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Effect of Charcoal Dust Additive on the Properties of Green Moulding Sand from Gamboru Kasuwa Borno State, Nigeria

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Abstract: *This project is to enable the local caster to know the effect of additives on the properties of green molding sand, in this study, effect of charcoal dust additive at varied proportion on some selected properties of molding sand were investigated. Consequently, samples with different percentage of the additive were prepared base on standard procedures. The prepared sample were subjected to basic molding sand testing including moisture content, clay content, permeability, sieve analysis, compaction, thermal stability using standard method and equipment. From the test result, the charcoal dust additive was found to improve the selected molding properties of the base (silica) sand.*

Key words: *Charcoal Dust, Green moulding sand, metal casting.*

I. Introduction

A foundry is a factory that produces metal casting. Metal are cast into shapes by melting them into a liquid pouring the metal in a mould and remaining the mould material or casting after the metal has solidified as it cools. The most common metals processed are aluminium and cast iron. However other metals such as bronze, brass, steel, magnesium, and zinc are also used to produce casting in foundries. In this process pans of desired shapes and sizes can be formed (Degarma & Kosher, 2003).

Green sand is an aggregate of sand, betonies clay, pulverized coal (or charcoal dust) and water. Its principal use is in making moulds for metal casting. The largest portion of the aggregate is always sand, which can be either silica or olivine. There are many recipes for the proportion of clay, but they all strike different balances between moldability, surface finish, an ability of the hot molten metal to degas. The coal dust, typically referred to in foundries as sea-coal, which is present at a ratio of less than 5% partially combusts in the surface of the molten metal leading to off-gassing of organic vapours. Charcoal dust (known as Sea Coal) is added to control casting quality during expansion of the sand when hot metals are poured into the molds.

II. Literature Review

Vannocio Biringoccio in 16th century (around 1500 AD) is considered as father of foundry industry in the western part of Rome. In its most basic format, sand casting is the process of creating a metal object by pouring molten metal into a mould made of sand. The casting technology which produces product by pouring molten metal into a mould was first developed in China, approximately 7 century BC (Ihom, 2002). It is generally thought that the Chinese bronze were technology achieved and extremely high temperature by utilizing below and from this line of technology, it is assumed that pig iron was developed by melting iron with high carbon content. The effect of moisture content added to the moulding sand if not properly and accurately added in right proportion will affect the surface finish during casting. Responds on foundry development in Nigeria asserted that additive. That is added to moulding sand helps to improve surface finish of iron and steel casting (Gordian, 1986). The amount of additive to be added varies based on the type of additive used. And also the type of thin sectioned castings used. For instance small thin sectional casting might require only about 2%-4% of additive depending on the additive used, while large heavy section then should required about 10%-13% of additive also depending on the additive used (Gordian, 1986).

Coal Dust is commonly used in green sand and dry sand moulding for protecting mould surfaces against the action of molten metal and improving surface finish of cast iron castings. When the moulten metal come in contact with mould surfaces containing coal dust, a gaseous envelope is formed which resists the fusion of sand to metal. Use of coal dust increases both green and dry strength, reduces expansion, tendency to scabbing and metal penetration. It, however, tends to reduce the permeability of sand. Good quality coal dust suitable for foundry use should consist of finely crushed bituminous coal free from foreign material, and should have fineness about 150 mesh BS sieve, equivalent to 106 micron IS sieve. It should have a minimum 30% volatile matter, maximum 20% ash, 3% moisture, 1% sulphur and 0.2% phosphorus content (McKie, 2016).

The term Green Sand denotes the presence of moisture in molding sand and indicates that the mold is not baked or dried. Raw sand is mined and then processed to give it a consistent distribution of grain sizing. When processed for molding, organic clays are added to bond the grains together (Degarma, 2003). Charcoal dust is added to control casting quality during expansion of the sand when hot metals are poured into the molds. Other additives, such as pitch, cellulose and silica flour, are also used. The additive used depends on the metal cast. The sand is blended in a mixer, where the water and the additives are blended with the sand. The sand is then ready to be used to make a mold (Degarma, 2003).

There are several methods of molding but all methods squeeze or compact the sand against a pattern to make an impression of the part to be cast. The patterns are separated from the mold halves or mold cake and the mold is then closed creating a part cavity. Types of molding range from automatic high-pressure high-speed molding, automatic match plate molding, automatic tight flask molding (used for large molds) and jolt squeeze molding. Large molds are also made on the floor and rammed up by hand. (AMT Market Forecast, 2006).

The most common casting process used in the foundry industry is the sand cast system. The principal constituents of moulding sand are: silica sand, grains clay (bond), moisture, and organic additives. Virtually all sand cast moulds for ferrous casting are of the green sand type. Green sand consists of high-quality silica sand about 10 percent betonies clay, 2 to 5 percent water and about 5 percent sea coal, other materials may be added to the sand mixture to enhance certain properties, and for defect-free cast products (AMT Market Forecast, 2006).

III. Method/Procedure

Borno sand deposit is found in the northern part of Nigeria by the river Alau basin. The river forms the upper part of the river Yola linking it to river Benue, which is one of the major rivers that flow through Nigeria. Various sand system in Nigeria have been investigated including this sand deposit. Studies have clearly shown that the shape and sizes of sand grains, the nature and content of clays, moisture and additives, efficiency of the raw materials, etc., are very important in deciding the properties and behaviour of the sand mixture.

The sample in this study underwent some processes and charcoal dust additive of different proportions – from 1% to 9% - were added to green sand in order to enhance its physical and chemical properties in the best interest of molding. Below are the test conducted:

Sieve Analysis Test (Test1)

i. Sample packer was used to fetch the sample and weigh it on weight balance (i.e. 50kg of sand was weighed)
ii. The weight sand was then passed through a sieve shaker and then sieved for ten [10] minutes before removing it from the shaker.
iii. Each sieve plate contained some amount of the sample which was weighed on an electronic balance.
iv. After the sieving was carried out, a table was made having four columns with the following headings: sieve sign, mass obtained, mass passing and percentage passing.
v. The above procedure was undergone for the sand sample from Gamboru Kasuwa

Permeability Test [Test2]

i. The sample sand (300g) was measured and mixed with 90 ml of water.
ii. The compaction mould was filled to the brim observing three layers.
iii. Each layer of the sample in the compaction mould was rammed six (6) times before adding the next layer.
iv. A hose was connected to the burette and then linked to a pem-meter. The point where the hose was connected to the pem-meter was then clipped in, to avoid any leakage with the help of the clip.

v. Water was poured into the burette and an allowed to flow into the perm-meter until the sample was saturated then water stoped passing through the outlet of the perm-meter.
vi. A timer was set to read the time taken for the sample to be saturated
vii. After observing the above procedure, the perm-meter was dismantled and saturated sample was collected in a container
viii. The charcoal dust added to each sample was ranged from one percent (1%) to two percent (2%)

Compaction Test (Test 3)

i. Sample packer was used to fetch the sample of 3kg after being weighed on a weight balance.
ii. Three percent (3%) of water was required for the entail test, so 3kg was converted to gram (g) and then multiplied by three percent (3%) (i.e 3/(100x300) =90 mil.
iii. The measured sample was the poured into the head pan and is mixed with 90ml of water.
iv. The compaction mould was weighed along side with the container used for collecting sample.
v. After the mixture, the sample was then poured into the compaction mould, observing three layers making sure that it is filled to the brim and ensure that the cooler was being added to the compaction mould to enable proper filling.
vi. Lubricating the cooler before usage to ensure easy removal of the sand after compaction.
vii. Note; each layer is stoked/rammed 27 times before proceeding to the next layer.
viii. The compaction mould is weighed with sand inside it using a weight balance.
ix. Using a container, some amount of the sample was taken and the weight of the container plus sample was taken.
x. The above procedure was repeated for 3%, 6%, 9% 12% 15% 18% and 21% of water.
xi. After taking the weight of the sample plus the container, it is passed into an oven for 24 hours and the weight was measured again.
xii. Some procedure as listed above were repeated but this time additives were added two percent (2%) of the sand (2/100x300=60g) additives used were graphite and charcoal dust.

Clay Content Test (Test 4)

i. Small quantity of prepared moulding sand was dried
ii. Separate 50g of dry moulding sand and transfer to wash bottle
iii. And 475cc of distilled water was added plus 25cc of a 3% sodium hydroxide ($NaOH$).
iv. Agitate this mixture about 10 minutes with the help of a sand stirrer
v. The bottle was filled with water up to the marker.
vi. After the sand has settle for about 10 minutes, siphon out the water from the wash bottle.
vii. Dry the settled down sand
viii. The clay content can be determined from the difference in weight of the initial and final sand samples.

Moisture Content Test (Test 5)

i. 20 to 50 g of prepared sand is placed in the pan and is heated by an oven for 2 to 3 minutes.
ii. The moisture in the moulding sand is thus evaporated.
iii. Moulding sand is taken out of the pan and reweighed.
iv. The percentage of moisture can be calculated from the difference in the weights of the original moist and the consequently dried sand sample. Percentage of moisture content = W1-W2/W1x100

Thermal Stability Test (Test 6)

i. The grain sand was mixed with 90 ml water and threaded until the sand was well mixed without to be
ii. Cope and drag moulding was used, the pattern was centralized in the drag box.
iii. Drag box was turned into the cope box and rammed, additional moulding sand was added and then rammed again until the drag box was filled.
iv. Straight edge was used to trim off the excess sand on the drag box.
v. The drag box was then retuned back to its normal position.
vi. Then cope box was place in position on top of the drag box.
vii. Parting sand was sprinkled on the face of the drag box.
viii. Sprue pin was placed in position and mould sand was paired into the cope box and rammed.
ix. The sprue pin was removed.
x. Pouring cope was separation from the drag box.
xi. The cope box was separation from the drag box.
xii. The pattern was then removed.
xiii. Bellow was used to blow off all broken sand in the mould cavity.
xiv. The cope was returned back to the drag box.
xv. The complete mould is now ready to receive the molten metal.

Melting Process

(i) The furnace and the crucible pot were preheated for 20 minutes.
(ii) After preheating, the aluminium ingot was charged into the crucible pot.
(iii) The furnace was closed and fired using manual hand blower.
(iv) After 30-40 minute, additional charcoal was added so as the firing to continue.
(v) The furnace was opened and flux (carbide was added)
(vi) At 700^{o}c skimming spoon was used to remove the slag.
(vii) Tong was used to remove the molten metal from the furnace to the already prepared mould.
(viii) The molten metal was poured into the mould cavity through the down gate steadily until the pouring cope was filled.
(ix) The mould was allowed to solidify for 20-30 minutes.
(x) After the solidification, the mould was broken and the cast object was removed.
(xi) After completing the casting operation it was observed that the casted object was within the tolerance.

IV. Data Presentation and analysis

Table 1: Dry strength versus percentage charcoal dust content for Green sand sample from Gamboru Kasuwa

% of Charcoal dust additive	Dry Compression (KN/m^2)
1	63
2	97
3	90
4	70
5	50
6	35
7	27
8	12
9	8

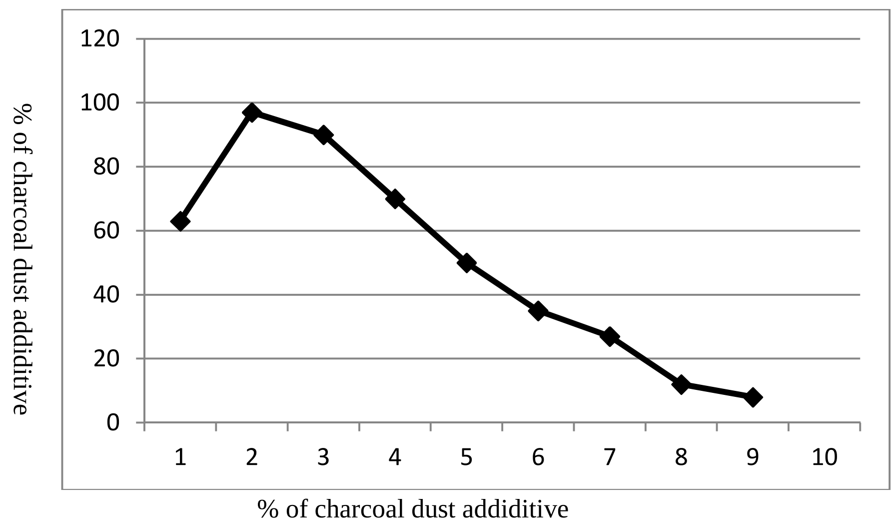

Fig. 1: Dry strength versus percentage coal dust content

The effects of adding various percentages of charcoal dust on the green compression and are presented in Fig. 1. Addition of charcoal dust (dry) up to 2% by weight relative to the molding sand, increased the green compression. The peaks of these strength values occurred at a coal dust addition of 2% by weight (dry). A further addition of charcoal dust beyond 2% by weight relative to the moulding sand caused compression strength to fall from their peak values. Beyond this percentage the dry compression strength began to decrease with increasing coal dust addition.

V. Conclusion

Gamboru Kasuwa Green sand is an effective binder for molding sand, this work has characterised the effects of charcoal dust as additive on the properties of the molding sand. This work further confirms that charcoal dust can be effectively used as an additive in molding sand without adverse effects if used within the optimum range of values. Improved mechanical properties of the molding sand are also obtained by coal dust addition when the optimum amounts are used.

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