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Development of gas fired boiler for preservative treatment of sympodial bamboo species in Ghana

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Abstract: A high temperature preservative treatment boiler for sympodial bamboos in Ghana was designed and built with locally available raw materials, locally composed low density bricks, mortar and gas burners. This is a solution to improve the preservation methods adopted by local craftsmen, industry and some research institutions working with bamboo. Fire box of the boiler enhancing utmost heat maintenance is available in keeping boiler temperature high for leaching out of starch and effective penetration of chemical preservatives.

Key words: Bamboo, heat retention, preservation, low density bricks.

INTRODUCTION

Bamboo has a long and well established tradition as a building and construction material in Ghana. Bamboo is widely used in many forms of construction like housing, furnishing, joinery and paneling. An important factor, which limits the use of bamboo, is its durability, since it is subject to attack by fungi and insects and reducing the expected life of the bamboo to less than five years. The Department of Integrated Rural Art and Industry, Kwame Nkrumah University of Science and Technology (KNUST), teaches students to carry out works of art in bamboo; however, the Department lacks the facilities for preservative treatment of bamboo. The preservative treatment facilities used by some industries to improve the life expectancy of bamboo are not environmentally friendly, because of the use of wood fuel (Ubidia, 2002). It poses health hazards to users and is deficient in use of energy consumption, as much of the energy input is lost into the atmosphere. An attempt has been made to devise a facility for giving preservative treatment to bamboo that operates with little or no health hazards, efficient in the use of energy and fueled by liquefied petroleum gas.

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MATERIALS AND METHODS

The method adopted for the construction of the preservative treatment boiler is basic. The boiler is a metal container shaped in a convenient way to take bamboo of specific lengths. Underneath the trough is the fire box, a chamber for housing heat for heating of the trough (Fig. 1).

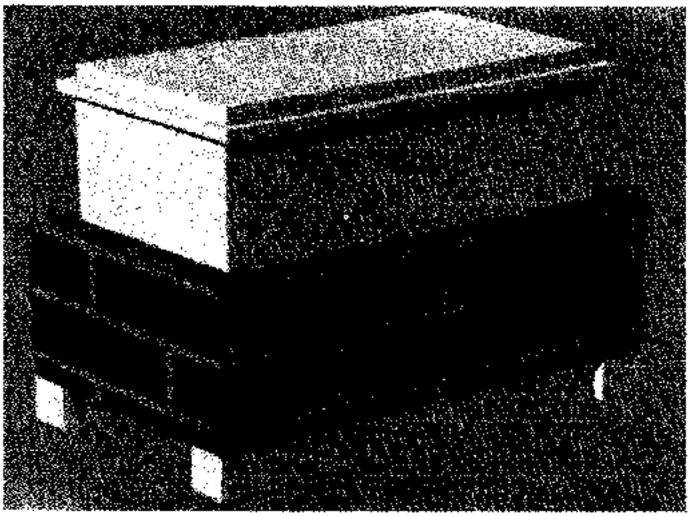

Figure 1. A schematic diagram of the boiler

Fabrication of the rectangular open trough by electric arc welding is easy such that any one will be able to fabricate without much difficulty. Effort was made to meet the objective of using a minimum amount of energy as well as to reduce loss of energy through evaporation. The trough was covered with a lid to prevent the escape of steam and gas while boiling goes on and a rubber gasket was introduced between the lid and the rim of the trough. To avoid pollution of the environment and also to avoid operators of the boiler from inhaling vapors that could be toxic, a steam escape pipe was provided on the lid of the boiler, from which the steam from the boiler is taped and condensed into the trough. A fire box was designed to have high heat retention property. For this, low density bricks were composed from local earthenware clay and sawdust. This type of fire box is most suitable for housing heat for kilns and has been used in areas where heat retention is required. (Kwawukume, 1999; Rhodes, 1968).

Composing low density bricks

There are other ways of producing low density bricks or insulating bricks apart from the type made from refractory fireclays and kaolin. The clay is mixed into a heavy slip and air bubbles are introduced by chemical means. When the material is set and dried, it is fired and later cut and shaped into sized bricks. Insulating bricks are designed

Table 1. Properties of low density bricks

True porosity (%)	40.0
Density (g/cm³)	0.889
Crushing strength (kg/cm²)	60
Maximum service temp (°C)	1100
Average mass of each brick (g)	500
Size of brick(cm)	5.0 x 7.5 x 15.0

specially for greater heat retention and they are of low density, porous, with poor thermal conductivity. large number of air cells in the material and form an effective heat barrier (Rhodes, 1968).

For making low density bricks for the construction of the fire box, experiments were conducted using Nfensi clay, sawdust, water and sodium silicate (deflocculant). The clay formed the main body component in the composition, the sawdust the second component which was a combustible material and eventually burnt off during firing to create the multitude of air cells required for retention of heat. The sodium silicate deflocculated the entire composition, reducing the quantity of water and plasticity required for binding and reducing the time for drying.

It was observed that, after firing the bricks, they became very light in weight as compared to their green-ware. The tensile and compressive strengths of the fired bricks were reduced, likewise the density. The high porosity in the bricks produced was an evidence of the presence of entrapped air pockets which made porous bricks an effective heat barrier with an excellent property of heat resistance. Properties of low density bricks are given in Table 1.

The mortar for laying of the bricks was composed locally from raw materials, such as local plastic clay (30 kg) as suggested by Rhodes (1968).

The fire box

The construction of the fire box started with the laying of the foundation in the metal frame constructed for it (Fig. 2). The base tray of the frame was lined with the low density bricks and gaps in between the bricks were filled with mortar followed by laying of the walls of the fire box. Local mortar was used to create level ground on which the bricks were laid. The exhaust holes and burner holes were provided during the construction of the walls of the fire box (Fig. 3).

After construction, a well deflocculated white slip was used to paint the inner part of the box (Fig. 4) which secured the wall surface from thermal pressure by aiding reflection in the box. After the construction, the box was allowed to set for three days and after that the boiler trough was mounted on the fire box for testing (Fig. 5).

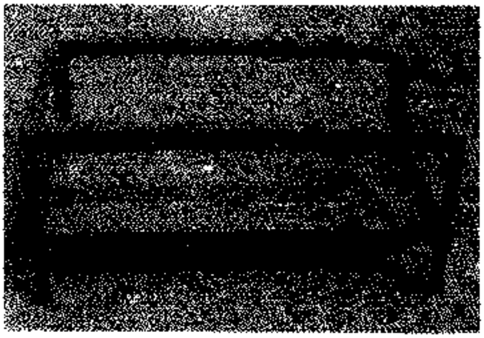

Figure 2. Frame of fire box of boiler

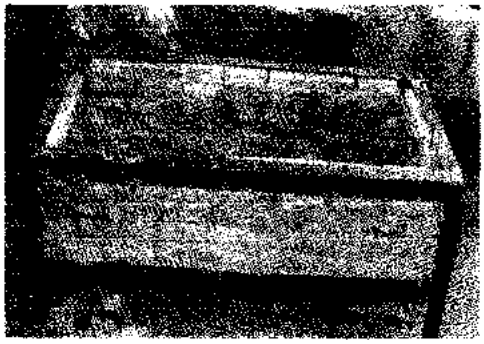

Figure 3. Construction of fire box

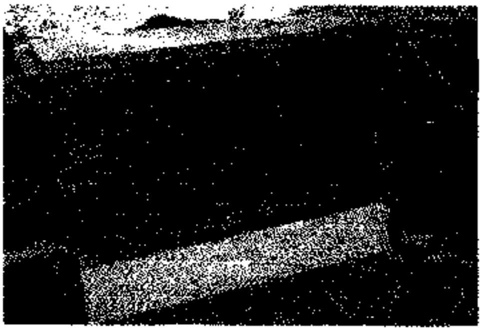

Figure 4. The fibre box with the rim lined with heat resistant ceramic fibre

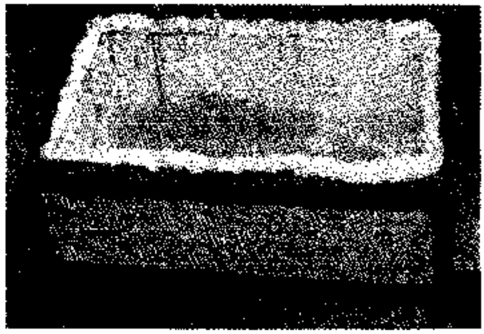

Figure 5. The gas fired boiler

Operating the boiler

The boiler operates mainly on liquid petroleum gas (LPG). The gas burner was placed at the burner hole of the fire box to heat up the boiler bringing its content (bamboo in preservatives) to boiling point. The boiler was designed in a way that allows its exhaust gases from the fire box to be used to accelerate drying of previously boiled bamboo or to bring already dry bamboo to baking point for effective diffusion in the diffusion trough. After the exhaust heat has been used for accelerating drying, it is redirected through the outlet to warm up gas cylinders used for firing the boiler; this is done to prevent the gas from freezing. The toxic gases from the boiler are channeled through a rubber tube and condensed into the trough.

Bamboo preservation

Preservation in the boiler started with primary preparation and processing of the freshly harvested bamboo. The culms were crosscut to the required length and the hard silica saturated epidermis was scraped off. Culms were further processed into splits and slivers. The inner lining of the splits, the lumen, was removed with a sharp knife and back planed to run parallel to the inner side. A long pointed 20 mm diameter iron rod was used to break through the nodes of the culm to make way for the liquid preservatives to run through. The prepared and processed culms, splits and slivers were tied up in bundles and placed into the boiler trough. Water was added to the bamboo just enough to cover it and the corresponding quantity of preservative (Dursban 4E) was also added. A galvanized metal mesh was placed on and a supporting weight to keep the processed bamboo submerged. The lid was firmly fixed to the trough, sandwiched by a rubber gasket and the gas burner was lit and directed into the burner hole.

Two hours of continuous boiling in preservative solution was given. Measures were taken to keep the bamboo submerged to ensure total preservation of the bamboo. The bamboo in the boiler was hooked out and the boiler was reloaded. This allowed draining of the excess preservatives. After draining, the bamboo was stacked for drying. Three chemical preservatives were used: Dursban 4E (2% a.i.), Pyrinex 48EC (2% a.i.) and Neemazal 0.3EC (0.3%, a.i.). The active ingredient in Dursban 4E and Pyrinex 48EC is chlorpyrifos; 20 ml of Dursban or Pyrinex was mixed with one liter of water for both boiling and diffusion. The Neemazal is a Neem extract based insecticide containing 0.3 per cent Azadirachtin; 20 ml of Neemazal was mixed with 1 liter of water for preserving bamboo by boiling or diffusion. About 50 liters preservative solution was used for the boiling.

Exposure to termites

Samples of all the three different preservatives treated bamboo and split bamboo, untreated bamboo, and selected artifacts made from bamboo preserved at the boiler were exposed to termites for four weeks. The third and fourth days of this observation period were met with the rain, after which the sample pieces were found covered with mud three days after the rain. The artifacts were not fully covered; the mud had covered only part of the piece by the seventh day. Presence of mud around the samples was evidence of the presence of termites on the pieces. The undisturbed termite mounds built up for seven to eight days. There was evidence of continuous movement of termites to and from one piece to another. After the third week, it was observed that parts of the mounds created around the pieces had given way, making visible several path ways of the termites as they move to and from different directions.

RESULTS AND DISCUSSION

Samples of untreated bamboos were found totally infested and eaten up by the termites. Untreated *Bambusa vulgaris* var. *vitata* samples were found severely attacked, and there was nothing left for observation and description. Untreated samples of *B. bambos* and *B. vulgaris* were also found infested. In *B. bambos* the entire lumen of the sample was eaten up leaving only parts and pieces of the bambos sample. The samples that were preserved and split were also taken out, cleared of mud for close observation. *B.*

Figure 6. Preserved bamboo after one month exposure to termites

bambos and *B. vulgaris* samples were not affected, but part of *B.vugaris* var. *vitata* exposed as a result of splitting of the material was found eaten up by termites. The other set of samples were also removed, cleared of the mud and examined for infestation by termites. Although the termites have built mounds around the test samples, there was no evidence of any part of the samples infested or eaten up (Fig. 6). The bamboo that was also partially covered with the termite mounds was not affected by the termites.

Considering the tests conducted so far and the active ingredients in the preservative, it was observed that Neemazal, a biological preservative, was more suitable for the preservation of domestic products such as ladles, chopping boards, fruit trays and articles serve as container for edibles. Preservatives that contain toxic chemicals as the active ingredient like chlorpyrifos must be used for the preservation of non- domestic items like table legs, door frames, window frames and constructional material produced. From the test results, it was evident that *B. bambos* is more resistant to pest and fungal attack than *B. vulgaris* and *B. vulgaris* var. *vitata*. Thus, *B. bambos* is more suitable for constructional purpose. *B. vulgaris* is suitable for domestic products and *B. vulgaris* var. *vitata* for products which will be subjected to heat, like ladles and chopping boards. Another observation was that, apart from lamination of split bamboo into boards, whole culm products should be made to completion, preserved and finished, to avoid cutting after preservation which can expose unpreserved parts of the material in use. When laminating bamboo into boards, heavy planing after clamping should be avoided, because that can also expose unpreserved areas of the material. In view of this, splits must be planed to corresponding sizes, glued with adhesive impregnated with the right preservative and clamped. Smooth planing at this point will not do any harm if the planed surface is retouched with preservatives. Avoiding cutting, planing or sanding after preservation also provides protection against inhaling of toxic dust that is formed as a result of cutting, sanding and planing of preserved bamboo.

CONCLUSION

Preservation of the different bamboo species by boiling was done in the boiler comprising the boiling trough and the fire box. The time taken for the bamboo to be brought to boiling point was depended on the quantity of bamboo and the level of the preservative in the boiler. The fire box was able to house the flame produced by gas burner and very little heat was lost. This was evident in the frequent touching of the bricks by finger and the number of times one cylinder of 13 kg of liquid petroleum gas was able to fire the boiler. This is a confirmation that the quality of local low density bricks composed and manufactured for the construction of the fire box was very good, and because of the quality of bricks, the energy input of the plant is effectively utilized. The ceramic fiber which lined the edge of the fire box prevented any loss of heat that would have taken place in between the fire box and the boiler trough. It was also revealed that the tube directing vapor from the boiler to condense into the trough worked as expected and there was no leakage. When boiling the split bamboo, it became obvious that when the strips or splits are tied up in bundles, it is easy to load and unload from the boiler. In the case of whole culm, scraping off the culm epidermis and breaking through the nodes are required to ensure improved capillary activity for the displacement of the sugar, starch and other ingredients in the bamboo and also effective penetration of chemical preservatives.

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