

# Influence of Industrial and Agricultural Additives to Clay Mitigates Fuel Consumption on Red Bricks Manufacturing

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**ABSTRACT:** The aim of this study is to manufacture model building green bricks with different cheap solid additives [industrial and agricultural], petro-coke, animal dung, and saw-dust as an internal fuel. Model samples were manufactured, dried smoothly, and then fired through a suitable predetermined firing technique at range of temperature, 750, 800, 850, 900 and 1000°C. The experimental measurement was performed on these samples at Brick and Road Research Institute (BRR) University of Khartoum, Sudan in order to evaluate internal and external fuel consumption in red brick production and mitigation measures of environmental contamination.

The main bricks properties used for assessment are loss-on-ignition, density and crushing strength that related to the lowest specific fuel consumption and cost. Numerous measurements on samples have compared relative to internal and external energy and fuel consumption. The petro-coke sample was found to be the best, with the lowest fuel consumption, higher crushing strength and very good density of clay bricks as well as with the minimum firing cost. The results reveal the firing temperature is significantly affected densities properties of the clay bricks additive material above 900°C, while the crushing strengths and loss-on-ignition are increasing steadily to 1000°C.

**KEYWORDS:** Building brick, drying, heating energy, petro-coke, firing cost, mitigation fuel consumption, Pollution.

## I. INTRODUCTION

Red bricks widespread use in all building construction such as: the apartments, offices, shops and almost houses with lack of other proper material for building. Traditional kilns for brick production are manufactured using conventional firing techniques for lack of knowledge for better process and quality and without safety measured by the fuels type impact on environmental pollution [1]. Brick kilns product solution can be solved using inexpensive, easily obtainable and appropriately designed for the varied environment, low energy cost and reduce the air pollution problems [2]. The conventional source of fuel bricks making are used highly polluted to fire materials that billowing black cloud, heavy smokes and hydrocarbon emission[3]. However, the high cost of air pollution and CO<sub>2</sub> emission and global crisis of environmental contamination, lead to developing the brick industry to reduce the energy combination and decrease aerosol pollution [4]. The waste materials utilized as an air pollution mitigation method is employed to a type of additive as an inner and an external source of energy for red bricks to minimize the emission of pollution in the surrounding area [5].

The clay substance is represented mainly compounds relative to the formula, AL<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, 2H<sub>2</sub>O when heated at 650°C then splits up into separate constituents as silica, alumina and water [6]. This water is known as combined water and considered as a constituent or part of the clay, which is driven off the green bricks as steam. The dry green brick is losses the weight when is heated to the maximum firing temperature 900°C. This loss is termed as loss-on-ignition of clay that variation in quantities for different types of clay content [7]. The carbonate is compounds often found in clay

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as impurities and in certain cases regarded iron, magnesium, and calcium. These are decomposed by heating into metal oxides and carbon dioxide and high temperature the gas evaporated as a black cloud. The iron oxide and magnesium oxide are separated by the temperature in the range of 400–700°C, while calcium oxide is formed in the temperature from 700 to 900°C [7, 8].

Calcium carbonate,  $\text{CaCO}_3$  is the common impurity in building brick clay being present as pieces of limestone. This can cause trouble if carbonate is present in large pieces (1/8 inch) of limestone and at that stage carbon dioxide expands through the burning of bricks cause imperfection. The carbonaceous matter is different in nature of different types of clay present normally of about 7% to 8% that a start burning out varies in temperature from 20°C to 35°C and then up to 450°C [9].

Mechanical water is a technique of adding water to the clay mechanically that bricks during the manufacturing process, which is driven off in the dryer from the wet brick over the temperature range from 10 to 150°C [7]. It is usually determined by weighing green bricks before and after drying, which is differed for all brick types due to the process of manufacturing. Bricks process depends on the duration of firing and the rate of firing that control relative to the mechanical water, combined water and carbonaceous matter is present in the brick [10]. Therefore, the firing is governed by the size of the product and the densely in the setting of the bricks. The firing of bricks is generally during the water smoking period that mechanical water must be slowly driven off from the bricks set in the kiln. Usually a brick set contains about 5% of mechanical water. Still, the water is moved due to pressure increase and exhausted as vapor through the stack (chimney) during the process. The high percent of moisture in the brick is required to slowly firing process to avoid a sudden increase of temperature that can cause cracking of the product [11]. The preheating temperature can be increased at a greater rate once water smoking has been discharged and the temperature is raised to about 650°C. Therefore, the most important reaction takes place at the 650°C while the chemically combined water is driven off from the bricks at this stage of the carbonaceous matter oxidized from the bricks [12].

However, there are certain drawbacks associated with the use of rapid temperature range; vapor steam may persist for around the bricks. This excludes air or oxygen that is needed to complete the oxidizing action, which leads to black cored bricks [13]. The good quality of brick production is required slowly heating for a suitable satisfactory time allows excess air for the oxidation to take place. A soon as all the carbonaceous matter has been burnt the iron oxidized the temperature can be raised rapidly from 650°C to the verification temperature. Verification is usually taken to commence at about 900°C that extended to the highest temperature the brick can withstand without serious distortion [14].

The amount liquid formed depends on the temperature reached, the duration of heat and the amount fluxes, soda, potash, magnesia, lime and ferrous oxide present in clay. The highest rates of burning of the fuel are used in the soaking period to reach the maximum temperature, but once this is obtained at the top part of the kiln a slightly lower rate may be employed [15]. Consequently, in order to hold the maximum temperature not to over-fire the bricks at the top of kiln whilst is increasing the temperature at the bottom of the setting [16]. The kiln is allowed to cool gradually after the fires have been burnt down. Crown cooling holes are gradually opened and then the wickered side doors are also gradually broken down. Slowly and gradually cooling is almost well preferred since it will minimize brick cracking [17].

The additive upon fermentation is improving the plasticity of the bricks material and act as reinforcing fibbers and reducing the cracks. Thus, fibbers ignite is assisting in even firing of the brick and minimizing the development of high temperature gradients within the brick unit. These fibbers are burnt out and they leave cavities within the brick that the resulting being a reduction of the unit weight. The thermal characteristic is an important of the firing and the characteristic of cavities on the top and bottom surfaces of the brick increase the bond when brick is built [17].

Sudan standard for common burnt building brick are deemed necessary so that the water absorption not exceeded 35% and crushing strength in the range of 25 kg/cm<sup>2</sup> and dimension (25×12×7 cm, or 23×11×6 cm) is highly required for quality control. The brick kilns in Sudan are dependence on traditional fuel as a major source of energy, which is an important building material in all the country [18]. This study is aimed to minimize brick cost of firing as much as possible and improved the quality by using the available agricultural and industrial wastes in the Khartoum province. These wastes were very cheap for having a high heating value, which can be utilized as an internal fuel that to be mixed with the green brick unit by a certain percentage [19].

The source of fuel energy for heating new stack of green bricks in a kiln mainly huge quantities such as; wood staves and animal dung (Zibala) and industrial petro-coke without estimation of consuming energy request [20]. In order to

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overcome the bricks production fuel consumption problem an appropriate brick design was used in this work. Soil, clay and river sand is available at free of cost on the Blue Nile bank and inexpensive material used as fuels in addition to reduce environmental pollution in site residential area[21].

## II. MATERIALS AND METHODS

Sometimes an image may contain text embedded on to it. Detecting and recognizing these characters can be very The experiments were carried out on different samples in order to compare between bricks properties such as loss-on ignition, density, and crushing strength in the Building and Road Research Institute (BRRI), University of Khartoum, Sudan. The scope of this experiment is investigated step of improving the red bricks quality such as clay mixing, brick manufacturing process, brick drying process and brick firing process. The basic raw material free cost to be found in the Blue Nile clay deposits is mixed with water being added to yield a homogeneous mix to achieve about 17 degree of plasticity index to suit the vertical shaft brick kiln (VSBK) operation condition [22, 23]. Thus, the experiment was using mixed waste materials with three types diversifying raw materials with different properties to achieve low cost and good quality in addition to pollution reduction [24]. Corresponding additives petro-coke, animal dung (Zibala), and saw-dust wood were about ten percent (10%) by weight for each sample added to the raw material and left for a period of a week or more for fermentation. The brick modeling, machine was used to manufacture twenty pieces brick unit for each type studying for investigation. The green bricks dry method and firing process were subjected to predetermined firing temperature controlling method to eliminate variation in brick quality implanted by burning parameters such as: firing rate, maximum burning temperature, soaking time at the maximum temperature, and cooling rate [25].

Different operations of manufacture have been developed to accommodate the different raw materials; e.g. Hand-making, wire-cut, stiff-plastic, dry or semi-dry and soft mud process. A large variety of clay is used for making building bricks for comparisons between the three groups. These clays differ in composition and behavior when fired, variations also occur in the same type of clay and with the same clay sample hole at different parts of the hole or clay face. Thus, although there are certain characteristic similar for all clay, which other causes are differed in performance during firing and make it necessary to adjust the firing schedule to suit them [26].

## III. EXPERIMENTAL RESULTS

The green bricks were dried smoothly and then laid in a furnace and burned through a predetermined firing process to satisfy firing condition gradually heated up to 750, 800, 850, 900 and 1000°C. The samples of different types of the additives petro-coke, animal dung (Zibala), and saw-dust mixed by ten percent by weight had been invented by a modeling brick making machine. Comparisons between the three groups were built using many parameters for the characteristic assessment. The red bricks quality parameters have been determined experimentally by compared the effect of the additive firing temperature and dry brick weight losses. The data in figure 1 shows the loss-on-ignition is increased with respect to the temperature rising. The Fig.2 shows the highest crushing strength that brick will stand before failure was found in petro-coke sample, then followed by Zibala and then saw-dust that exhibit gradually linear relation versus temperature. Fig.3 is displayed the average values of the density test of the bricks of four samples of clay mixed with additive. Table1 shows the temperature variation and moisture contents of bricks that are processed similarly to obtain a proper characteristic for comparison relatives to internal and external fuels used.

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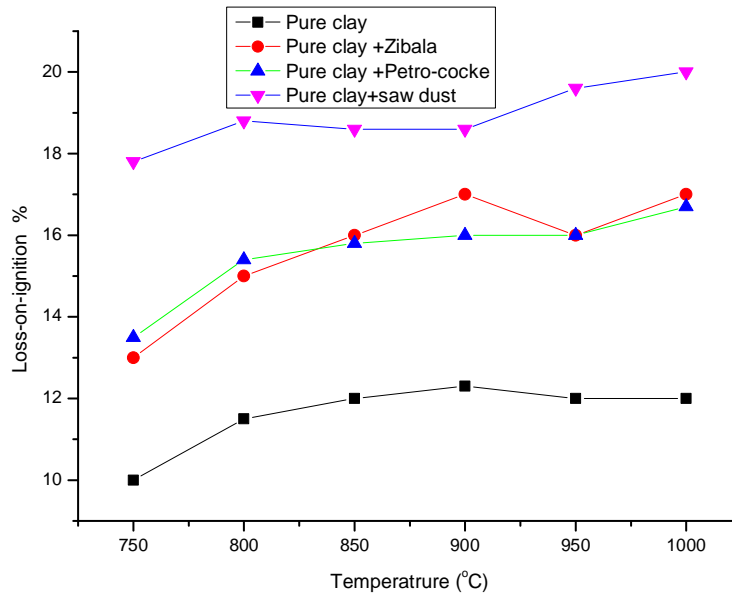


Fig.1. The average values of the loss-on-ignition bricks versus temperatures. The data show the high value of loss-on-ignition is indicated by pure clay and petro-coke and Zibala shows identical values at the medial position while saw dust shows the lowest data.

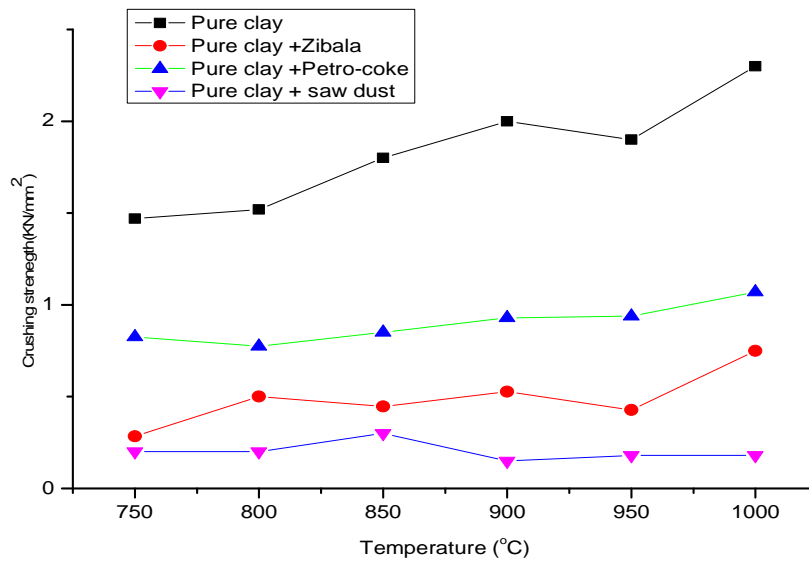


Fig.2 the average values of the crushing strength test of the bricks versus temperature variation. The measurement of crushing strength shows higher values for pure clay and steady data indicated by petro-coke and then flowed by Zibala and saw dust.

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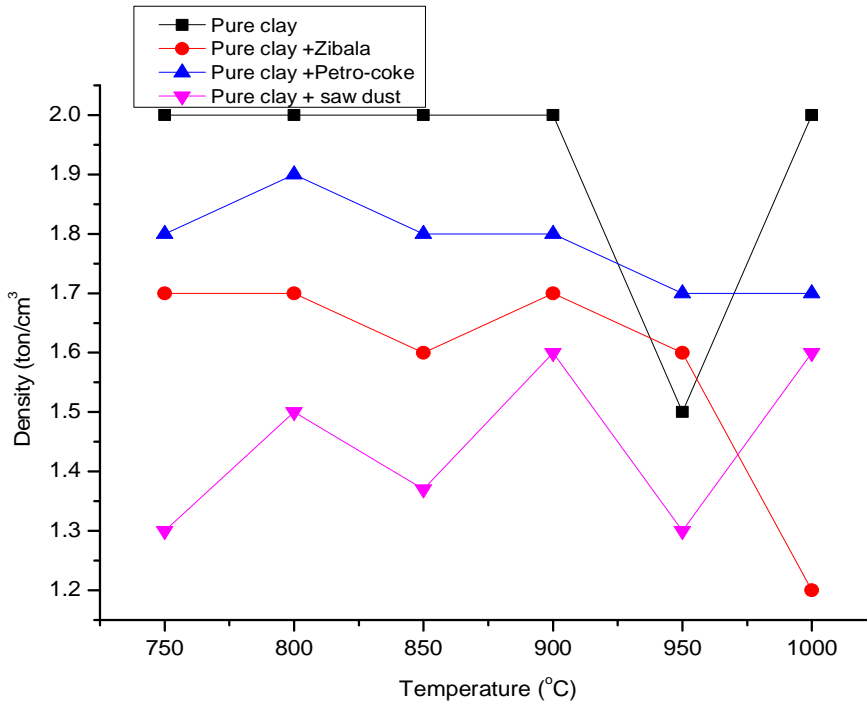


Fig.3 the average values of the density test of the bricks against temperature. The result in the graph is displaying the density of pure clay bricks indicates constant value from 750 to 900 decreases at 950°C and then petro-coke appears high density test with small variation up to 1000°C. The Zibala is indicating average data with steady measurement up to 950°C and the saw dust show instable data with temperature increasing.

Table1. Data of clay mixed with additive properties measurement. Three mixed clay bricks petro-coke, Zibala and saw dust is assessed at three different temperature measurements 850, 900 and 950°C. The first column indicates the fuel consumption at 850 and 900°C the petro-coke indicates lowest values and flowed by saw dust brick. Lower internal and external fuels are consumed by petro-coke and then Zibala bricks. The high moisture content of the mixed additives is measured in saw dust bricks and second value by petro-coke.

Pure clay+(10%) Additives	Specific fuel Consumption(S.F.C) (KJ/Kg of fired brick)	Internal fuel (Ton)	External fuel (Ton)	Moisture content %	Temperature (° C)
Pure clay +petro-coke	835.4	0.6	5.4	23	850
Pure clay +Zibala	842.2	1.2	11.2	18.8	
Pure clay +sawdust	864	1.4	13	36	
Pure clay +petro- coke	587	0.655	5	23	900
Pure clay +Zibala	891	1.3	12	18.8	
Pure clay +sawdust	848	1.4	12.9	36	
Pure clay +petro-coke	586	0.66	5.94	23	950
Pure clay +Zibala	585.3	1.6	14.4	18.8	
Pure clay +sawdust	488.7	1.78	16.02	36	

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## IV. DISCUSSION

The graph in fig.1 is the highest displayed as pure clay, petro-coke, Zibala and finally the saw-dust samples. The highest present of loss is indicated at saw-dust sample, followed by Zibala, petro-coke and then finally pure-clay sample. The density test in the graph shows the optimum firing temperature of the sample is 900°C. The results of the various samples had been approximated appear linearly relative to the temperature. Specific fuel consumption that relative to bricks properties were assessed on loss-on-ignition, density and crushing strength in the temperature of 850°C, 900°C, and 950°C on fuel consumed. However, the evaluation of the result was measured relative to the fuel consumption equivalent to 100.000 units of bricks and 6 tons of total fuel for external and internal fuel used in the techniques of all types under the study. The method indicates a significant reduction in exhaust and toxic emission by using internal fuel in the combustion process, which decreases energy consumption in bricks firing process.

## V. CONCLUSION

During this investigation, the aim was to assess energy and expenditure of firing bricks and industrial kilns and adapt different additives. Cheap wastes of agriculture and industry had been used as an internal fuel, that due to the high heating value gained and to overcome the pollution problem. This work was undertaken to design ten percent by weight had been mixed with unit green brick and evaluate bricks manufacture four samples relative to internal and external fuels utilized. The study was designed to determine the effect of a predetermined firing in the temperature range 750, 800, 850, 900 to 1000°C of fuels and energy to satisfy firing manufacturing process. The following conclusions can be drawn from the present study a comparison of brick properties such as loss-on-ignition, density, and crushing strength. The contribution of this study has been to confirm the petro-coke was found to be the best type, having the lowest specific fuel consumption then followed by Zibala and finally the saw-dust.

This study has shown that petro-coke as a fuel is cheap and reduces the firing cost of bricks to 40% in comparison with liquid oil furnace fuel. This research provides a framework for the exploration of energy produced from wastes that can be implanted in various applications and moreover reduced environmental contamination and using internal fuels may decrease pollution contamination. Consequently, additive types were employed as a source of energy material in tandem with climate change mitigation initiatives among the solution strategies.

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