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Full Length Research Paper

Synergetic performance of palm oil (*Elaeis guineensis)* and pine oil (*Pinus sylvestris)* as binders on foundry core strength

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Possibilities of foundry sand core binders made with combination of *Elaeis guineensis* and *Pinus sylvestris* have been evaluated and the combine effect of these oils as binder were discussed. Core specimens made with Ota silica base sand bonded with 6% of cassava starch in admixed proportion of *E. guineensis* and *P. sylvestris* were tested for tensile, compressive strength and permeability to establish the binding efficiency. Tensile strength of the green baked core were oven baked at 50, 100, 150 and 200°C; cooled to room temperature and tested with universal strength machine. The cylindrically shaped permeability specimens were tested with permeability meter. The combine synergetic performance of the oil with *Manihot esculenta crantz* at 3 and 6% respectively show an improved tensile strength of about 90% above the *P. sylvestris* admixed. A compressive strength (CS) with baking temperatures up to 1150 KN/m^2 was achieved at 6% starch with 2% (palm and pine oil) and 3% H_2O and increased up to 1350 KN/m^2 at 6% starch with 6% (palm and pine oil) and 3% H_2O. Cores made with composites of 6% starch, 6% palm and pine oil and 3% water and 6% starch, 6% palm oil and 3% water will be suitable for intricate copper, aluminium, iron and steel casting.

Key words: *Elaeis guineensis*, *Pinus Sylvestris,* cores, cassava starch, synergetic performance.

INTRODUCTION

In foundry industries, cores are used to form interior surfaces in casting to be produced with holes (Paul et al. 2007; Nuhu, 2010; Olakanmi and Arome, 2009; Silver and Maria, 2007; Ola, 2000; Debussy, 1980; Fayomi et al., 2011) and are made of sand particles bonded together to form an aggregate. Cores are made of core-sand mixtures from sand grains and binders (Ola, 2000; Debussy, 1980; Fayomi et al., 2011). A proper and formulated admixture 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 (Abdulwahab et al., 2008; Asuquo and Bobojama, 1991; Ayoola et al., 2010). Binders are of various types and each type is used to confer some desired property on a core for a particular use or set of conditions. Core binders serve to hold the sand grains together, impact strength, resistance to erosion and the breakage and degree of collapsibility. They are divided into two classes, organic and inorganic binders. Cereals resins, proteins pitch oils and molasses are organic binders. Cement, silicates and some esters are inorganic binders (Popoola and Fayomi, 2011). 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 require properties expected. Some of the common binders for core making are; cotton seed, ground nut, palm kernel (Fayomi et al., 2011), cashew nut and castor oils, vegetable oil, honey and soya beans (Abdulwahab et al., 2008; Asuquo and

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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

Table 2. Composition of the mixed oils and starch.

S/No.	% Mixture
1	6% Starch + 2% palm and 2%Pineoil + 3% water
2	6% Starch + 6% palm and 2%Pineoil + 3% water

Bobojama, 1991; Ayoola et al., 2010; Fayomi et al., 2011; Brown, 1994; Charles, 2004; Tunji et al., 2009; Narayama, 2002; Popoola, 2011). In this study, cassava starch, *Elaeis guineensis* (palm oil) and *Pinus Sylvestris* (pine oil) as an organic binder for producing sand cores locally using Ota silica sand have been proposed with higher percentage of starch and oil admixture. The present study is aimed at investigating the synergetic performance of the oils at the optimum starch percent with variable oils mixtures on the foundry properties; compressive strength (CS), permeability (PM), baked/ shear strength (B/SS) and time of collapse (TC).

MATERIALS AND METHODS

Materials

Silica sand which was the base material used for this work were collected from Ota in Ado-odo Local Government Area of 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 purchase 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.

Methods

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 min before the water above was poured. The starch residue was properly dried to white in line with Popoola (2011) research.

Sand preparation

The silica sand was collected from the Ota river side, washed to remove clay and dirts. The processed silica sand 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 is shown in Table 1.

Sieve analysis

Standard sieve test of BS 410 series to remove all coarse particles according to Popoola and Fayomi (2011) and Popoola et al. (2011) was used. Weight of sieved sand sample values in Table 2 were used to calculate grain fineness number (GFN) and fines (%) =

$$(GFN)\text{ and fines }(\%) = \frac{Total\ Product}{Total\ \%\ of\ retained\ grain}$$

Core mixture and core making

The mixtures constituent and % composition of the mixed sand particulate are shown in Table 2. 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

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_2O_3, 0.58% Al_2O_3 and 95.50% SiO_2. The silica content value is in line with the acceptable value suggested for moulding and core sands between 85% and 97%. According to Popoola (2011) higher silica content is essential to resist the heat from molten metal during casting operation.

Synergetic effect of oils admixture on the compressive strength (CS), permeability and baked/shear strength properties of core specimens

Figures 1 and 3 indicate how the foundry properties; CS, PM, B/SS vary with temperatures. From the admixture of 6% starch with 2% (palm and pine oil) and 3% H_2O (figure 1), there is an increase in compressive strength (CS) with baking temperatures up to 1150 KN/m^2 at 150°C. While the permeability (PM) and baked/shear strength (B/SS) increases up to 90 and 520 KN/m^2 respectively at 100°C, thereafter the values decreased.

In Figure 3, at 6% starch with 6% (palm and pine oil)

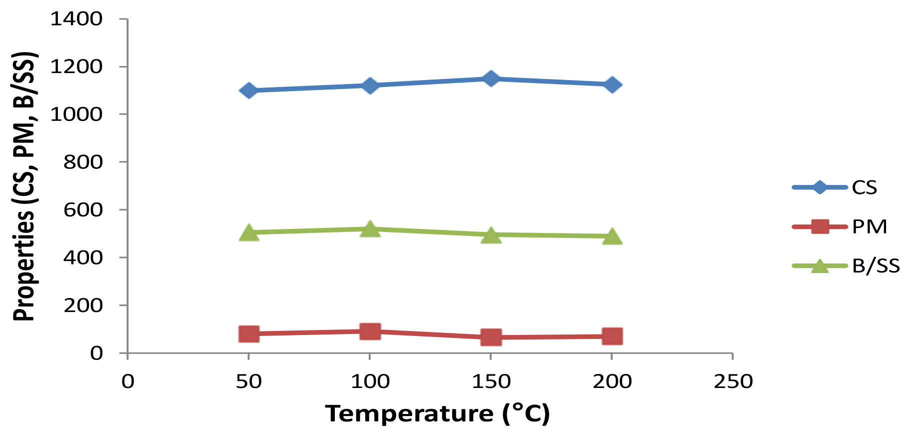

Figure 1. Variation of compressive strength (KN/m^2), permeability and baked/shear strength (KN/m^2), with temperature for 6% starch with 2% (palm and pine oil) and 3% H_2O.

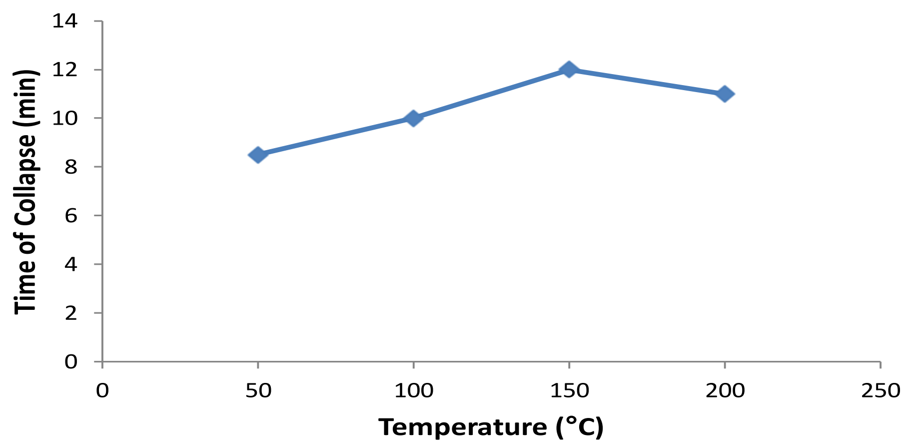

Figure 2. Variation of time of collapse (minutes) with temperature for 6% starch with 2% (palm and pine oil) and 3% H_2O.

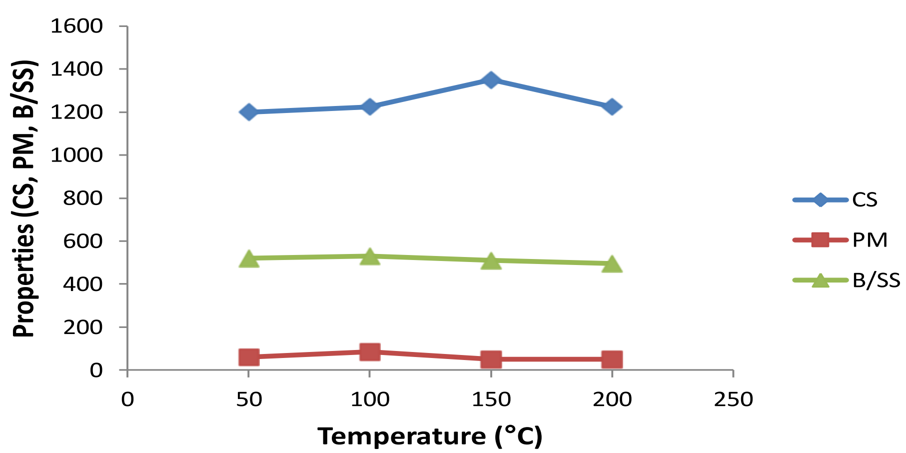

Figure 3. Variation of compressive strength, permeability and baked/shear strength with temperature for 6% starch with 6% (palm and pine oil) and 3% H_2O.

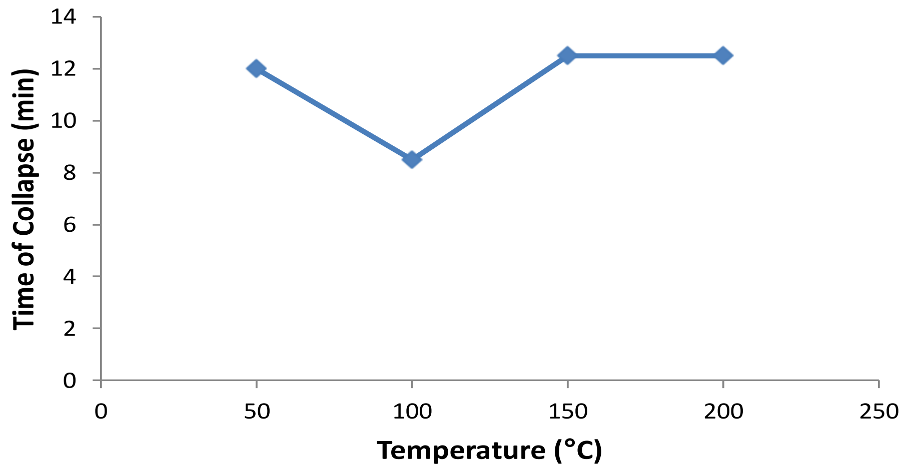

Figure 4. Variation of time of collapse (min) with temperature for 6% starch with 6% (palm and pine oil) and 3% H_2O.

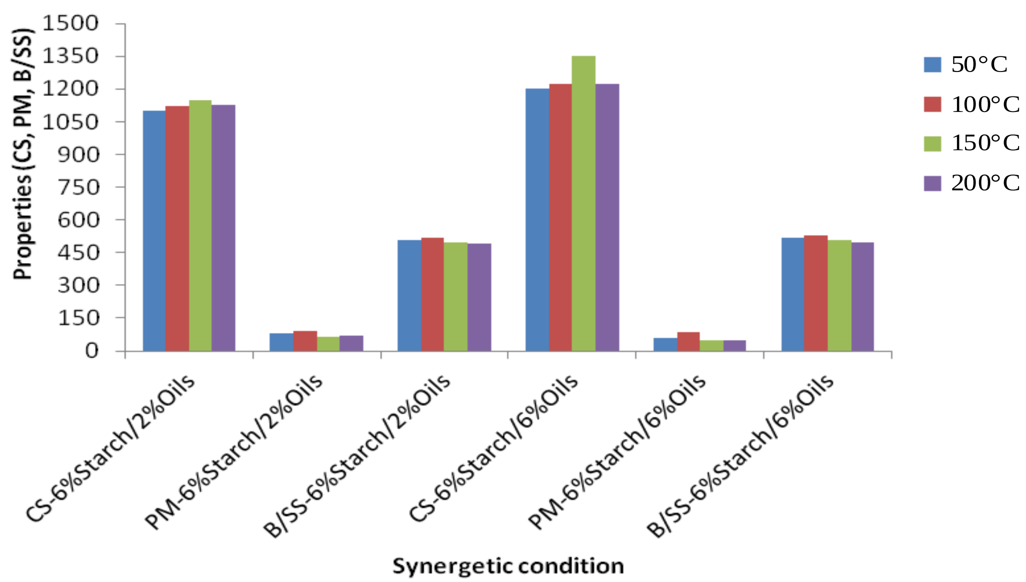

Figure 5. Synergetic evaluation of 6% starch with 2% (palm and pine oil) and 6% starch with 6% (palm and pine oil) at different baking temperatures.

and 3% H_2O, there is an increase in permeability (PM) and baked/shear strength (B/SS), with values as high as 85 and 530 KN/m^2 respectively. At this condition, the CS also increased with baking temperature similar to Figure 1 with a value of 1350 KN/m^2. From Figure 5, it is observed that foundry properties increased with compositions at various levels of binder combinations. The composition of 6% starch with 6% (palm and pine oil) has the highest CS value followed by 6% starch with 2% (palm and pine oil) binder in all the baking temperature considered. The permeability of the produced core was significantly enhanced with maximum value of 530 at 100°C. Generally from the study, the PC and TC have their optimum values at 150°C, while PM and B/SS showed an optimum values at 100°C.

Effect of time of collapse (TC) on the synergetic performance of oils admixture

The time of collapse (TC) increases with an increase in baking temperature with a value of 12 min at 150°C (Figure 2). While the TC decreased at 100°C, thereafter it increases (Figure 4). Equally, the TCs with baking

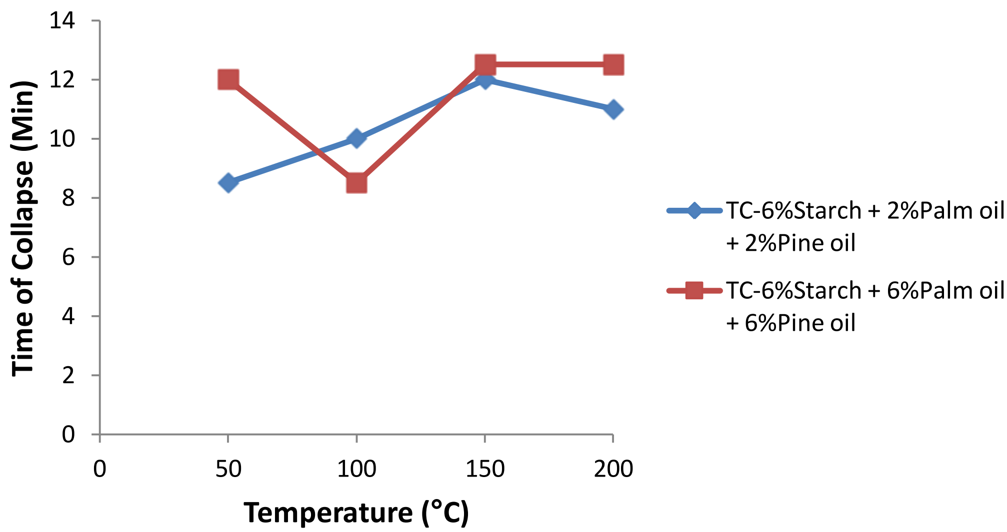

Figure 6. Comparative chart for TCs (minute) of different composition and at various temperatures.

temperature for the combined oils (Figure 6) indicate that TC for 6% starch with 6% (palm and pine oil) and 3% H_2O has optimum value of 12.5 min at 150 and 200°C. In general, this study revealed that higher time of collapse is obtainable at 150°C.

Conclusion

The synergetic effect of palm oil (*E. guineensis)* and pine oil (*P. sylvestris)* for foundry core strength have been demonstrated with significant improvement in foundry properties at all baking temperatures considered. From the results of synergy of the two oils, it can be said that the performance of combined effect of the oils performed better using 3% H_2O addition. The higher foundry properties were attained at 150°C baking temperature and that TC increased for the two foundry compositions considered.

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