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Investigation on Properties of River Sand for Sound Casting, River Niger, Bacita, Nigeria

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Abstract: The production of castings is essential to the industrial development of a Country. The manufacture of every machine and each piece of equipment used in transportation, farming, construction and mining and in water-supply and sanitation facilities is dependent on castings. Engine components may be broken or wear out and must be replaced. Effective local sources for these replacement parts are essential to avoid long delays in obtaining them from the original manufacturer or from more industrialized neighbouring countries as reported by Anosike. Quality silica sand is a vital ingredient for foundry production of castings. The need for this investigation arose out of the desire to establish locations of locally available quality foundry sand. The river sand is a good source for quality foundry sand. The service properties of the river sand obtained from the River Niger at Bacita, Niger State-Nigeria were measured. These include sieve analysis, permeability, green strength and sintering point. The investigation revealed the suitability of the river sand for the production of quality castings from various metal alloys.

Key words: Investigation, properties, river sand, sound casting, Bacita, Nigeria

INTRODUCTION

Currently, it is nearly impossible to design anything that cannot be cast by means of one or more of the available casting process. According to Webster and Fallon (1991) as in all manufacturing techniques, the best results and economy are achieved if the designer understands the various options and tailors the design to use the most appropriate process in the most efficient manner. The various processes differ primarily in the mould material (whether sand, metal or other material) and the pouring method (gravity, vacuum, low pressure, or high pressure). All of the processes share the requirement that the materials solidify in a manner that would maximize the properties, while simultaneously preventing potential defects, such as shrinkage voids, gas porosity and trapped inclusions as analysed by Mitsuo (1982).

To achieve quality casting, it is necessary to have uniform properties of sand mixture. This can be accomplished with good control practice. However, this is done by fixing the sand composition, the type of mixer and mixing time.

Jain (2003) state that in general, sand used in making sand cast moulds is fine, round grains that can be closely packed and forms a smooth mould surface. Sand cast moulds are designed to have a good collapsibility (the casting shrinks while cooling) to avoid defects in the casting, such as hot tearing and cracking. Clay is used to cohesively bond sand particles, giving the sand strength.

Ajuwa and Sheidi (2004) opined that the first consideration in making the sand mould involves the selection of proper materials, deciding from what source they can be best obtained and assembling the principal tools used for the moulding.

The river sands or quartz sands occur in abundance in nature under rivers and water basins and therefore, are cheap. Besides, they exhibit the desired properties, of which the main one is high refractoriness. The basic constituent of the sand is the mineral quartz or silica, of the chemical composition SiO_2.

THE BACITA RIVER SAND

The river sand deposit at Bacita, Niger State, Nigeria, on the River Niger was selected for this investigation.

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Granite rocks of stones are crushed and separated on rolling down valley to the river and remain as main form of silica sand. This type of sand is available through out the country along the River Niger bed and cheap to access.

The physical properties of the sand deposit were determined. It has an average density of 2.4 g cm^{-3} and the melting temperature of 1,575°C. Chemical analysis was also conducted and the result is presented in Table 1.

SIEVE ANALYSIS

The sieve analysis for 3 samples is shown in Table 2-4.

Table 1: Composition of river sand

S/n	Constituent	Composition (%)
1.	SiO_2	94.6
2.	$A1_2O_3$ (clay)	2.3
3.	Ferric-oxides	1.6
4.	Impurities	1.5
5.	pH	5.90

Table 2: Sand sieve analysis-sample 1. Sand type: Silica, Grain shape: Mixed, Sintering point: 1560°C, Grains retain: In 10 mesh sizes

Sieve analysis				
Mesh	1-10	(%)	Multiplier	Result
1.4	1.5	1.5	6	9.0
1.0	1.7	1.7	9	15.3
0.71	2.1	2.1	15	31.5
0.50	3.2	3.2	25	80.0
0.365	4.1	4.1	35	143.5
0.250	16.4	16.5	45	738.0
0.180	22.9	22.9	60	1374.0
0.125	25.6	25.6	81	2073.6
0.090	13.6	13.6	118	1604.8
0.063	6.5	6.5	164	1066.0
Sieve pan	2.1	2.1	275	577.5
Total	b = 99.7	99.7%	-	a = 77.36
ASF No = a/b = 7713.2/99.7 = 77.36				

Table 3: Sand sieve analysis-sample II. Sand type: Silica, Grain shape: Mixed, Sintering point: 1560°C, Grains retain: In 10 mesh sizes

Sieve analysis				
Mesh	1-10	(%)	Multiplier	Result
1.4	-	-	6	-
1.0	1.4	1.4	9	12.6
0.71	2.4	2.4	15	36.0
0.50	3.2	3.2	25	80.00
0.365	4.6	4.6	35	161.0
0.250	15.4	15.4	45	693.00
0.180	23.9	23.9	60	1434.0
0.125	26.6	26.6	81	2154.6
0.090	13.3	13.3	118	1569.4
0.063	6.7	6.7	164	1098.8
Sieve pan	2.1	2.1	275	577.5
Total	b = 99.6	99.6%	-	a = 7816.9
ASF No. = a/b = 7816.9/99.6 = 78.48				

Table 4: Sand sieve analysis-sample III. Sand type: Silica, Grain shape: Mixed, Sintering point: 1560°C, Grains retain: In 10 mesh sizes

Sieve analysis				
Mesh	1-10	(%)	Multiplier	Result
1.4	0.6	0.6	6	5.4
1.0	1.2	1.2	9	10.8
0.71	1.9	1.9	15	28.5
0.50	3.0	3.0	25	75.0
0.365	3.5	3.5	35	122.5
0.250	15.9	15.9	45	715.5
0.180	24.7	24.7	60	1482.0
0.125	25.3	25.3	81	2049.3
0.090	14.9	14.9	118	1758.2
0.063	6.2	6.2	164	1016.0
Sieve pan	2.6	2.6	275	715.0
Total	b = 99.7	99.7%	-	a = 7979.0
ASF No. = a/b = 7979/99.7 = 80.03				

$$\text{Average AFS No.:} = \frac{77.36 + 78.48 + 80.03}{3}$$

$$= \frac{235.87}{3}$$

$$= 78.62$$

The sieve analysis and the physical properties test result conform with standard. Hence, the applicability of the river sand in foundry process. Ofcourse, it is easily available and cheap to obtain.

RIVER SAND MOULD MIXTURE

Typical machine components were cast with a typical mould mixture of the river sand. The castings were of aluminium cast iron and steel alloys. The machined castings are presented in Plate 1-3. Appearance and crack inspection of the castings and finished items show very high quality that meet standard. The application of the high quality river sand provides the following advantages: economical for production of small quantity items, small initial investment, the production of intricate shapes, large castings and largely applicable for the ferrous and non-ferrous casting.

The castings were made in green sand mould. The green sand moulds were prepared from the fine grain river sand with the addition of binder and moisture. The mould sand mixture was to exhibit high deformability and binder expected to burnout at relatively low temperature.

Dispensable moulds were made for the castings. The moulds were made of moulding mixtures; the basic constituent of which was the river silica sand bonded with bentonite which impacts strength on the sand. Organic starch was also added to improve permeability and collapsibility. The moulds were finally skin-dried

Plate 1: Aluminium hub

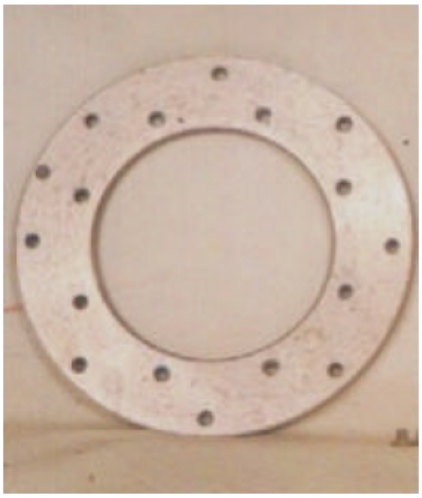

Plate 2: Cast iron friction surface

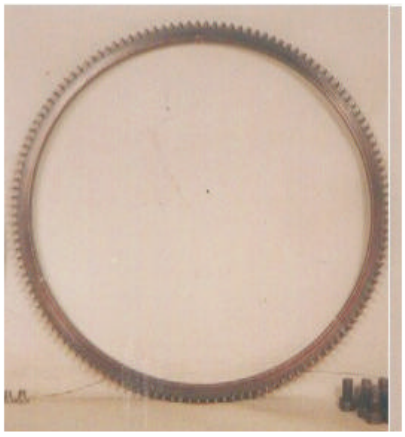

Plate 3: Steel alloy gear rim

Table 5: Mounding sand composition and properties

New sand (%)	Bentonite (%)	Starch (%)	Moisture (%)
100	10	5	8-12
Green Strength:		0.56 kg cm^{-2} for compression	
Permeability:		35%	
AFS No.:		79	

before casting. The hand moulding process was used. The composition of the moulding mixture and its foundry properties are shown in Table 5.

CONCLUSION

An evaluation of the basic properties of a river sand (silica, SiO_2) for foundry mould was described. The river sand was sourced locally from the River Niger at Bacita, Niger State, Nigeria. The service properties of the moulding sand were measured. These include sieve analysis, permeability, green strength and the sintering point. Sample castings each of aluminium, cast iron and steel alloys each were made in green sand moulds. The moulds were prepared from the fine grain river sand with the additions of binder, filler and moisture. Binder (bentonite) was used to cohesively bond sand particles, giving the sand strength and the filler (starch) burned-out at relatively low temperature to enhance gas permeability. The river sand moulds had good collapsibility (the casting shrinks while cooling) avoiding defects such as hot tearing and cracking. The castings were of smooth surface finish and sound in physical properties.

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