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Evaluation of Rubber Seed Oil as Foundry Sand-Core Binder in Castings

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ABSTRACT
Amongst oils of Marine, Mineral and Vegetable origins; consumable vegetable oils are the most widely applied in the foundry industry as binders. Their supply is however limited due to competing demands by food and cosmetic industries. A search into the use of non-consumable sources of vegetable oils as core oil for use in casting technology is therefore a necessity. Rubber seed oil was evaluated as core binder in foundry sand, consisting of a mixture of cassava starch; water and silica. An optimum baked strength of 1829kN/m^2 was achieved in a mixture consisting of 3% Rubber seed oil, 7% water 0.5%cassava starch and 89.5% sand.

KEY WORDS: *Backed strength; iodine value; cores.*

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I. INTRODUCTION

In casting, core plays a very significant role in the production of machine components or parts. All cavities produced in metal casting are supported by the use of cores[1]. Core binding materials are numerous and the mode of casting determines the material to be employed on both ferrous and non-ferrous foundries. Oils are among the core binders of industrial significance. Oils of vegetable, mineral and marine origins have been used as core binders. Their application is determined by their drying ability. The drying property of the oil determines the backed strength of the oil-sand cores and is a function of its ability to absorb oxygen during curing. The level of oxygen absorption by the oil is a direct indicator of the drying power of the oil, and is dependent on the degree of saturation of the fatty acids [2,3,4,5]. The iodine value is a measure of this property. Based on this scale, oils are classified as drying, semi-drying, and non-drying .

The use of vegetable oils has been most popular because of the relative low cost, good bench life and excellent core properties[6,7,8,9] Some locally produced vegetable oils include soy bean, cotton seed, groundnut, shear butter palm, palm kernel oils, etc. Investigations on these oils have shown that backed strength of 700kN/m^2 is achievable using soy bean oil. Aponbiede, reported a backed strength of 742kN/m^2 using clay as additive in a formulation consisting of 3% soy bean oil, 1.5% clay, 7% water and 85.5% sand [10]. Also, Akor in his work on investigation of soy bean oil sludge as foundry sand core binder[11], reported a backed strength of 587kN/m^2 in a formulation consisting of 3% soy bean oil sludge, 0.5%cassava starch, 7% water and 89.5% sand. The development of oil-sand cores using locally source raw materials is expected to be a significant contribution to the foundry industry[12,13,14]. The major problem is the limited supply of these vegetable oils due to competing demand by food and cosmetic industries. There is therefore a need for the research into non-consumable sources of vegetable oils for use in casting technology.

Rubber seed oil is non-consumable vegetable oil which has little or no application in human nutrition. This work aims at developing oil- sand cores using rubber seed oil as binder. Rubber seeds are been wasted in our plantations especially in the southern part of Nigeria 'The success of the work will enable local foundries maximize the utilization of this locally available raw material, minimize waste, be competitive and economically viable.

II. MATERIALS AND METHODS

MATERIALS : The raw materials used in this research work include sand, rubber seed oil and cassava starch. The sand was collected from river Kaduna, in Kaduna state. It was washed to remove clay, organic matter and sun dried for two days before sieving with a set of sieves.The rubber seed oil used was produced from rubber nuts obtained from rubber plantation in Ugep Local Government Area of Cross River State, Nigeria. the nuts were depericaped and crushed in a vessel. The crushed seeds were mixed with ethanol (solvent) in a mass ratio of between 0.5 and 0.91. The mixture was stirred for a period of 80minutes at constant temperature of 55 ^{o}C to allow the solvent force oil out of solid cells. The mixture was filtered and distilled to recover the solvent and the crude oil obtained. The crude oil was then dried in the oven for two hours at constant temperature of 105 ^{o}C to obtain the end product used in the experiment. The cassava was purchased from Kawo market in Kaduna, Kaduna State, Nigeria. It was processed for starch.Core preparation and test were carried out at the laboratories of Ahmadu Bello University Zaria, Kaduna State Nigeria, according to American Foundrymen Society (AFS) standard.

EXPERIMENTAL DESIGN : 2x6x4 factorial design comprising of two baking temperatures (160^{0}C and 180^{o}C), 6 water lrvels in pre-mixes (3,4,5,6,7and8%) and 4 baking periods (1.0,1.5,2.0,2.5hours) which yielded 48 experimental groups was used to evaluate optimum backed strength, oil level water level, baking temperature and baking period of the cores containing rubber seed oil at three levels (1.0, 2.0, 3.0%) with 0.5% cassava starch.In each group, determined quantities of sand, oil, water and starch were mixed and compacted into specimens in a standard core box with a standard rammer weighing 6.5kg; dropped from a height of 50mm. Three blows were applied in each case and a number of test specimen were produced for determination of backed strength.The oval shaped specimens of each experimental group 50mm; square at the middle section, weighing 105g each were backed at temperatures of 160^{o}C and 180^{o}C. After backing, the specimens were cooled overnight in desiccators containing calcium chloride and phosphorous pentoxide for proper drying before tensile strength was measured. Testing was done with the appropriate equipment.

III. DISCUSSION

The result showing backed strength (tensile strength) with their optimum values, oil level, water level and baking time are presented in Figures 1-12 The optimum backed strength was found to be 1829kN/m^{2} (fig 13) in a composition 3% rubber seed oil, 7%water, 0.5%cassava starch and 89.5% sand, backed at 160^{0}C for 2hrs. After a series of trials, 3% oil addition was found adequate in the production of the oil-sand cores. Oil content in excess of 3% resulted in excessive smoke during baking consequently producing weak cores.A survey of the results show that the tensile strength increased with increase in baking and water addition up to optimum values of 2hrs and 7% respectively, for both temperature ranges. The decline in strength value after this point shows that the binding property of the oil got destroyed when left at high temperature for longer periods than 2hrs. The tensile strength of cores baked at 160^{o}c for all mixes; Fig 1-6 appear to be higher than those baked at 180^{o}c. This indicates that 160oc is the appropriate temperature for baking rubber seed oil-cores. Water acts as a medium of mixing. It is added to activate the cohesive properties of the binder. It can be deduced from the results that, below 7% addition the ingredients are not well dispersed in the system and the desired wetting of the sand grains is lacking. The result show a gradual increase in backed strength for each experimental group as water content is increased, showing that as the mixture gets enriched with water ,allowing proper mixing and coating of the grains, a corresponding increase in strength results. Beyond 7% the cohesive properties of the binder is hampered for the two temperature ranges as shown in fig 1-6 for cores baked at 160^{o}c and Fig 7-13 for cores baked at 180^{o}c . The cores produce a lot of steam and backing is also hampered. This results to production of soft cores. A survey of the results show that for all mixes, the optimum water addition is 7%.

IV. CONCLUSION

On the basis of backed strength, the optimum value, 1829kN/m^{2} obtained from the experiment compares with what has been found in the industry where baked strength greater than 700kN/m^{2} are for class one cores for steel casting. The rubber seeds in our plantations are been wasted. It is hoped that this finding will encourage the production and use of rubber seed oil as core oil in our local foundries.

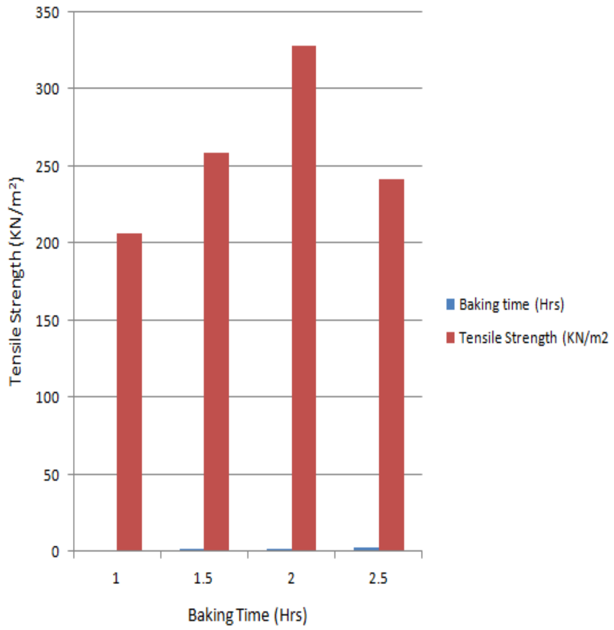

Fig 1. Baked Strength (kN/m^2) for cores (composition 3% Rubber seed oil, 0.5% cassavas starch, 3% water) Baked at 1660^0C for varying periods

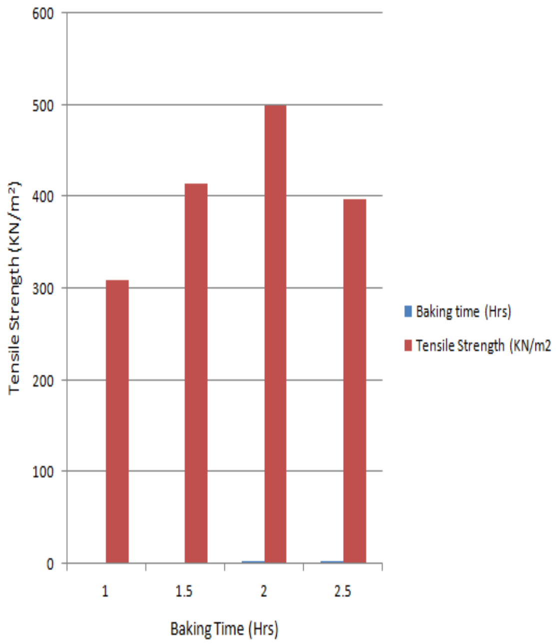

Fig. 2. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 4% Water) Baked at 160^0 C for varying periods.

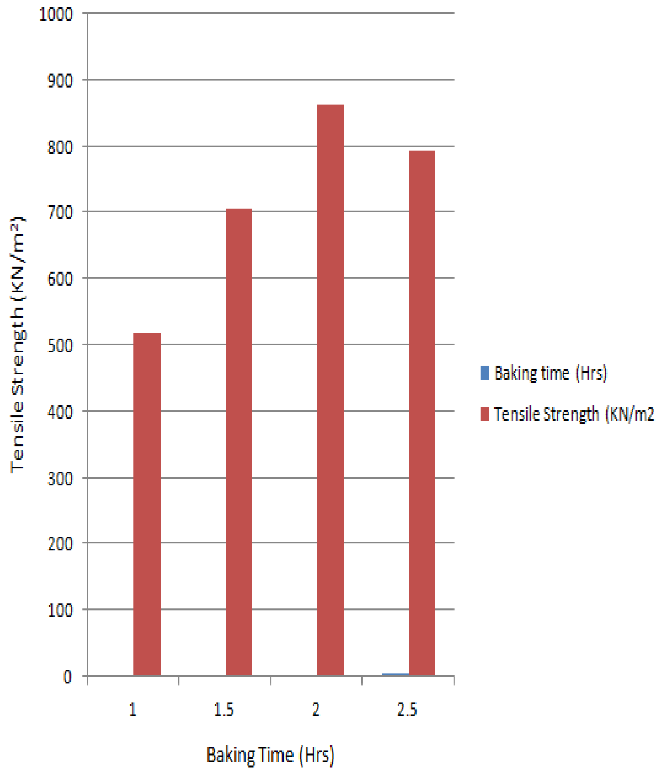

Fig. 3. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 5% Water) Baked at Baked at   160^0 C for varying periods.

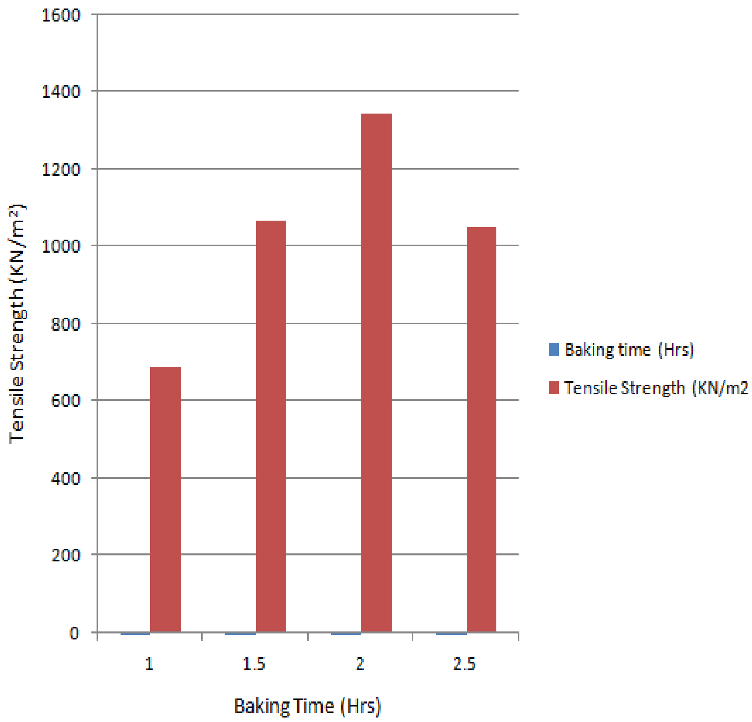

Fig. 4. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 6% Water) 160^0 Cfor varying periods.

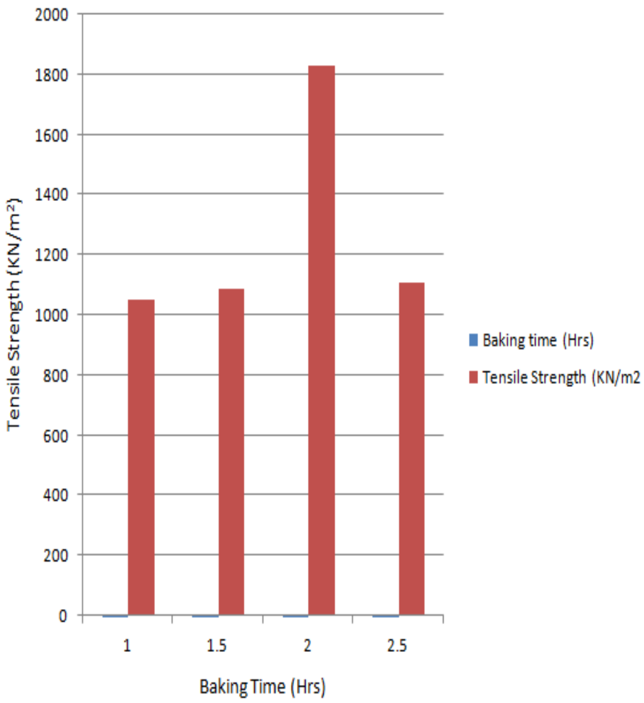

Fig. 5. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 7% Water) Baked Baked at 160^0 C for varying periods

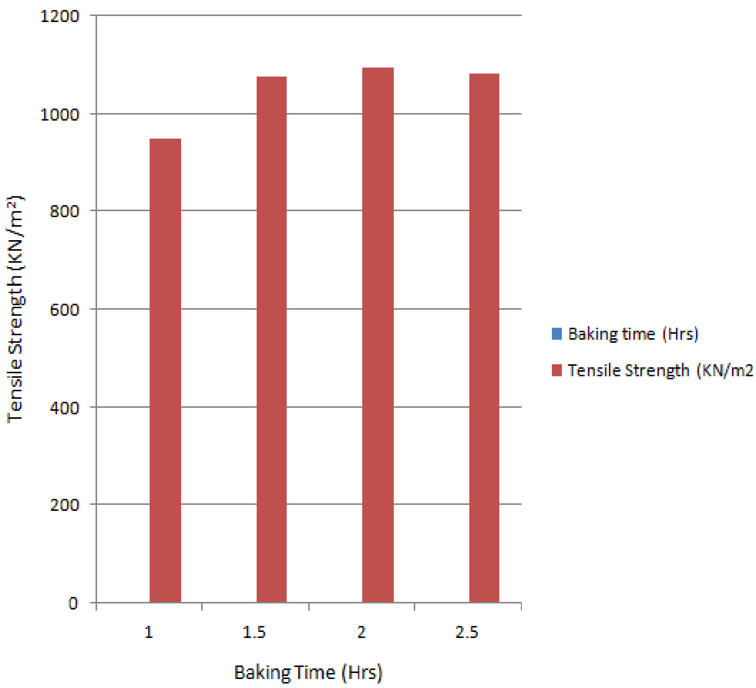

Fig. 6. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 8% Water) 160^0 C for varying periods.

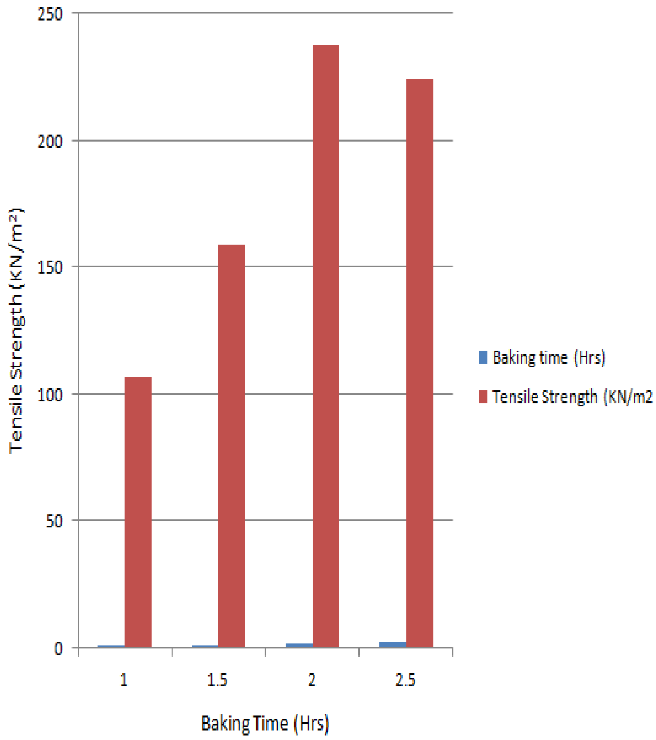

Fig. 7. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 3% Water) Baked at at 180^{0}C for varying periods.

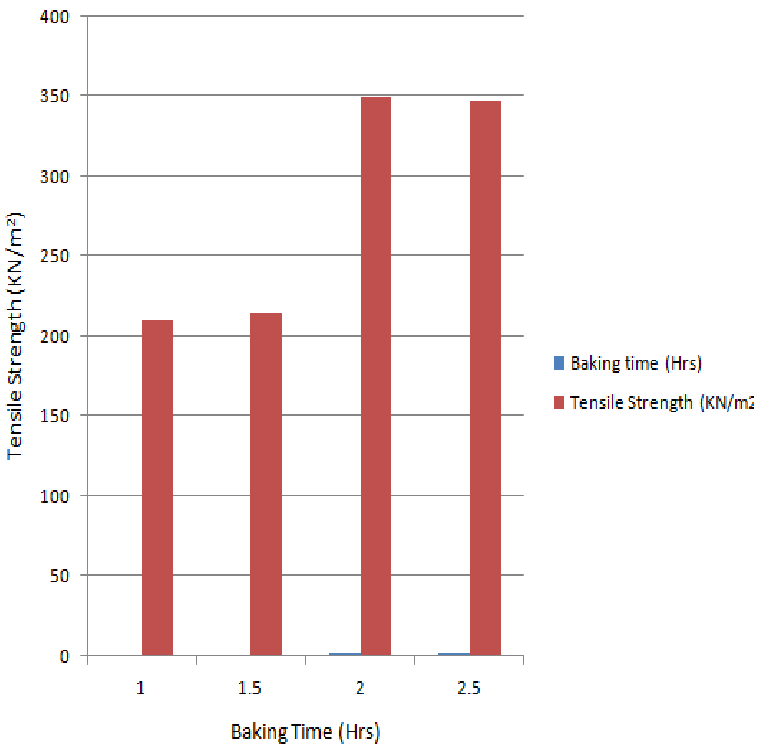

Fig. 8. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 4% Water) Baked 180^{0}C for varying periods.

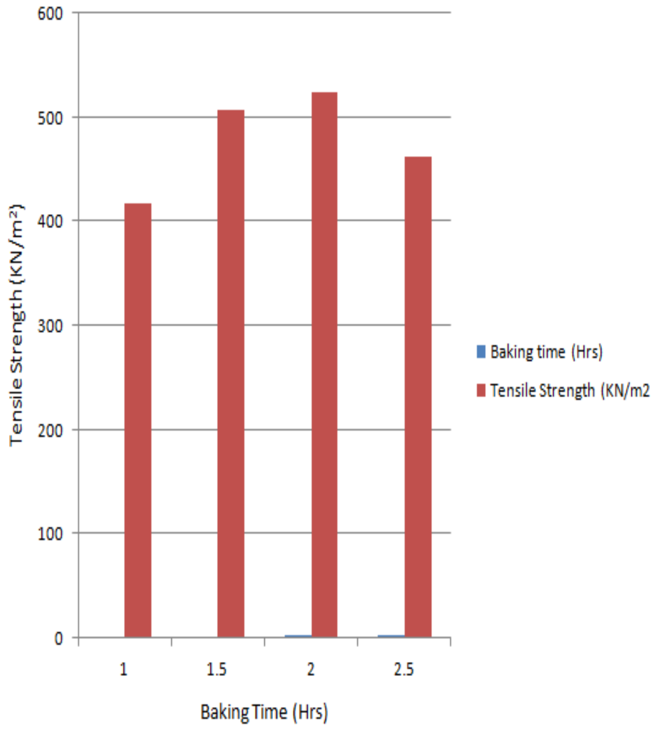

Fig. 9. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 5% Water) Baked at 180^{0}C for varying periods.

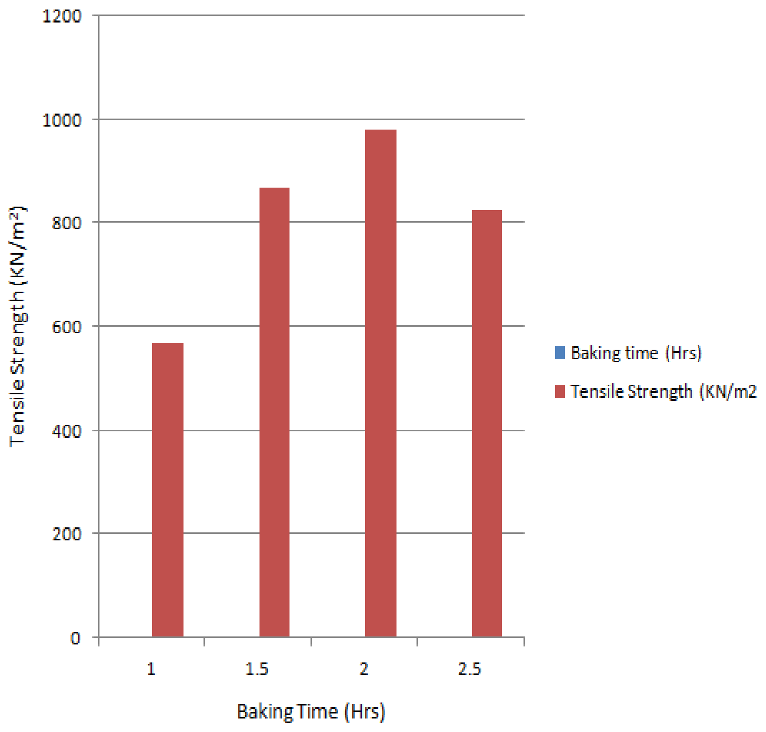

Fig. 10. Baked Strength (kN/m^2) for cores (composition 3% Fig. 10. Baked Strength (kN/m^2) for cores (composition 3% Baked at 180^{0}C for varying periods.

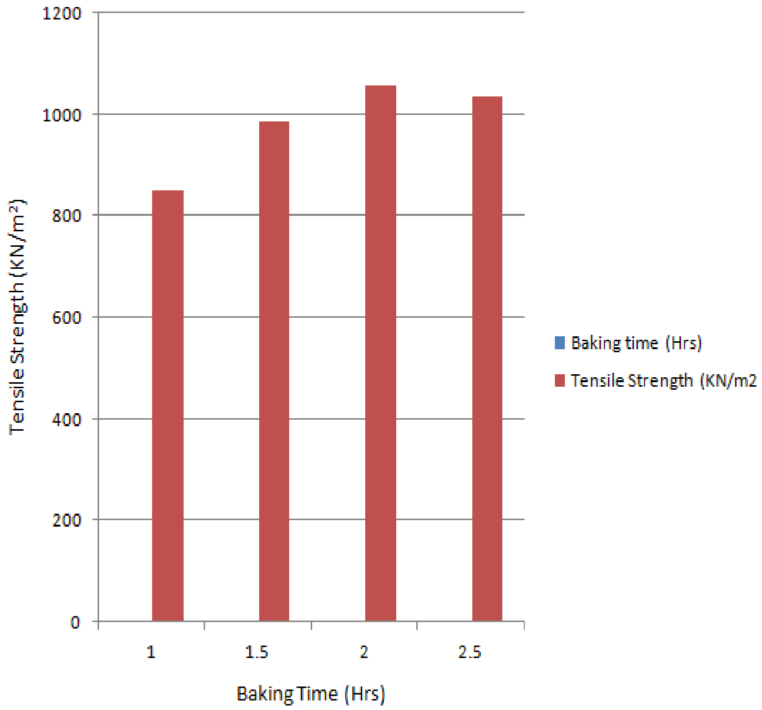

Fig. 11. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 7% Water) Baked at 180^{0}C for varying periods.

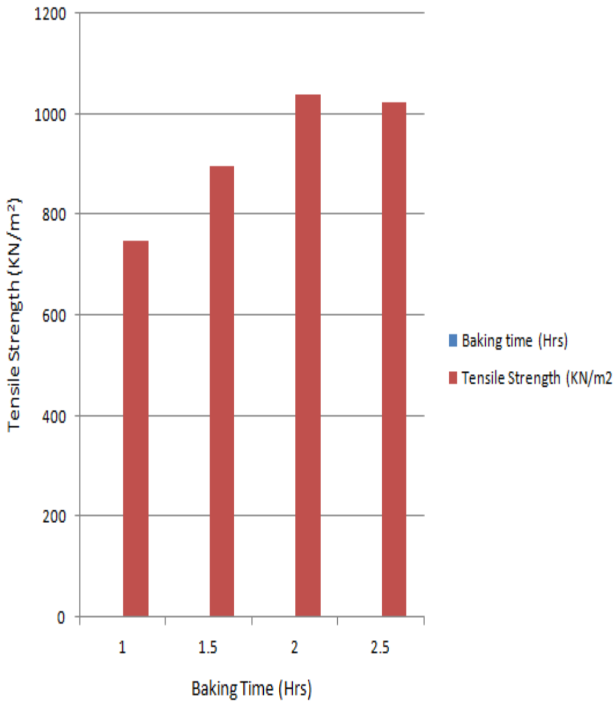

Fig. 12. Baked Strength (kN/m^2) for cores (composition 3% Rubber Seed Oil, 0.5% Cassava Starch, 8% Water) Baked at 180^{0}C for varying periods.

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