various sizes and quantities are made to close tolerance with little metal waste (Shuaib-babata and Olumodeji, 2014). Foundry industries in Nigeria use synthetic sand and binders for their production which result in high cost of manufacturing (Garba Elhusein, 2018).Fortunately, these raw materials are progressively substituted by locally available materials, hence there is need for proper information on the physical, chemical and moulding properties of locally available sands (Garba, 2009). A local source of good foundry sand is a generic problem faced by foundry industries, good sand has to be transported from one area to another, though silica sand is of low value, but the cost of transport over a long distance contributes significantly to high cost of production in foundry. This forced foundry operators to locate their foundries closer to the source of raw materials (Uhourtu, 2006). Foundry industries in this region has no enough information on the suitability of moulding sand around them, this can only be achieved by conducting a research with in-depth laboratory tests.

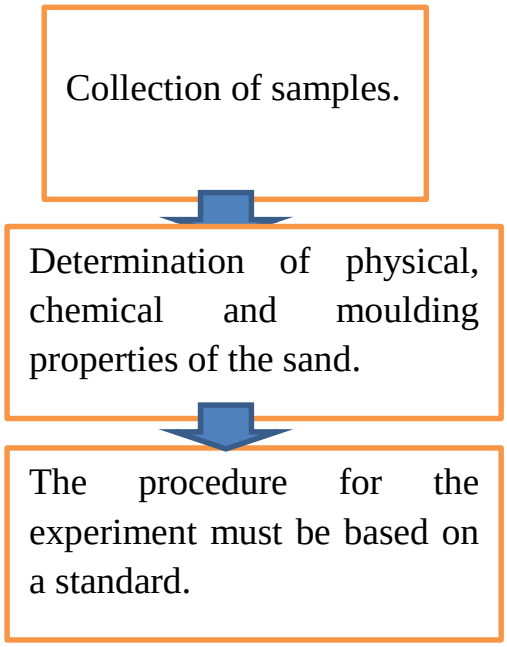
Table 1: Standard properties for sand casting in foundry industries.

Metal	Green Compressive Strengths (KN/m2)	Permeability No	Dry Strengths (KN / m^2)
Heavy Steel	70-85	130-300	1000-2000
Light Steel	70-85	125-200	400-1000
Heavy Grey iron	70-105	70-120	350-800
Aluminum	50-70	10-30	200-550
Brass & Bronze	55-85	15-40	200-860
Light Grey iron	50-85	20-50	200-550
Malleable Iron	45-55	20-60	10-550
Medium Grey Iron	70-105	40-80	350-800

Source: (Ademoh and Abdullahi, 2009).

Methods

The figure below shows the step by step procedure used to carry out materials analysis.



Preparation of the Natural Moulding Sand.

The sample of the natural moulding sand was prepared using American Foundry-Men Society (AFS) guidelines. To remove moisture from the sand, it was sun dried for days, and subsequently filtered to remove the debris and other unwanted materials from the sand (Shuaibu-Babata, 2019).

Materials and equipment
Materials

The materials used to carry out the experiment are;

- Sodium Chloride
- Lime Stone
- Potasium Chloride
- Sand Sample
- Aluminum Scraps
- Cast Iron Scraps
- Bentonite
- Honey
- Distilled Water
- Caustic Soda Solution
- Calcium Carbide
- Hydrogen Tetraoxosulphate Six Acid

- Resin (Molasses)
- Plywood
- Top Bond Glue
- Nails
- Body Filler
- Water

Equipment

The equipment used in the research includes;

- Georg Fischer Model
- Sieve Rack
- sieve Shaker
- Digital Scale.
- Speedy moisture teller
- Calcium carbide
- Calibrated container
- Standard weight scale.
- A drying oven
- A balance and weight
- A sand washer
- Sand clay washer
- Laboratory sand rammer
- Standard permeability meter
- Specimen tube
- Sardness tester
- Specimen tube
- Laboratory sand rammer
- Universal sand strength testing machine
- Holder for compression test
- Shatter index tester
- Steel tube holding tools.

Physico-Mechanical Properties of the Moulding Sand

The following were some properties required for moulding sand in foundry industries:

Shatter index is the major of plasticity of the mould.

Flowability is to be measured with AFS flowability meter.

Mouldability It determines the cohesiveness or natural binding capacity of the sand grains.

Permeability known as porosity is one of the most important property of the moulding sand. It is the ability of the moulding sand to allow gasses to pass through. (Agbo *et* al., 2014) This property depends on clay, binding material and moisture content in the mixture. Permeability number of moulding sand depends on degree of fineness of the sand, as well as the moisture content presences (Ademulegun, 2008),

Green Compression Strength

The green compression strength is the strength of the moulding sand in the green or moisture condition. (Shuaibu *et* al., 2017).

The compression strength of natural moulding sand is the ability of the moulding sand mixture to hold its geometric shape and size under the condition of mechanical stress imposed during the casting process is the sand stress.

Dry compression strength

Dry compression strength is the strength of the moulding sand in a dry condition and the strength is measure in KN/m2. (Shuaibu *et* al., 2017).

Moisture Content

Moisture content is an important parameter needed for moulding sand to determine the suitability of the sand for casting. It ensures ease of moulding, good quality mould and casting (Yusuf & Shuaib, 2014). The excessive moisture tends to increase defects in casting, as the water content is converted to steam at high temperature. In order to obtain a satisfactory casting there is need to control the moisture content of the moulding sand (Onche *et* al., 207)

Refractoriness

The refractoriness is the property of sand to with-stand high temperature of molten metal without fusion or softens (Ademulegu, 2008). Mould with low or poor refractoriness many burn when molten metal is poured into the cavity of the mould.

Clay contents

Foundry sand (Base sand) consist of primarily of clean, uniform sized high proportion of silica and have quality which depend on the sort of clay mineral and its content present. Clay is the major second constituent of the moulding sand (Muhamoud *et* al., 2017). It consists about 5 – 8% of the moulding sand. The clay provides cohesion and strength to the moulding sand Mshelia *et al*., (2016). Analyzed the mechanical properties of foundry moulding sand. They found that the moulding sand consist of largely grains of silica (SiO_2) with 5 – 6% clay to act as a binder which is one of the requirement of the effectiveness of sand used for moulding making.

Grain size distribution

The size of the sand grains and their distribution are of fundamental importance in controlling the properties of sand mixtures which ultimately influence greatly the surface finish of the casting product. The finer the sand grains size, the smoother the finish within certain limits (Bukar *et* al., 2017).

Suitability of Some Selected Sand for Use in Foundry Industries

(Shuaib-Babata *et al*.,(2017) study the suitabity of Ado-Ekiti (Nigeria) natural moulding sands for use as foundry sands in manufacturing of Aluminium alloy cast. They found that the sands sample are of high amount of silica, with 75.22% - 79.23% silica oxide and flowability values between 67.25 and 68.50% which varies in sand with moisture and clay contents. The permeability test results recorded for the tested sand range between 86.2 and 87.5 which indicate the sand samples had good natural green permeability for casting number of ferrous and nonferrous metals. The green and dried shatter index of the sand specimens is between 0.03 –0.50 and 0.05 – 0.22 respectively. The shatter value indicated that the sand sample was tough enough to aid satisfactory lift during pattern with-drall. The green sands strength was within the recommended range of 70 - 100 $KN/m^{2,}$ which showed an adequate green strength of sand to retain it shaped without distortion or collapse even after pattern removed. The study revealed that all sand samples at wet state were suitable for casting aluminum alloy.

Yekinni *et al*., (2015) Investigate mechanical properties of founding moulding sands. They found that, the sand samples has good mechanical properties and would produce sound casting with an addition of water up to 3.5%, 3.0% coal dust and $0.6^0/_0$ bentonite. It also revealed from the result that with little control each moulding sands can meet a particular foundry requirement in its usage for casting different types of metals or their alloy.

Agbo *et al*., (2018). Studied the influence of Bentonite on the foundry moulding properties of River Niger Onisha Beach sand. They conclude that the result of the mechanical properties of the moulding sand was found to be within the range suitable for casting non-ferrous alloy at moulding moisture of $4^0/_{0,}$ for both bentonite and water. But however Onitsha Beach sand is composed of about $94.49^0/_0$ silica which is not within the range that can be used for steel and other heavy metals in the foundry.

Mshelia *et al*., (2016). Study the characterization of (Dala Lawanti, Pompomari, Gwange, Gamhoru and University of Maiduguri) natural moulding sand for foundry application. Due to the high range of clay content from (21. $8^0/_0$ to $47.2^0/_0$) which is far above the standard range limit ($10\text{-}12^0/_0$) recommended by (AFS) for natural moulding sands required for producing good quality aluminum casting. However it does not mean the sand cannot be used for casting but its reusability should be closely observed to timely reconditioning in order against the production of defective casting.

Tokan and Mohammad, (2007). Determination of moulding characteristics of Dindima river sand with Alkalri clay as a binder. They revealed that the sand is triangular in shape and has clay content of 0.6%. The lower content of clay makes it suitable for used as core sand in addition to its suitability for used as moulding sand as6l/n indicated by AFS standard (1979). The result of the grain fineness number of Dindima river sand was found to be 61.15AFS. This grade showed that it can be used for all kinds of casting alloy as this belong to the grade fineness number that has a wide range of application in the foundry.

Bam et al., (2015) worked on the improvement and comparative Analysis of River Benue foundry sand using Guinea-corn, cassava, maize as binders in casting. It was found that the sand is lacking in certain properties like dry compression, shatter index and permeability. After investigation, the result showed that cassava and Guinea-corn were more effective when added in liquid starch form.

Garba, (2009). Study the moulding properties of River Bank sand around Jebba for use in foundry. The results indicate that the sand has high refractoriness, permeability, fine grain and considerable clay content. Conclusively, it was found to be suitable for non-ferrous metal casting only.

Aweda, (2009). Evaluate the properties of Natural moulding sands in Ilorin and Ilesha. The sands exhibit good properties for casting of non-ferrous metals.

Ademoh, (2008) work on the foundry properties of River Sand Behind Ajokuta Steel Company. The results show that the sand has high clay content with low fusion temperature of 1380^0C.

CONCLUSION

- The physical, chemical, and moulding properties of the sand should be determined.
- Use of additives such as saw dust, kaolin, bentonite etc. to improve the performance of the material.
- To determine the impact of clay and moisture contents on the properties of sand.
- To make a mould using the sand and cast some engineering components which will help to determine their suitability for foundry use.

Recommendation

It is recommended to make variance analysis of the sand using any of the software in use.

ReferencesAgbo A.O, Ameh E. M and Idenyi N. E (2018). Influence of Bentonite on the Foundry Moulding Properties of River Onitsha Beach Sand. American Journal of Engineering Research (AJER). 7(8), pp-104-111, e-ISSN: 2320-0847, pp-ISSN: 2320-0936. www.ajer.org.

Agbo A O, Nwankwo N. E. and Nnuka E. E (2017). Efficiency of moisture content on the moulding properties of river Niger Onitsha beach sand. Using ukpor clay as a binder. International journal of multidisciplinary research and development. Volume. 4. Page no. 16 – 20.

Ademoh, N.A. & Abdullahi, A.T. (2009). Assessment ofFoundry Properties of Steel Casting Moulds Bonded with Grade 4 Acacia Species (Gum arabic). International Journal of Physical sciences. 6, 238-241.

Ademoh, N. A. (2008). Effect of kaolin clay Addition on Mechanical Properties of Foundry Sand Mould Bonded with Grade 1 and 2 Nigerian Acacia Specie, 3(10), pp 240-244, International Journal of Physics Sciences.

Ademoh N. A and Abdullahi, T.A. (2008). Estimation of the Effect of kaolin Clay Addition on the Mechanical Properties of Foundry Moulding Sand Bonded with Grades 3 and 4 Nigerian GUM Arabia (Acacia Species), 3 (3), pp. 126-208, Indosi Publications.

Ashaka for Foundry use. International Journal of Scientific and Engineering Research 9 (7). ISSN 2229 – 5518.

Aweda, J.O. & Jimoh, Y.A. (2009). Assessment of Properties of Natural Moulding Sand in Ilorin and Ilesha Nigeria. Journal of Research Information in Civil Engineering. 6(2). 68-77. [4]

Ademulegun, Manufacturing Process. Tess- Tech Educational Publisher. Ikeja, Nigeria, 2008.

AFS (American Foundry- Men Society Standards) (2019). Mould and Core Testing Handbook. 2nd Edition, Foseco Ltd, Permangon Press, Oxford, England.

Bam, S . A., Akaaza J.N (2015): International Journal of Applied Research. 1 (8): 712 – 714.

Bukar, M., Aji, I.S. and Mshelia, Z.A. (2017). Grain Size Analysis of Biliri and Damaturu Moulding Sands for Foundry Application, university of Maiduguri Faculty of Engineering Seminar Series 8 (80).

E. Garba, A Raji, S. Hamzat, A. B Usman, A. O. Donald and R. Aliyu (2018). Effect of moisture and clay on moulding properties of composite sand of River Gongola along

Ibitoye, S.A. (2005). Effect of the Addition of Sodium Silicate and Bulk Density Variation on the Permeability of Potter's Clay-Bonded Moulding Sand. Nigerian Society of Engineers Technical Transactions. 40, 67-77.

Ibhadode, AOA, 2001. Introduction to Manufacturing Technology, 2nd edition, Ambic Press, Benin City, Nigeria, 212-272.

Shuaib-Babata, Y. L., Abegunde, A. J. and Ambali, I. O.: Evaluation of chemical and physico-mechanical properties of Ado-Ekiti (South West, Nigeria) natural moulding sands for foundry applications, Arid Zone Journal of Engineering, Technology and Environment (AZOJETE), Vol. 13, No. 4, 2017, accepted for publication.

Shuaib- Babata, Yusuf Lanre, and Olumodeji, J.O (2014). Anakysis of Ilorin Sand Moulding properties for Foundry Applications. International journal of Engineering Research and Technology (IJERT). 3 (1). ISSN 2278-0181.

Shuaib-Babata, Y. L., Ibrahim, H. K., Ajao, K. S., Ambali, I. O.4 and Bello, M. O.(2019). Evaluation of the Foundry Properties of Oyun River (Ilorin) Moulding Sand . Adeleke University Journal of Engineering and Technology [AUJET] 2 (1)E-ISSN: 2672-5932

Tokan, A., Adelemoni E. A. A. and Datau S. G (2004). Mould characteristics of Azare foundry sand. Journal of raw material research V. PP: 67-80.

Tokan, A. and Mohammad Sulaiman, U. (2007). Determination of moulding sand characteristics of Dindima river sand with Alkaleri clay as a binder. JORMAR 4(1&2) 2007, 79 – 88.

Tokan, A., Adelemoni, E. A. and Datau, S. G.: Mould Characteristics of Azare Foundry Sand, Journal of Raw Material Research (JORMAR), Vol.1, No. 1, pp 67-78, 2004. [17]

Nwajagu C. O.: Foundry Theory and Practice, 1st Ed., ABC Publisher Ltd, Enugu Nigeria, pp. 418419, 1994. [18] Bala, K. C. and Khan, R. H.: Characterization of Beach/River sand for foundry application, Leonardo Journal of Sciences, Vol. 12, Issue 23, pp 77-83, 2013.

Muhammad, MH., Bawa, MA., Akuchi, NT. 2003. Characterization of Alkaleri and Gombe Foundry Sand Samples. Proceedings of Nigerian Metallurgical Society Conference and 20th AGM, 31-33.

Mshelia Z. A, Abolarin M. S, Abubakre O.K and Ademoh N. A. (2016): Characterization of Natural Moulding Sands from Selected Deposits in Maiduguri, Nigeria, for Casting Applications AZOJETE, 12:110-121. ISSN 1596-2490; e- ISSN 2545-5818; www.azojete.com.ng.

Onche E.O, A. Raji and L. Elueme (2007). An investigation on the characteristics of upper river Benue sand. Golobal journal of engineering research. Volume 6: 89 – 92.

Uhourtu, M. (2006). Moulding properties of dindima River Sand using Alkaleri clay as Binder. Unpublished post Graduate Diploma project, Department of Mechanical Engineering, Abubakar Tafawa Balewa university, Bauchi, Nigeria.

Yekinni, AA., Bello, SK. Animasaun, LA. And Olaiya, KA. 2015. Assessment of Mechanical Properties of Foundry Moulding Sands. International Journal of Engineering and Industrial Research 4(2): 365-372.