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Dirai Sulfur Fumigation Facility for Small-Scale Rattan Craftsmen in Ghana

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Abstract
For Ghana to be competitive in the global rattan handicraft industry, it is a sine qua non to ensure that the aesthetic quality, structural strength and durability of the products are in the top notch. Descriptive survey studies have, however, shown that about 85 % of small-scale manufactures in the rattan industry in Ghana do not fumigate rattan stems against biodegradation because they cannot afford standard large scale fumigation facilities. The objective of this research material is to design and construct an appropriate effective and efficient sulfur fumigation facility as a solution to the poor fumigation methods adopted by small-scale local craftsmen, and some research institutions that use rattan stems as raw material in Ghana. A high fuming preservative and sulfur treatment facility was designed and built with locally obtainable materials - mild steel plate, locally composed high density insulating bricks, metal mesh, compressed fiber gasket and locally manufactured regulated gas burners rated at 160, 000 joules. Twenty-four hour sulfur fumigation of rattan stems from the innovative facility showed remarkable vivid chromatic change and invulnerability to pests, borers or fungi.
Keywords: Rattan, sulfur, fumes, preservation, biodegradation

1. Introduction

The Republic of Ghana is located in West Africa and has a population of about 25 million people. Ghana is rich in many natural resources including an enormous biodiversity. Many prudent economic interventions have contributed immensely to a study growth in Gross Domestic Product (GDP) which now stands at approximately 39.2 million dollars . One of such interventions is the African Growth and Opportunity Act (AGOA) promulgated to enhance trade and development between the United States and Ghana. AGOA accords specific traders, which include rattan craftsmen, in Ghana the opportunity to produce and export quality rattan products to the US as additional market outside Europe and the West African sub-region. The promulgation of AGOA has caused unprecedented increase in rattan product manufacturers in Ghana. Nevertheless, preliminary descriptive survey studies have shown that about 85% of small-scale rattan product manufacturers do not adhere to the standard fumigation requirements for cane and rattan articles. The varied reasons include lack of education (in view of the fact that majority of them are school dropouts), the use of unacceptable fumigants or insecticides and low purchasing power to afford large-scale fumigation facilities.

The survey also showed that the enormous natural resources of Ghana, which now include oil, made government lost focus on non-timber forest products like rattan. All things being equal, there should be clear government policies on rattan handicrafts industry in Ghana to compete with Malaysian and Indonesian rattan industries in the global market. Ironically, the Department of Integrated Rural Art and Industry (DIRAI) and the School of Creative Arts of the two accredited tertiary institutions in Ghana, Kwame Nkrumah University of Science and Technology, Kumasi (KNUST) and University of Education, Winneba, respectively, teach students to produce works of art in rattan. The two universities lack rattan fumigation apparatus. Furthermore, the rattan fumigation facilities used by some local industries and craftsmen to improve the life expectancy of rattan are not environmentally friendly; they pose health hazards to craftsmen and users!

The objective of this research project, consequently, is to investigate, design and construct an appropriate fumigation facility for small-scale rattan craftsmen to enhance the quality of their products for domestic consumption and the export market. The facility, which is fueled by liquefied petroleum gas, is environmentally friendly and operates with little or no health hazards.

2. Materials and Methods

Laccosperma opacum and laccosperma secundiflora are the commonest rattan species in Ghana used for manufacturing cane furniture and a wide range of handicraft products like hamper baskets, normal baskets, serving trays, babies-cots and other products. Rattan has very high aesthetic value when combined with metal, wood or glass. However, rattan is biodegradable and must necessarily be subjected through primary treatment of fumigation before the secondary processing stage.

Baur (2011) explained that fumigation is a method of pest control that completely fills an area with gaseous pesticides or fumigants to suffocate or poison pests within structures or any permeable matter. He further explained that, it is utilized for the control of pests in buildings, soil, grain, and produce, and is also used during processing of goods to be imported or exported to prevent transfer of exotic organisms. The method destroys pests such as woodborers and dry wood termites that inhabit the physical structure or permeable matter Baur (2011) affirmed. Ranjan *et al* (1986) observed that fumigation is done in several cultures adopting traditional technologies. Ranjan and his team noticed that, the artisans of the Khiamngan Naga tribe of north-eastern India often subject their finished handicraft products of bamboo and rattan to prolonged smoking over a fireplace. In Ghana, small-scale rattan craftsmen employ similar inefficient technologies with associated problems such as uncontrolled smoking that results into uneven smoking, lost of true chromatic properties and awkwardly prolonged smoking time frame. Other hazardous treatments include the use of deadly chemicals like dichlorodiphenyltrichloroethane (DDT

The concept of the DIRAI sulfur fumigation facility is based on the unique control technique of generating a high lethal concentration of sulfur fume in a vertical hermetic rectangular metal chamber over a specific exposure period and at an ideal temperature that could kill any living organism in the rattan stem. The facility, which has a unique design based on identified locally available materials, has three basic components and measures 170 cm in height, 45 cm each in width and breadth. The three components are the conflagration pot, fumigation chamber (with built-in temperature/pressure unit) and a basin of water for the solubilization of residual sulfur fume. The diagrammatic presentation of the complete facility, which is user friendly, is shown in Fig. 1.

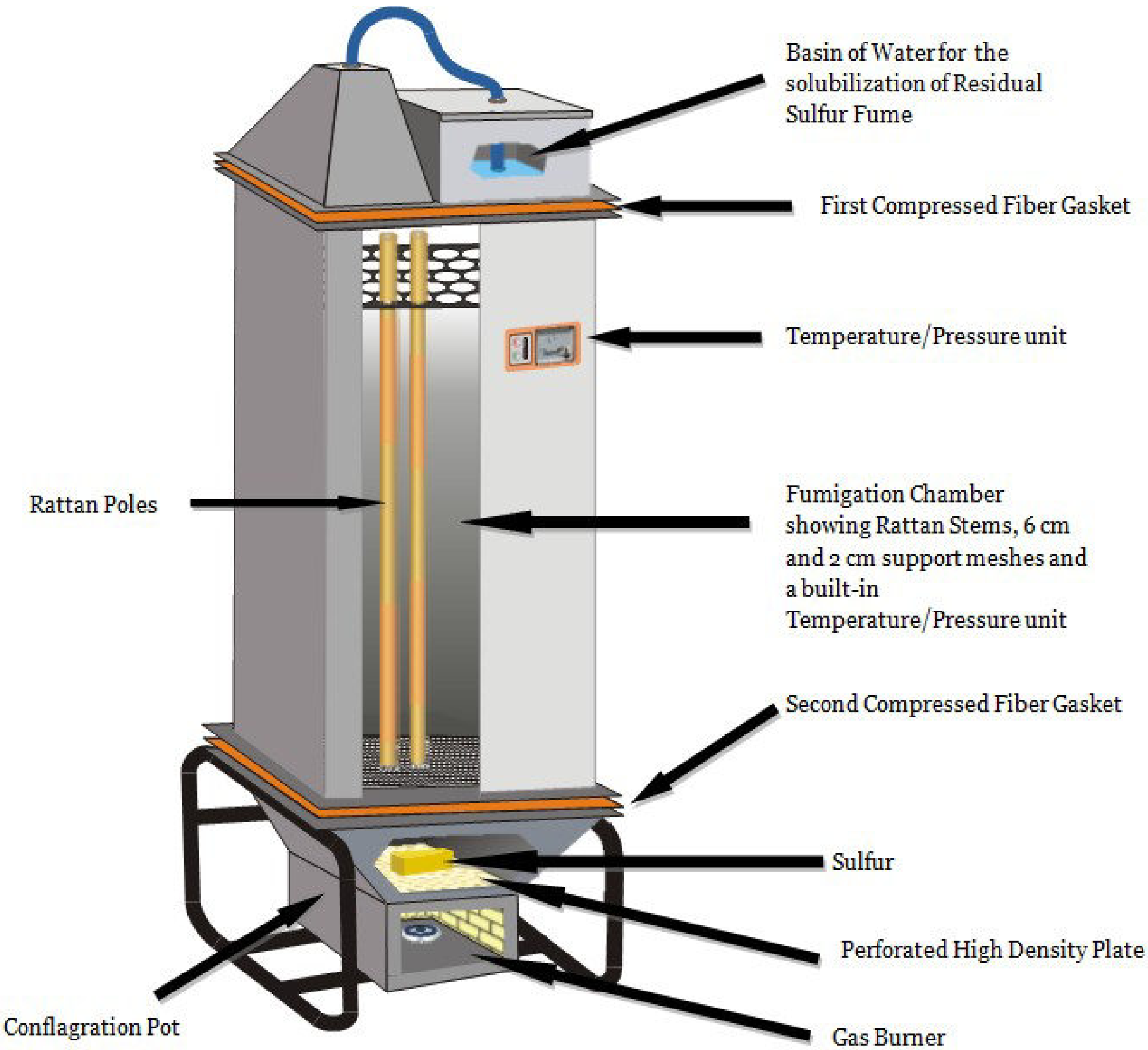

Figure **1.** DIRAI Fumigation Facility for Small-Scale Rattan Craftsmen.

2.1 The Conflagration Pot

The conflagration pot or component as shown in Fig. 1 derives from the Ghanaian traditional charcoal pot, which has two segments – the upper funnel-shape trapezoidal segment welded to a rectangular base. For stability and durability, a 5 mm mild steel plate for the fabrication of the conflagration pot is used. The conflagration pot has two important functions. Firstly, it has a perforated ceramic plate of very high density positioned at the joint of the trapezoid and the rectangular base. In principle, the 2 cm thick perforated ceramic plate serves as support for the sulfur fumigant. Secondly, the rectangular base lined with especially composed insulation bricks with heat retention properties, serves as the main conflagration chamber for the Liquefied Petroleum Gas (LPG) burner.

To arrive at a suitable body composition for the insulating bricks, several experiments were conducted with local clay (*Nfensi* clay) as the base material. Steiner *et al* (2010). The other materials include sawdust, water and sodium silicate a deflocculant.

2.2 Composing insulating bricks.

There are several ways of producing insulating bricks separately from the type made from refractory fireclays and kaolin. 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. According to Rhodes (1968) insulating bricks are also available from recent developments, coming into use during the 1930s. Rhodes explained that, insulating bricks are designed specially for greater heat retention and that they are of low density, porous, and has poor thermal conductivity and that the multitude of air cells in the material forms an effective heat barrier.

The researchers therefore considered the creation of multitude air cells in the bricks for the insulation of the conflagration pot of the fumigation tube as necessary physical properties required for the retention of heat in the conflagration box.

To arrive at a suitable body composition for the manufacture of insulating bricks for the construction of the conflagration pot, Steiner et al (2010) suggested that several experiments should be conducted with local clay to arrive at the suitable composition for the clay body.

The materials that were used for the experiments were Nfensi clay, sawdust, water and sodium silicate (deflocculant). In this it was expected that, the clay would form 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 of 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 was reduced, likewise the density. The high porosity in the bricks produced in was an evidence of the presence of entrapped multitude of air pockets which makes light, porous bricks an effective heat barrier and an excellent property of heat resistance, was shown in the high percentage of water drawn into the brick when subjected to moisture absorption test.

Table 1. Properties of insulating bricks.

True porosity, %	39.0
Density in g/cm3	0.899
Crushing strength in kg/sq cm.	60
Maximum service temp. in Celsius	1100
Average mass of each brick in grams.	250
Size of brick. in cm	2.5 x 7.5 x 15.0

The mortar for the laying of the bricks was composed locally from raw resources accessible to the researchers such as local plastic clay as suggested by Rhodes (1968)

2.3 Composing the high density perforated plate.

There are clays that are naturally high density and require enormous amount of energy to bring them to a point of vitrification. On the other hand some require the introduction of a second or third material to attain the property requirements necessary. Such situations require the formulation of ceramic bodies like the composition of the insulating body for heat retention. In this particular situation the material to be formulated require that after firing, the body should dense, impervious, and should have an appreciable level of strength. Korankye et al (2008) define a clay body as a mixture of clays and other earthy mineral substances which are blended to achieve a specific ceramic purpose. For this study a mixture of local kaolin, ball clay, feldspar and builders sand was formulated in accordance with suggestion made Kwakwume (1999) to achieve the purpose of the study and this was fired to 1200ºC.

2.4 Suggested recipe

- Ball clay – 50 %
- Kaolin- 30 %
- Builders sand- 10 %
- Feldspar 10

This composition was used to produce all the perforated plates used in the conflagration box of the Fumigation tube.

2.5 The Fumigation Chamber

The fumigation chamber was designed and produced in 3mm mild steel. It is a square tub designed to sit on the conflagration pot. At the top of the tube is fitted a galvanized mesh of size 50 mm x 50mm which separates the individual rattan poles in the tube during fumigation. This ensures even distribution of generated sulfur fumes in the chamber. A cap which receives exhaust fumigants at the top of the fumigation chamber redirects the fumigants through the escape pipe fitted at the top of the cap covering the fumigation chamber into the solubilization basin.

2.6 Solubilization Unit

This is a rectangular metal basin, designed and fabricated to fit the top of the facility as shown in fig 1. This basin which is 75% filled with water, is for the solubilization of residual sulfur fumes. This done to prevent the pollution of the environment with sulfur fumes.

2.7 Fumigation of rattan in the chamber

Kwabena Adu Baah (2011)(personal communication) acknowledged that since there is lack of poisonous constituents in most rattans, rattan forms a ready food source for a range of organisms. He explained that considerable quantity of starch and other soluble sugars in rattan makes it more attractive to destructive pests. He claimed that soluble sugars in the rattan form the principal nutrients of the degrading organisms and that if these can be removed or reduced from the rattan, the risk of decay will be drastically reduced. Dhamodaran and Bhat (1995) reported that fumigation is done by exposing rattans to fumes from burning sulphur. They agued that no standard practices that without adversely affecting the utilization value were arrived at from systematic scientific studies. The use of sulfur fumes was one option that was encouraged by writers and interviewees for the study.

Preparatory process for fumigation of selected rattans started with primary processing of the freshly harvested rattan by deglazing. The rattans were crosscut to the required length that will fit the chamber, they were twisted in the hand and sand from the beach was put in to a sack cloth and was used as abrasive to clean the rattan. This was done immediately after harvesting. The rattan pieces were washed in water and were dried under shade. Zeick (1976) explained that this primary processing is aimed at removing the inner epidermis of the leaf sheaths adhering to the stem and the silicified epidermis. In all these, big rattans with diameters above 40 mm are the ones washed and prepared for Fumigation, green rattans according to Arpit (2011)(personal communication) are not recommended due to the possibility of acid formation and subsequent chemical reactions resulting in chemical degradation of the rattan stem.

The processed rattans which were 130 cm were put into the fumigation chamber and arranged to stand erect in the chamber. The individual poles were separated by the 50mm x50mm galvanized mesh at the top of the fumigation chamber. The chamber was mounted on the conflagration pot in which was placed 60 grams of sulfur flakes. The cap for the tube was finally mounted on the fumigation chamber and the escape pipe fixed to direct exhaust fumes into the solubilization unit to reduce pollution of the environment. The locally produced gas burner was lit and directed into the conflagration pot to burn the sulfur to produce fumes for the fumigation of rattan. In this the gas burner was not used at full blast, but rather was set and regulated to produce flames that will support combustion of the sulfur and eventual production of sulfur fumes for fumigation.

In this facility, adequate fumes was generated and accumulated in the fumigation chamber and was use over time. The gas escape pipe was also regulated to hold back fumes generated by clipping the pipe that directs the fumes from the chamber into the solubilization unit to avoid pollution of the environment. With intermittent release of exhaust sulfur fumes to allow chamber to receive fresh sulfur fumes, the entire process took 24 hours of rattan fumigation.

3. Results and Discussions

There was an improvement in colour of the fumigated rattan pieces compared to the unfumigated ones. This was a confirmation of the statement made by Gnanaharan et al (2007). Four samples of fumigated or sulfur treated rattan and four untreated rattan, were exposed to borers for four weeks. There was evidence of post borer powder found around the untreated rattan pieces with perforations indicating that the untreated rattan has been infested by the borers. On the contrary the other four pieces which were fumigated did not show any sign or indications of the presence of borers or pest of any kind. Accidental occurrence that was worth noting was colour

variation on two short rattan pieces that dropped to the floor of the fumigation chamber forming a cross, had their contact point without any improvement in colour. It was clear that, that part was not treated.
Another test result that was of interest to researchers was that a smaller diameter rattan of about 10 mm was not infested although that piece was not treated or fumigated. This researcher's believed was because that particular rattan has not matured to store sugar, the principal food of degrading agents. This most probable confirms the statement made by K.A.Baah,(2011) Kwame Nkrumah University of Science and Technology in an interview that, the sugar content of large diameter rattans which is part of the principal food for degrading agents is very high and this makes the material's natural resistance to pest and fungi very low.
This study has led to the believe that sulfur treatment of large rattans apart from improving rattan colour quality, injects or impregnates the pores of the rattan with sulfur fumes killing the possible degrading agent inhabiting it and rendering the rattan unattractive to pest.

4. Conclusion

The fumigation of the two different rattan species was done in the fumigation tube, comprising conflagration pot, Fumigation chamber and the solubilization unit. For the number of times the fumigation tube has been fired, the time taken for the rattans to be brought to treatment point was 24 hours. The conflagration pot was able to house the flame produced by gas burner and very little heat was lost. It was also observed that the tube directing exhaust fumes from the fumigation chamber to condense into the solubilization unit worked as expected and there were no leakages. In this fumigation process it became obvious, that when the rattan stand erect in the chamber, the rattan are well fumigated because they stand parallel to the direction of the movement of fumes, and this ensures effective treatment. The ability of the facility to retain the fumes over a long period also helped in the effective penetration of the fumes. Products from this facility have resisted pest infestation and have shown no signs of fungi attack.

Figure 2. Rattan before sulfur fumigation

Figure 3. Rattan after sulfur Fumigation

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