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Potentials of *Elaeis guineensis* and *Pinus sylvestris* as binders on foundry core strength

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The potential of foundry sand core binders made with palm oil (*Elaeis guineensis)* and pine oil (*Pinus sylvestris)* were investigated. Core specimens made with Ota silica base sand bonded with percentage of cassava starch in admixed proportion of *Elaeis guineensis* and *Pinus sylvestris* were tested for tensile, compressive strength, permeability and time of collapse to establish the binder's efficiency. Tensile strength of the green baked core were oven baked at 50°C, 100°C 150°C and 200°C; cooled to room temperature and tested with universal strength machine. The combined evaluation of the oils at higher percentages of starch addition indicates a significant improvement on the foundry properties. The cylindrically shaped permeability specimens were tested with permeability meter. Study revealed that cores baked at 150°C for palm oil attained a significant strength at lower baking periods than others. Pine oil showed an improve properties at 6% cassava starch at 200°C.

Keywords: *Elaeis guineensis*, *Pinus Sylvestris,* sand grains, foundry cores, baking temperatures.

Introduction

Development of suitable molding raw materials for foundry intricacy such as silica sand, clay, binders and additives for foundry practices have been of great interest recently. Before now all foundry raw materials are entirely dependent on importation. Countries have developed rapidly in the use of core binders locally sourcing for industries in order to boost the ailing economy[1-10]. In foundry, when a casting is to be produced with holes, cores are used to form these interior surfaces[6-12] and are made of sand particles bonded together to form an aggregate. Cores are made of core sand mixtures from sand grains and binders[10-12]. A proper and formulated mixture gives good green compressive strength and adequate baked strength to prevent premature collapse during usage. Bonding material is usually a constituent of synthetic foundry sand and binders[13-15]. Binders are generally grouped as mineral materials, organic binders, inorganic binders or miscellaneous binders based on source and chemical composition[14-16]. Sand grains cannot adhere to each other without the introduction of binders that cause them to stick together and produce the cavity into which molten metal is introduced[6-12]. Binders are introduced into the molding and core mixtures in order to improve their properties especially the strength[5-15]. Clay has been found to be most used binder for moulding sands; however when used ordinarily as a binder for core production may not give the required properties expected depending on the based sand. Some of the common binders for core making are, cotton seed, ground nut, palm kernel[12], cashew nut and castor oils, vegetable oil, honey and soya beans[12-20]. The use of *Manihot esculenta crantz* (Cassava Starch) for sand core processes has not been widely study in the literature, and hence the continue need to investigate its prospect with other binding additive such as palm oil and pine oil in this respect is considered necessary. Cassava starch has therefore been chosen for the study because is easily sort for and cheap with excellent bonding features. Equally, cassava starch, palm oil and pine oil has no negative health implication; they are environmental friendly for the production of sand cores and most importantly reduce the total addiction on foreign materials to promote the development of indigenous technology. Palm oil are available in Nigeria abundantly especially in the eastern and southern Nigeria. This study aimed at

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Table 1—Mineralogical composition of the foundry sand used for the study

Composition	SiO_2	Al_2O_3	K_2O	CaO	$Ti0_2$	Cr_2O_3	MnO	Fe_2O_3	MgO	CuO	Na_2O
Wt%	Balance	0.58	0.08	0.34	1.60	0.02	0.02	0.45	0.16	0.04	0.04

producing sand cores locally using Ota silica sand, cassava starch, palm oil and pine oil as binder and examining their suitability and behaviour during casting process.

Experimental procedures

Materials

Silica sand which was the base material used for this work were collected from Ota in Ado-odo Local Government, Ogun state, Nigeria. Binders which are cassava starch, was extracted from cassava tubers obtained from Arobieye in Ota, Ogun State, Nigeria. The palm and pine oil was purchased from Nigeria and South Africa market respectively. Equipment such as universal strength testing machine, weighing balance, mixer, measuring cylinder, specimen rammer, permeability meter, oven, shaker, sets of sieve, crucible, furnace, hack saw machine, mould box, core box and wire brush were used.

Method

Preparation of Manihot esculenta crantz

Peeled and washed cassava tubers were grinded into pulp and water was added for extraction. The admixed particulate was left to stay for 180 minutes after which the water was removed away. The starch residue was properly dried to white in line with (Popoola, 2011).

Sand preparation

The silica sand was collected from the Ota river side, washed to remove clay and dirt. The processed silica sand was dried and sieved using shaker of different meshes and aperture. The obtained and dried sand was studied with ED X-ray fluorescence analyzer for mineralogical composition as shown in Table 1.

Sieve Analysis

Standard sieve test of BS 410 series to remove all coarse particles according to Popoola (2011) was used. Weight of sieved sand sample values in Table 1 were used to calculate grain fineness number $\left(GFN = \frac{Total\ Product}{Total\ \%\ of\ retained\ grain}\right)$ and fines (%).

Table 2—Composition of the mixed oils and starch

S/No	% Mixture
1	3% Starch + 2% palm oil + 3% water
2	3% Starch + 6% palm oil + 3% water
3	3% Starch + 2% pine oil + 3% water
4	3% Starch + 6% pine oil + 3% water
5	6% Starch + 2% palm oil + 3% water
6	6% Starch + 6% palm oil + 3% water
7	6% Starch + 2% pine oil + 3% water
8	6% Starch + 6% pine oil + 3% water

Core mixture and core making

The mixtures constituent and % composition of the mixed oils are shown in Table 2 below. The blended admixed constituent was gradually put into 45 mm diameter by 50 mm height and immediately rammed with a rammer. Subsequent to the ramming, the core specimen was ejected directly from the sleeve by a piston. Thereafter the ejected core was transferred to an electric oven with temperature of about 1200°C capacity.

Results and discussion

Results

Figure 1 represents a comparative chart of foundry properties; CS, PM, B/SS at different addition of starch and oils against foundry composition for 50, 100, 150, and 200°C. While Figure 2 indicates the time of collapse at various foundry compositions for variable temperatures.

Discussion

Sand mineralogy study

From the ED X-ray fluorescence analyzer for mineralogical composition during sand preparation it shows that the Ota sand contains 0.45%Fe_20_3, 0.58% Al_20_3 and 95.50% $Si0_2$. The silica content value is in line with the acceptable value suggested for moulding and core sands which are between 85 and 97%. According to a study by Popoola (2011), higher silica content is essential to resist the heat from molten metal during casting operation.

Effect of baking temperature, percentage starch and oils on foundry properties

The variation in compressive strength (CS), permeability (PM), baked/shear strength (B/SS) and time of collapse (TC) with baking temperature

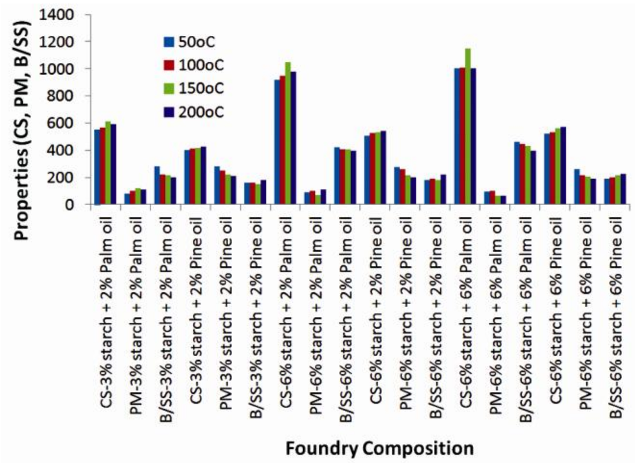

Fig. 1—Comparative chart for properties and combined foundry composition with 3% H_2O

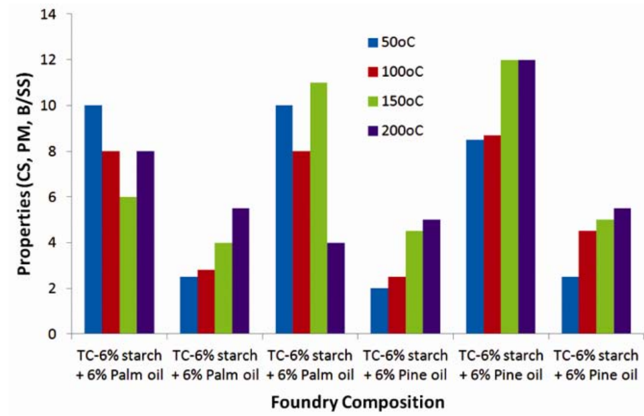

Fig. 2—Comparative chart for TCs of different foundry compositions and temperatures with 3% H_2O

was determined for oil bonded cores produced from various admixtures. From the results, as the temperature increases, compressive strength and permeability increases up to 150°C and the baked/shear strength decreases slightly down from its optimum strength of 280 KN/m^2 at 50°C (Figure 1). While at 3% starch, 2% pine oil and 3% water content, compressive strength increases throughout the baking temperature. While permeability and baked/shear strength decreased significantly with the temperature and an increase in the baked/shear strength at 200°C. This behavior is attributed to the variance in admixed composition and the mechanism during baking. Equally, in Figure 2, the time of collapse for 3% starch with 2% palm oil and 3% H_2O decreased up to 150^{o}C while that of 3% starch with 2% pine oil and 3% H_2O increases with baking temperature. The compressive strength and permeability of the 6% starch with 2% palm oil increases with the baking temperature and higher CS was obtained at 150^{o}C baking temperature (see Figure 1). The baked/shear strength decreased with baking temperatures. Therefore, lower baking temperature of 50^{o}C favored the baked/shear strength with higher value of 420 KN/m^2. The time of collapse for this foundry composition was found to be lower at the highest temperature of baking (Figure 2). Similar result can be obtained[5,12]. While at the same 6% starch addition but with 2% pine oil binder, CS, B/SS, TCs increases with baking temperatures. However, the permeability for this foundry composition decreases with baking temperatures. The results obtained for 6% starch with 6% palm oil binder in Figures 1 and 2 indicate an increase in CS with temperature up to 150^{o}C (1150). Whereas, PM and TC increased with temperature up to 100^{o}C after which these properties remained constant at a value of 65 and 12 respectively. The B/SS properties decreased throughout the baking temperatures considered in this work. Specifically, the results of the 6% starch with 6% pine oil binder; it shows that CS, B/SS and TCs increased with the baking temperatures. While PM decreased with temperature.

Comparative study of the effect of baking temperature on foundry properties at various binder compositions

In Figure 1, the variation in foundry properties; CM, PM and B/SS as a result of the composition admixture are compared along with baking temperatures. Equally, it can be seen that these properties increased with change in composition at various levels of binder additions. Specifically, composition of 3% starch with 2% palm oil has the highest properties, followed by 3% starch with 2% pine oil binder in all the baking temperature considered. While an increase in the starch content at 6% significantly improved the foundry properties for various level of percentage palm and pine oil binders (see Figure 1). It can however be said that all the properties investigated are favoured at 150^{o}C for most composition at all temperatures. This observation is similar to the previous report by Popoola (2011). The time of collapse using pine oil as binders increased with baking temperatures for majority of foundry compositions as against the trends obtained in palm oil as binder; which increase and decrease in a fluctuating manner (Figure 2).

Conclusion

The use of palm oil (*Elaeis guineensis)* and pine oil (*Pinus sylvestris)* as potential binders on foundry core strength have been established to significantly improve foundry properties at different baking temperatures. From the results and discussion, the following are concluded:

1. Foundry properties improved with starch and oil additions at different baking temperatures considered. Specifically, it can be said that the PM increases with baking temperature using 3 and 6% starch with 2 and 6% palm oil as binder.
2. The higher foundry properties can be obtained at 150°C baking temperature and higher TCs for pine oil in all compositions are obtainable at 200°C baking temperature.
3. That higher starch and oil additions favored the CS with palm oil reaching a value of 1150 at 150°C; equally, B/SS for palm oil (460 KN/m^2) at 50°C is higher than pine oil (225 KN/m^2 at 200°C) and that PM value for pine oil are higher than palm oil in all admixtures.

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