International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 3, May-June, 2025 pp: 335-340 ISSN: 2584-2145 www.ijemh.com

Effect Of Additives to Some Selected Foundry Moulding Properties of OTAMIRI River (OWERRI) Bank Sand

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Date of Submission: 09-06-2025 Date of Acceptance: 20-06-2025

ABSTRACT
In metal casting sector, the quality of green casting is dependent on the SiO_2, clay and moisture contents of the foundry sand. The output also has a relationship with the hardness, refractoriness and green strength compression of the moulding sand. The study was on the effect of saw dust additive to Nekede end of Otamiri River bank sand. The result showed that the sand contains 85.27% of SiO_2, 11.66% of moisture and 8.8974% of clay contents. The result also shows increase in hardness and green strength compression as the percentage of saw dust increases from 55.8 – 91.9 Kg.mm^2 and 18.6 – 65.2KN/M^2 respectively. There was a decrease of refractoriness with increase of saw dust percentage from 1534 – 645^{0}C. The ANOVA analysis shows significant difference to all the parameters. The 0% and 8% saw dust additive can be used to make mould for casting iron while higher percentages of the additive will be good for aluminum castings.

Keywords: Additives, refractoriness, mould hardness and Green strength compression.

I.INTRODUCTION

Foundry sand is a mass of sand with some properties and contents that allowed them to be used for making suitable mould in casting processes. These types of sand contain binders and additives (Altan, 2022). These sands could be natural or synthetic. They can be classified as silica sands, zircon, olivine, chromate and aluminum silicates. Natural sands contains enough natural occurring clays as binders while synthetic sands are foundry sands that have been washed and conditioned with the desired binders and additives to produce an optimized sand for casting. Water is a basic additive to foundry sand. All foundry sands have some properties such as: green compression strength; dry compression strength; hot compression strength; moisture (water); permeability; flowability; refractoriness; thermal stability; collapsibility; mould hardness; deformation; production of good casting finish; reusability and rate of heat removal from casting. (Agbo *et al*, 2018). Most often natural sand used as foundry sand is silica sand which contains 6 – 10% bentonite clay as binders with 2 – 8% water or moisture. (Sani *et al*, 2020). The properties of foundry mould sand is greatly being affected by percentage of clay (binder) content, moisture content and chemical content of the foundry sand. In conditioning the sand to achieve a desired hardness, green compression strength and refractoriness; additives can be added to actualize this. In this work, the use of saw dust at varying percentages can bring out optimum percentage of additives for best foundry moulding sand properties.

Moulding sand can be obtained from bank of rivers or on lands where desired properties of foundry sand are seen. In the work of Mathew *et al* (2010), they obtained foundry sand from river Niger bank. He achieved good foundry sand by varying the moisture content of the sand. The properties of foundry sand greatly affect the final casting from the foundry work. Rone and Pawan, (2017) obtained their foundry sand from land which contains zircon and aluminum silicate which they used to produce near perfect castings.

Foundry sand is being conditioned with additives to bring out the desired sand moulding properties. Rice husk is one of the additives that bring out good properties of moulding sand. Charnnarong and Chaiyan (2016) applied rice husk as additives in their research and realized foundry sand with good hardness, green strength and permeability. There was an improved green strength of synthetic foundry sand by Loto (1990) with cassava flour as additives.

To actually understand the properties of foundry sand, the testing of the mechanical properties of the sand is necessary. Friday *et al* (2022) tested for moisture content of the foundry sand, its chemical composition and some properties like refractoriness and permeability. Olawale *et al* (2015) in their work tested for permeability and pouring temperatures of their foundry sand.

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Adekola and Babs (2016) investigated moulding properties of Nigerian clay – bonded sand. They equally determined the percentages of the clay to ascertain its effects on castings. Abdulamer (2021) brought a new innovation by testing for flowability of green sand mould with sensor controlled by a remote. The result was realized through a computerized system. Furthermore, Sampath (2022) improved green sand moulding quality using Taguchi technique. Similarly, Abdulamer (2023) showed the impact of different moulding parameters on properties of the green sand mould.

Many additives including saw dust has been used to condition the properties of moulding sand but varying the percentages of saw dust on moulding sand is yet to be understood on its effects to the moulding properties. The use of varying percentages of saw dust can be best understood when foundry moulding sand with such varying percentages of additives are being tested. The results and its analysis are capable of bringing new knowledge. The foundry moulding sand for this research work was sourced from Nekede bank end of Otamiri River in Owerri, Imo State of Nigeria. The Otamiri River flows from Egbu in Owerri through the city to other suburbs such as Nekede, Ihiagwa, Eziobodo, Olokwu, Umuishi, Mgbirichi and Umuagwo down to Rivers State into Atlantic Ocean.

II. MATERIALS AND METHOD

The materials used for this study were: Silica sand obtained from Otamiri River at Nekede bank sand; Saw dust collected from Ogbosisi timber market Naze in Owerri and water. The equipment used for the analysis were wood moulding core, digital scale, calibrated container, standard weighing scale, a drying oven, Furnace, sand clay washer, laboratory sand rammer, hardness tester, universal sand strength testing machine, sand mixer, holder for compression test, moulding board, trowel, lifters chaplets, mesh, spike and watering can.

Research Process

A) Collection of silica sand from Otamiri River, Nekede bank sand.
B) Collection of saw dust from Ogbosisi timber market Naze Owerri.
C) Testing of chemical contents of the silica sand, moisture content, clay content and collection of results.
D) Sample preparation for tests in hardness, refractoriness and green compression strength of the foundry sand.
E) Testing for the samples and collection of result.
F) Analysis of the result.

III. METHOD

Chemical Analysis

The X – ray florescence (XRF) spectroscopy was used for the chemical analysis. The samples were dried in an oven at 60^0C for 30 minutes, grinded into powder and particle size 100 mesh (0.15micron) recommended for XRF analysis. The equipment ran for about 5 hours with recommended voltage and current of 45 volts and 40A respectively.

Moisture content Test

The digital balance was used to weigh the sand sample and obtained 50g of it. The sample was dried at a temperature of 105^0C – 110^0C for 2 hours to evaporate all the moisture in the sand sample. The sand was reweighed and obtained a new weight. The weight difference was expressed in percentage to give the moisture content of the sand sample.

$$M = \frac{N-O}{N} x\,100 \quad (1)$$

Where: M = percentage of moisture content (%); N = Initial sand weight before heating (g); O = Final sand weight after evaporation of the moisture content (g).

Clay content Test

The clay content was determined using the dried sample from the moisture content determination. This sample was washed five times till the surface was clean. It was dried and reweighed. The weight difference was expressed in percentage to give the clay content of the sand sample.

$$P = \frac{Q-R}{Q} x\,100 \quad (2)$$

Where: P = Percentage of clay content; Q = Weight of dried soil sample from moisture test (g); R = Weight of washed and re-dried sand sample from moisture test (g).

Sand Preparation

The Nekede end sand bank from Otamiri River was prepared by mixing it with water in a sand mixer. Other percentages of saw dust additive were added respectively and properly mixed with sprinkling of water. Little sprinkling of water was added to the point that the mixture never stick to the palm of the hand. The American foundry men society standards were followed in sample preparation with a tube of DIN 50mm diameter and 50mm height. The residual standard sand rammer conforms to the size was subjected to a pressure of 1MPa (Loto, 1990). Twenty one (21) samples were prepared with three

(3) samples for each percentage as follows: Sample without additive, 8% saw dust additive, 12% saw dust additive, 16% saw dust additive, 20% saw dust additive, 24% saw dust additive and 28% saw dust additive. One sample from each set was moulded into cone shape.

Green Compression Test.

The universal sand strength testing machine was used. One of the prepared samples without additive was mounted to the compression head. The sample was gradually loaded as the magnetic rider moved. At maximum strength the sample failed and the magnetic rider remained in the position of the ultimate strength as the load gradually returns. The procedure was repeated for samples with saw dust additive of 8%, 12%, 16%, 20%, 24% and 28% respectively.

Hardness test

The sand mould hardness tester was used. The indenter was pressed to set the pointer reading to zero. It was used on the sample without additive on the two flat surfaces and two points on the round surface to measure its hardness. The average of the four measurements was taken as the hardness of the sample. The procedure was repeated for samples with saw dust additive of 8%, 12%, 16%, 20%, 24% and 28% respectively.

Refractoriness Test

The sample moulded into cone shape without additive was dried in oven at 110^0C. The sample was sintered in the furnace to a temperature of 500^0C. A standard pyrometric cone of known softening temperature and the sintered sample without additive were arranged in the furnace to test for refractoriness. The cones were heated gradually until softening in the cones corresponds with the softening in the pyrometric cones. The temperature at which this happened was recorded as the refractoriness. The fusion point was observed and recorded. The procedure was repeated for samples with saw dust additive of 8%, 12%, 16%, 20%, 24% and 28% respectively.

IV. RESULT AND DISCUSSION

Table 1: Chemical composition of Otamiri River, Nekede bank sand end

Chemical composition	SiO_2	Al_2O_3	Na_2O	K_2O	CaO	MgO	Fe_2O_3	NaO
% of Composition	85.27	0.58	0.24	0.16	0.52	0.34	0.96	0.84

Percentage of Moisture content
Weight of sand sample before heating = 50g
Final weight of sand sample after the evaporation of the moisture content = 44.17g
Percentage of Moisture content = 11.66%
Percentage of Clay content
Weight of dried sand sample from moisture test = 44.17g
Weight of washed and re-dried sand sample from moisture test = 40.24g
Percentage of Clay content = 8.8974%

Table 2: Result of Green Strength compression, Hardness and Refractoriness Tests

% of saw dust additives / Sand Property tests	0%	8%	12%	16%	20%	24%	28%
Green Strength Compression(KN/M^2)	18.6	24.7	43.4	48.5	51.4	63.4	65.2
Hardness (HRB) (Kg/mm^2)	55.8	76.5	81.4	84.6	87.8	88.9	91.9
Refractoriness (^{0}C)	1534	1225	1115	958	735	693	645

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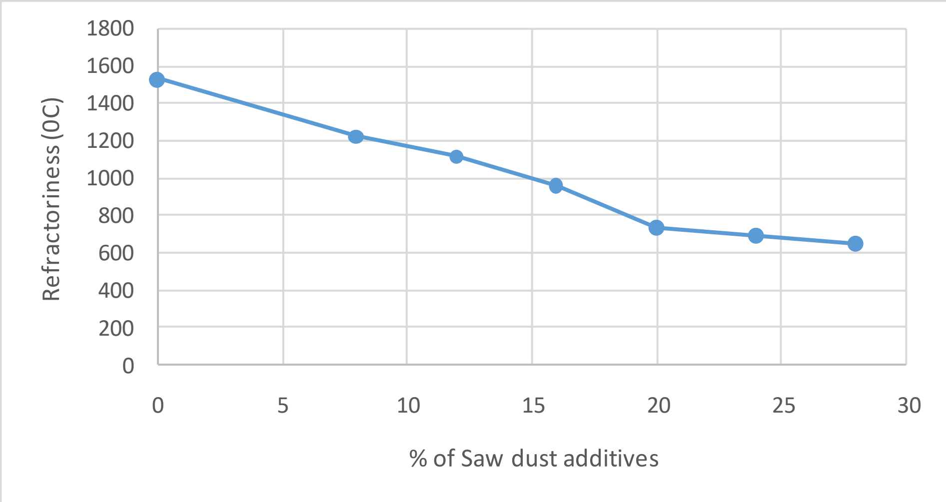

Fig 1: Effect of % of saw dust additive to Refractoriness of Otamiri River bank sand

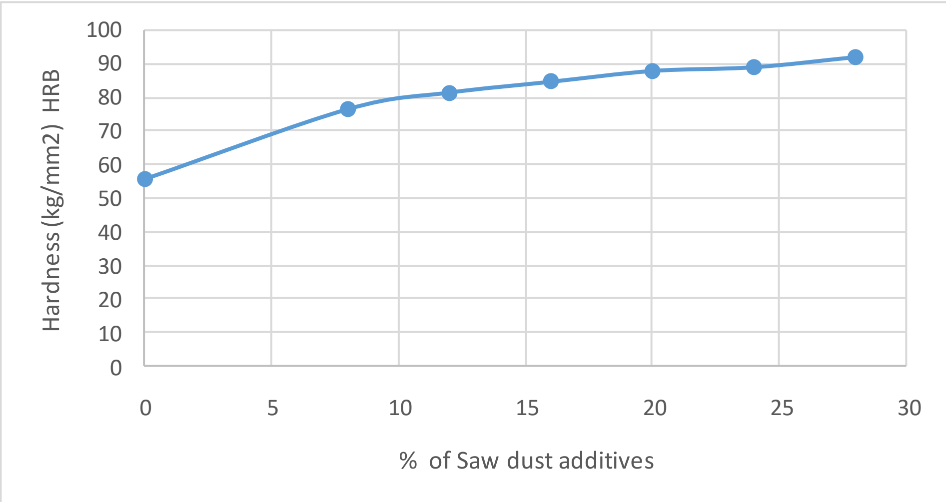

Fig 2: Effect of % of saw dust additive to Hardness of Otamiri River bank sand

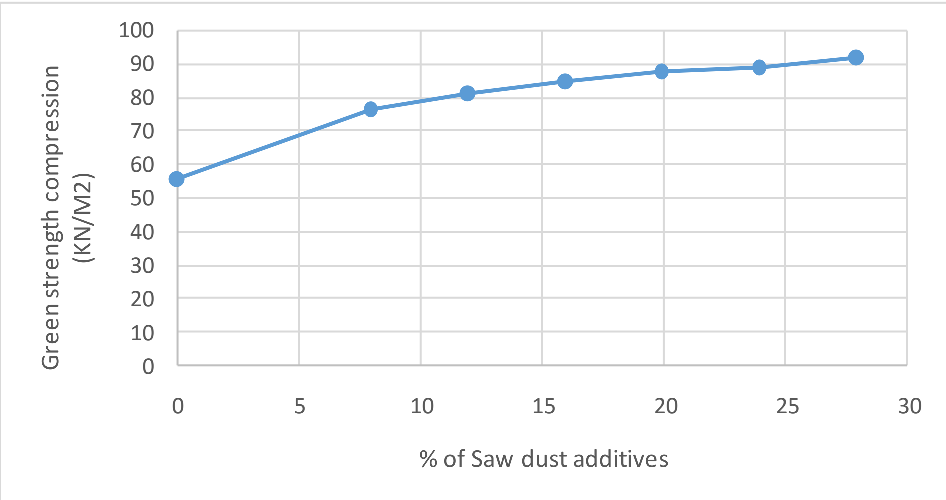

Fig 3: Effect of % of saw dust additive to Green Strength compression of Otamiri River Bank sand

Table 3: ANOVA result of table 2

% of saw dust additives	Green strength compression (KN/M^2)	Hardness (HRB) (Kg/mm^2)	Refractoriness (^0C)
0	18.75 ± 0.21^a	55.75 ± 0.07^a	1534 ± 0.70^g
8	24.80 ± 0.14^b	76.60 ± 0.14^b	1326.00 ± 1.41^f
12	43.50 ± 0.14^c	81.50 ± 0.14^c	1116.00 ± 1.41^e
16	48.60 ± 0.14^d	84.55 ± 0.07^d	958.50 ± 0.70^d
20	51.56 ± 0.35^e	87.85 ± 0.07^e	734.50 ± 0.70^c
24	63.45 ± 0.07^f	88.70 ± 0.28^f	694.00 ± 1.41^b
28	65.30 ± 0.14^g	91.67 ± 0.35^g	645.50 ± 0.70^a

The result of chemical composition of Nekede end of Otamiri River bank sand was shown in table 1. The percentage of SiO_2 was 85.27%. This is slightly higher than the range of 77 – 83% for best SiO_2 for moulding sand as determined by Sani *et al* (2020). This is also in variance with Adekola and Babs (2016) that found out that the SiO_2 content of their moulding sand was 55.91% and that of Agbo et al (2018) with SiO_2 content of their moulding sand being 94.49%. The SiO2 content of Nekede end of Otamiri River will be near excellent foundry moulding sand that will produce good quality castings as all mineral element content each were below 1%.

The clay content was discovered to be 8.8974% with 11.66% moisture content. Friday *et al* (2022) affirmed that good foundry sand should contain 10 – 12% of clay and 5 – 7% of moisture. The result shows that the sand will be perfected by adding just a little of synthetic binders and little drying.

Table 2 shows the result of the effect of percentage of saw dust additive to hardness, refractoriness and green strength compression while table 3 shows the result of the ANOVA of table 2. Fig 1 shows the graphical representation of the effect of saw dust to refractoriness; Fig 2 shows the graphical effect of saw dust to hardness while Fig 3 shows the graphical effect of the percentage of saw dust additive to the green strength compression.

The result of green strength compression shows significant difference and continues increase as obtained by Agbo *et al* (2018). The effect of saw dust additive also shows significant difference to the hardness with increase in the percentage of saw dust. Similarly, the result of the refractoriness shows also significant difference with decrease in refractoriness as the percentage of saw dust increases. The result of the refractoriness, hardness and green strength compression shows that only 0% and 8% of saw dust additive of the sand sample can be used to cast metals with high melting temperatures like iron while higher percentages of saw dust additive can only be used for casting metals like aluminum with low melting points.

V. Conclusion

The sand at Nekede end of Otamiri River bank in Owerri has 85.27% of SiO_2, 11.66% of moisture and 8.8974% of clay. The result of addition of saw dust to the sand sample gave rise to green strength compression of between 18.6 – 65.2KN/M^2; hardness of between 55.8 – 91.9Kg/mm^2 and refractoriness of between 1534 – 645^0C. The result also shows that as the percentage of saw dust increases, hardness and green strength compression increases while refractoriness decreases. The result shows that only 0% and 8% of saw dust additive can be used to make moulds for casting high melting point metals like iron whereas higher percentages of saw dust to the sand will only be useful for low melting metals casting like aluminum. The sand can be made perfect by addition of little quantity of synthetic binder and removal of little water content from it.

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