COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)

FOOD RESEARCH INSTITUTE (FRI)

TECHNICAL REPORT ON THE ASSESMENT OF IMPROVED DRYING SYSTEMS FOR HIGH QUALITY CASSAVA PRODUCTS

BY

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JUNE, 2014

Table of Contents

1. Summary

Typically, the square type batch bin dryers with product heating through the perforated plated at the base of the bin is used in Ghana. Bin dryers from five High Quality Cassava Flour (HQCF) processing companies in Ghana were assessed. Detail technical evaluations were performed on two of the bin dryers. The Ahlborn Gmbh ALMEMO 2890-9 advanced measurement and data logging device was used to measure temperature, moisture, air flow rate, electrical energy consumption and heat transfer in the bin dryers. Additionally, a point and measure infrared thermometer was used to measure the surface temperatures of the bin dryer. During drying, random samples were taken every 30 minutes from the bin and the moisture content analyzed in the laboratory using the oven drying technique. Based on the technical evaluation of the bin dryers in Ghana, technical modifications to the existing dryers have been identified. A new design for bin dryer has been proposed. The present heat exchangers are about 50% inefficient. Extra piping in the exchangers have been proposed. To improve efficiencies, the assessed bin dryers need at least 50 mm thickness lagging of the walls and floors to improve the temperature reaching the products by 20 °C. Additionally inclusion of a control system for reduction of the blower fan speed especially the drying moisture between 25 and 12 % for the cassava products has been proposed to reduce the drying time by at least 1 to 2 hours making energy saving costs

2.0 Key Findings

From the evaluation of the bin dryer, a total drying time of about 8 hours was needed to dry sliced cassava chips of weight 510 Kg from moisture content of 58 % to 12%. For grated and pressed cassava of weight 350 kg, a total time of 6hrs was needed to dry the products from moisture content 47% to 12% using the bin dryers in Ghana. With regards to the technical components of the bin dryers assessed in Ghana, the present heat exchangers were in efficient, losing about 50% of the generated heat from the burner. There is need for redesigning the heat exchangers which is proposed in this report. There were also heat losses from the walls of the dryers. To improve efficiencies, the assessed bin dryers need at least 50 mm thickness lagging of the walls and floors to improve the temperature reaching the products. The blowers of the bin dryers were uncontrolled sometimes leading to the excessive removal transfer of heat through the dryer. Inclusion of a control system for reduction of the blower fan speed especially at lower drying moisture contents of the cassava products will increase the drying efficiencies, reduce drying time and cut down cost of energy for running the bin dryers.

3.0 Background

Cassava and yam are important food security crops for approximately 700 million people in the world. Post-harvest losses however are significant and come in three forms: (a) physical; (b) economic through discounting or processing into low value products and (c) from bio-wastes. This assessment aims to reduce these losses to enhance the role that these crops play in food and income

security. 3 impact paths have been identified namely; reduction of physical losses, value added processing reducing physical and economic losses in yam and cassava and improved utilisation of wastes (peels, liquid waste, spent brewery waste) producing products for human consumption including snack foods, mushrooms and animal feed.

The key task is the optimization of existing dryers. Current designs of bin (Ghana) and flash dryers (Nigeria) are known to operate with low energy. In the task, dryer designs will be optimized in collaboration with SME partners such that best bet technologies can be made available.

4.0 Methodology

The bin dryers in Ghana for drying roots and tubers are the square type batch bin dryers with product heating through the perforated plated at the base of the bin. The dryers are heated using either wood, liquefied petroleum gas, or diesel fuel.

An evaluation of the bin dryers from various SMEs was undertaken and a detail technical evaluation was performed on the bin dryers at Food Research Institute (FRI) in Accra, Ghana for drying HQCF and Cassava Chips and Andyco Godsway Company Limited, Kpeve in Ghana for Cassava Mash and Chips.

The bin dryers identified (Figure 1) are the shallow-layer batch bin dryers. These take the form of a rectangular tray with a perforated base which is made of stacked aluminum bars overlapping on top of the other with a 2-mm gap in between for hot air to flow through. The bin is inclined at an angle of 5 to 10 degrees for ease of offloading or collecting of final dried products through the product outlet. The identified energy sources for the heat exchanger were firewood, diesel or LPG. Figure 1 shows an LPG gas atomizer for heating the bin dryer. To avoid contamination, mild steel constructed heat exchangers are used to transfer heat into the dryer. An electric operated motor is used to suck fresh air through the heat exchanger and blow the warmed air into the bin dryer. Warmed air is blown into the plenum chamber beneath the bin dryer and then up through the perforated base then through the cassava products to be dried. The dryers in Ghana are manually loaded and unloaded into bags for further processing.

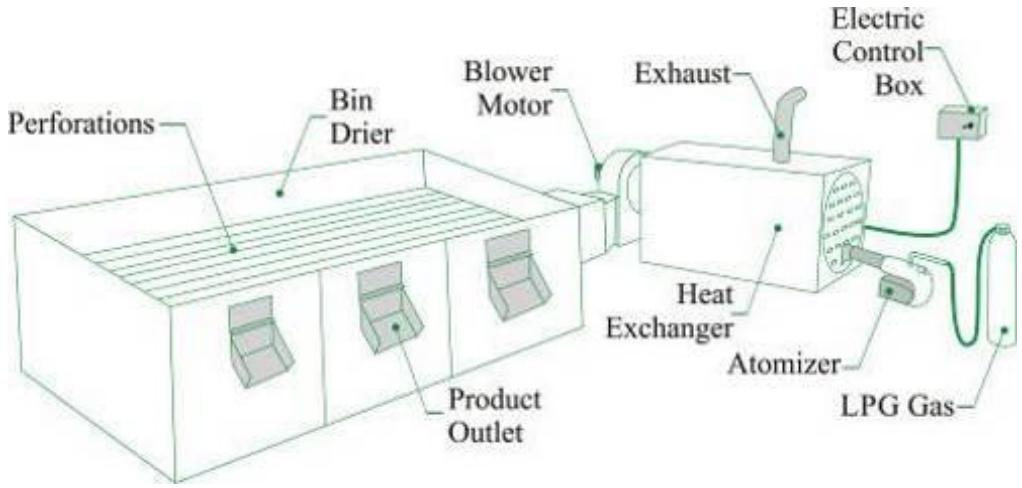

Figure 1**.** A Typical arrangement of the bin dryers using Liquefied Petroleum Gas, LPG for cassava drying

Measurement and Instrumentation

An advanced measurement and data logging device (Ahlborn Gmbh ALMEMO 2890-9 data acquisition device from Germany) capable multi-channel measurement of temperature, moisture, air flow rate, electrical energy consumption and heat transfer was used in measurement and data logging. The data logger was set to record every 10min from onset to finish of drying. Additionally, a point and measure infrared thermometer was used to measure the surface temperatures of the bin dryer.

Figure show the measurement setup for the bin dryer. Every hour 3 random samples were taken from different locations of the bin dryer and the moisture content analyzed in the laboratory using the oven drying technique.

Figure 2**.** Bin dryer showing product outlet points

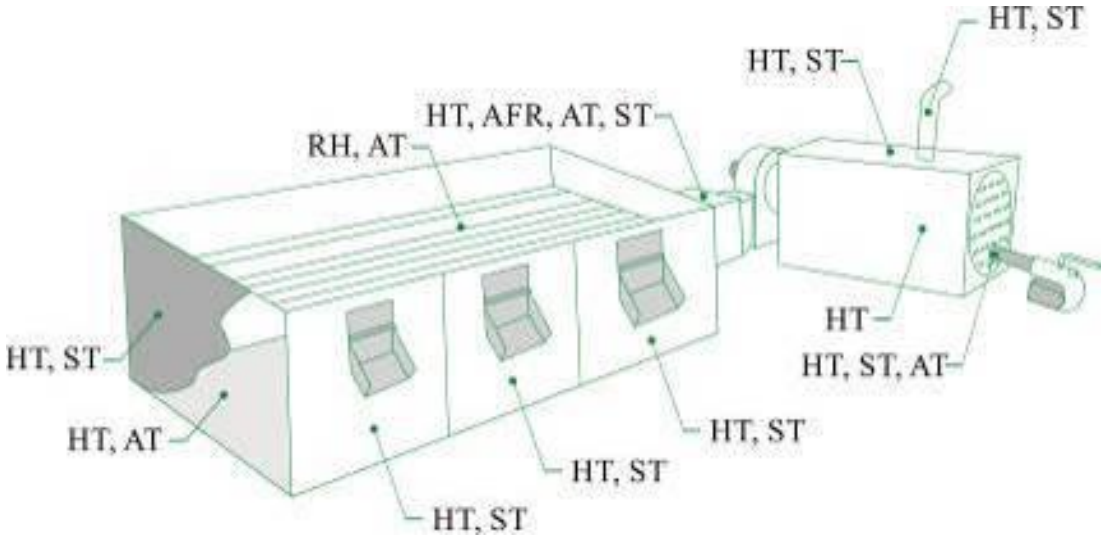

Figure 3. Measurement set up showing position of sensors; HT-Heat Transfer, ST-Surface Temperature, AT-Air Temperature, AFR-Air Flow Rate, RH-Relative Humidity

Cassava processing for drying

The first set of tests of the bin dryer was performed at the Food Research Institute in Accra, Ghana on the 15th of January, 2014. Freshly uprooted cassava was peeled, washed and weighed. A weight of 508 kg of peeled cassava was chipped in a cassava slicer. The bin dryer was filled with the sliced cassava to a depth of about 10cm. Air and surface temperature, relative humidity, air flow rate, heat transfer, and surface temperatures were recorded by sensors at specific points of the bin dryer as described in the previous section. Fuel and electricity consumptions were also monitored during the drying operation.

The second set of tests on the bin dryer was performed using the Andyco Company Limited's dryer in the Volta Region of Ghana on the 17th of April 2014 using grated and pressed cassava mash. The dryer consists of a gas burner, blower system, bin stand made of burnt bricks and the bin itself. In the evaluation, 700kg of peeled cassava was grated and pressed using manual labour and a mechanised grater. After pressing 410kg was recorded which was then disintegrated by machine and spread inside the bin. The bin dryer was filled with the cassava mash to a depth of about 7cm. Air and surface temperature, relative humidity, air flow rate, heat transfer, and surface temperatures were recorded by sensors placed at specific points. Fuel consumptions were also monitored against initial and final dried weight.

5.0 Results

Assessment of the bin dryer at the Food Research Institute in Accra, Ghana

The setup for the assessment of the bin dryer at the Food Research Institute in Accra, Ghana is as shown in the figure below.

Figure 4. The setup at Food Research Institute in Accra, Ghana

Temperature distribution

The temperature at the atomizer section of the bin dryer ranged between 150 °C and 250 °C depending on the pressure in the cylinder of the compress LPG. When a new pressurised cylinder was installed, the temperature rose to over 220 °C, but started to drop as the pressure reduced.

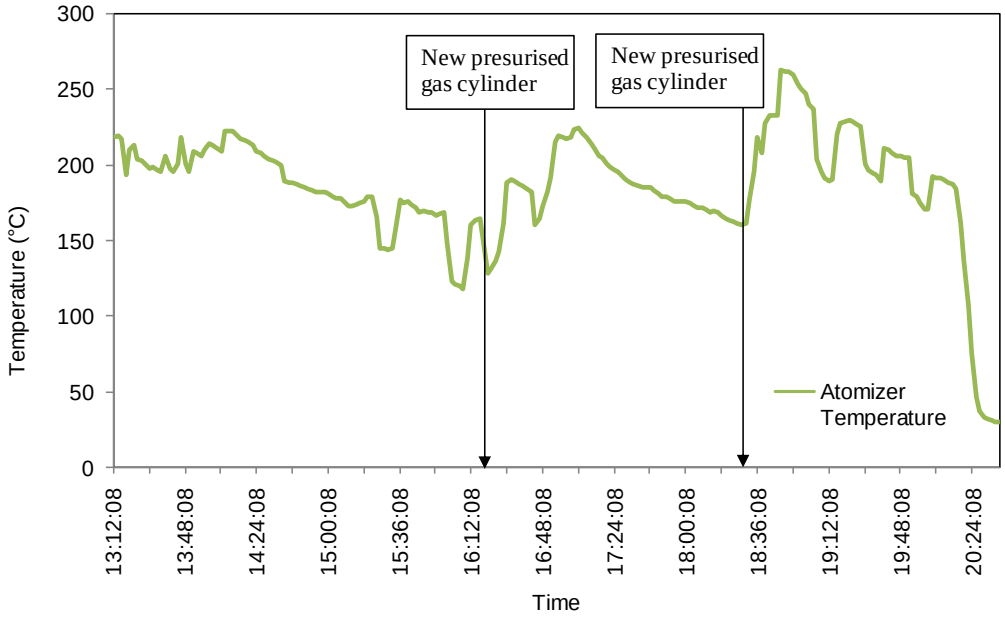

Figure 5. Air temperature measurement inside the heat exchanger at the atomizer

Although the temperature at the atomizer was very high at over 200 °C, the temperature at the plenum chamber beneath the bin dryer was only 45 °C to 50 °C. The heat exchanger could be described as not efficient as most of the heat was not transferred through the exhaust chimney at temperatures of over 120 °C. Figure shows the distribution of heat on the surfaces of the bin dryer.

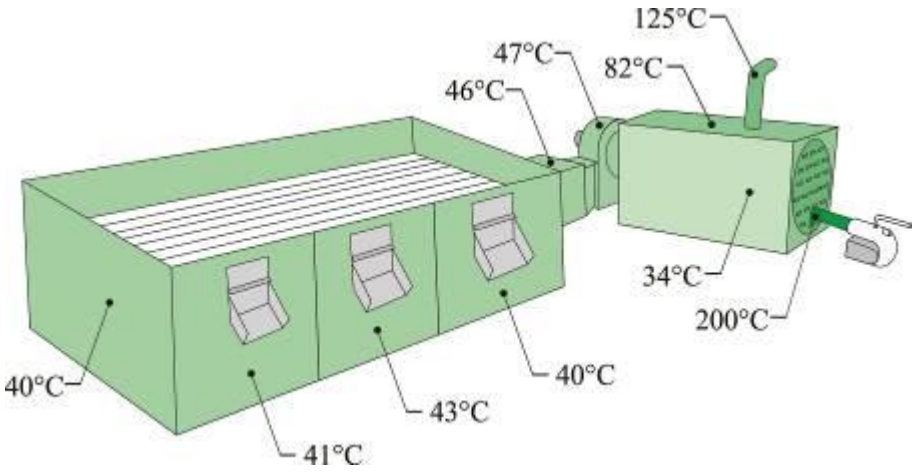

Figure 6. Surface temperature measurement on the bin dryer

Using the heat transfer plate to measure the heat losses from the surfaces of the bin dryer, it was realized that due to lagging of the heat exchanger, heat losses recorded were lower (13.2W/m^2, 15.8 W/m^2 and 11.5 W/m^2) compared to the rectangular bin body (79.2 W/m^2, 84.1 W/m^2, 82.5 W/m^2). For this reason, most of the heat from the atomizer is lost to the environment before it reaches the products in the bin dryer.

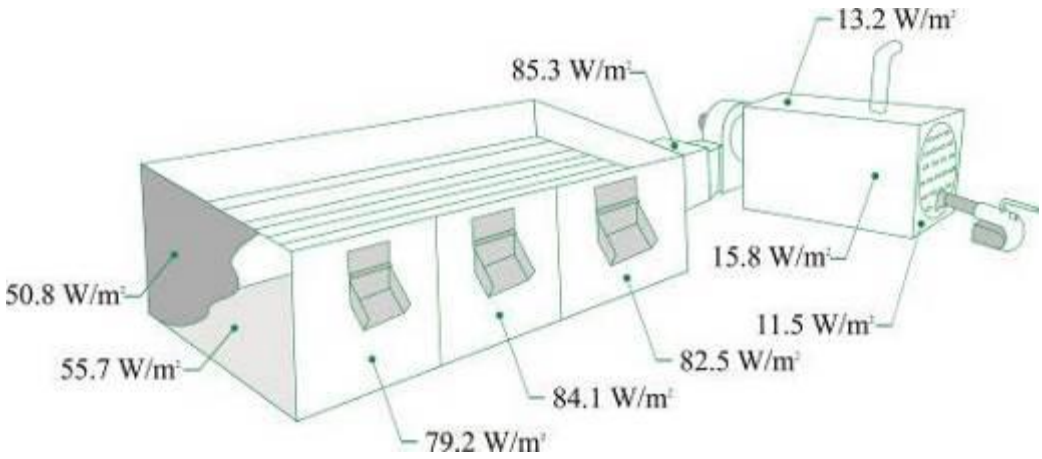

Figure 7. Heat losses from the surfaces of the bin dryer

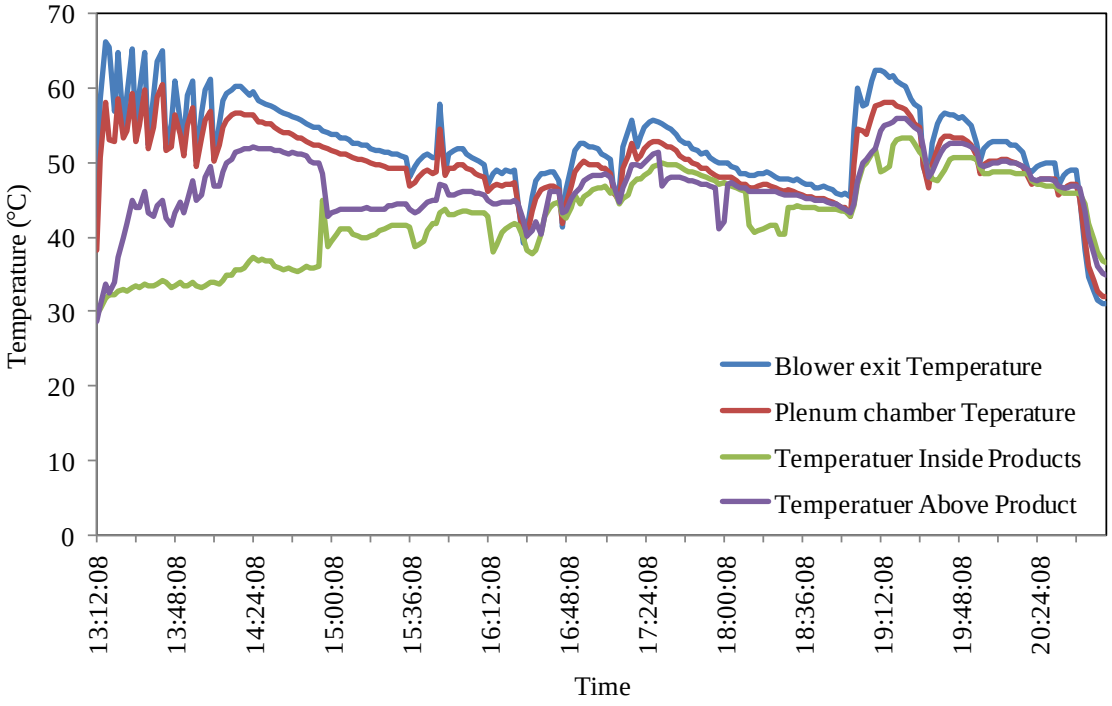

Figure 8. Temperatures at blower, plenum and drying cassava vs. Time

Though the target temperature of drying with the bin dryer was 50 °C, there were variations in measured temperatures due to improper functioning of the atomizer at low LPG gas pressures. Figure shows the sensor recorded temperatures after the fan blower, the sensor at the plenum chamber below the bin dryer, temperature of the sensor placed inside the drying cassava and that placed above the drying cassava slices.

Removal of Moisture

Cassava samples were taken every 30 minutes during the drying period and the moisture content analysed. Figure shows the results of the laboratory analysed moisture as compared to the moisture in the product measured with air relative humidity sensor placed in the products. The results show that the moisture sensor placed inside the product is quite useful in predicting the moisture of the product being dried.

The total drying time was about 8 hours to reduce the moisture content from 58 % to 12%. The initial weight of the cassava chips was 510 Kg and the final weight was 180 Kg.

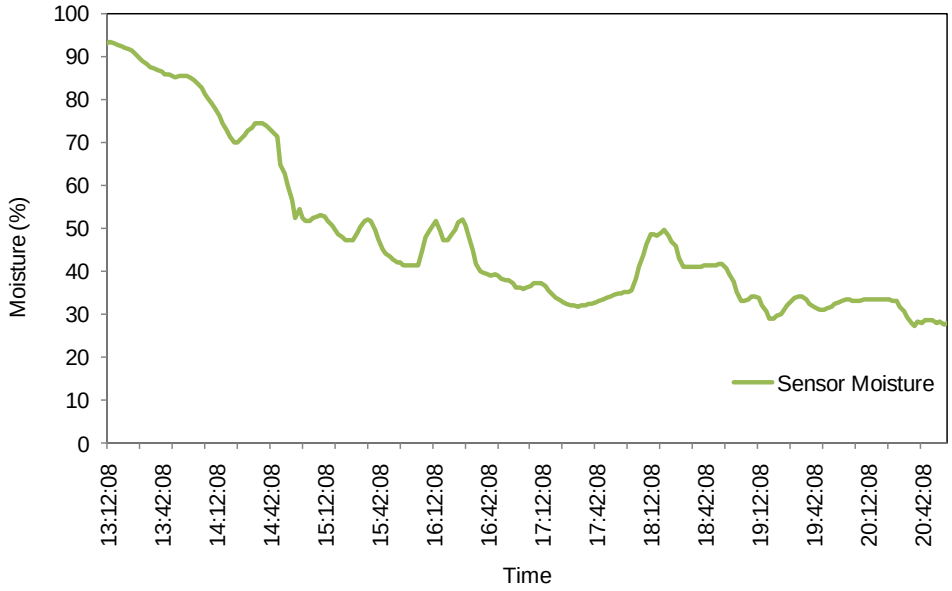

Figure 9. Laboratory analyzed moisture against moisture in the product measured with air relative humidity sensor placed in the products

Assessment of bin dryers at Andyco Company Limited, Kpeve, Ghana

The bin dryer at Andyco Company Limited, Kpeve, Ghana was slightly different from that at the Food Research Institute in Accra, Ghana. The dryer consisted of a gas burner, blower system, bin stand made of burnt bricks and the bin itself. The blower sucks and blows heat produced by the gas burner to the bin from the bottom (i.e. the burnt brick stand). The set up is shown in the Figure below.

Figure 10. Gas burner and body of the bin dryer at Andyco Company ltd., Kpevein the Volta

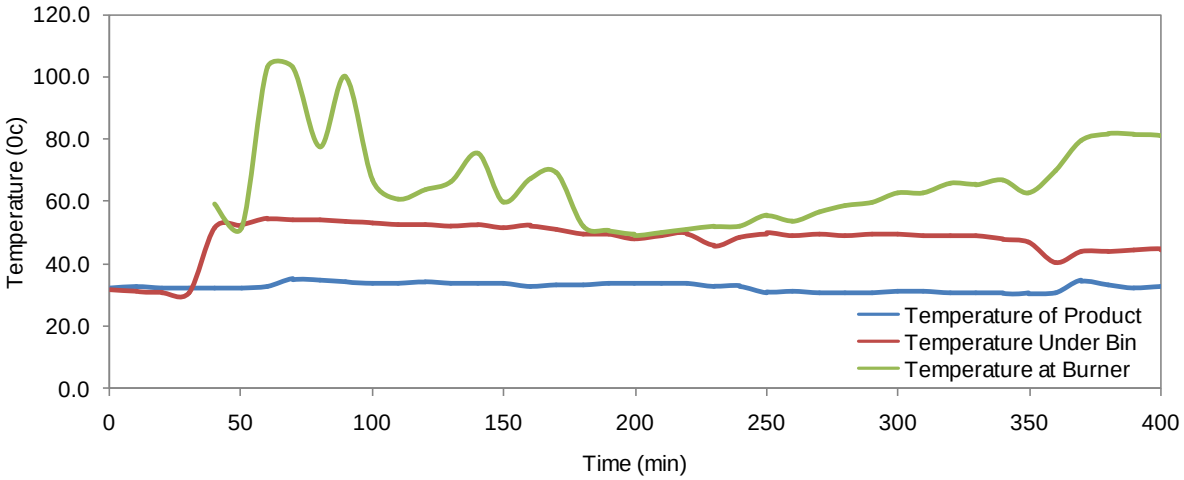

Figure 2. Temperature distribution in bin dryer at Andyco Company Limited, Kpeve in the Volta Region, Ghana

The temperature at the burner was about 80°C. The dryer was able to maintain a drying temperature of about 32°C during the drying duration. The temperature under the bin dropped from 55°C to about 42°C towards the end of the drying. The difference in temperature in the products and under the bin dryer was a result of heat losses on the walls and the floors of the bin dryer.

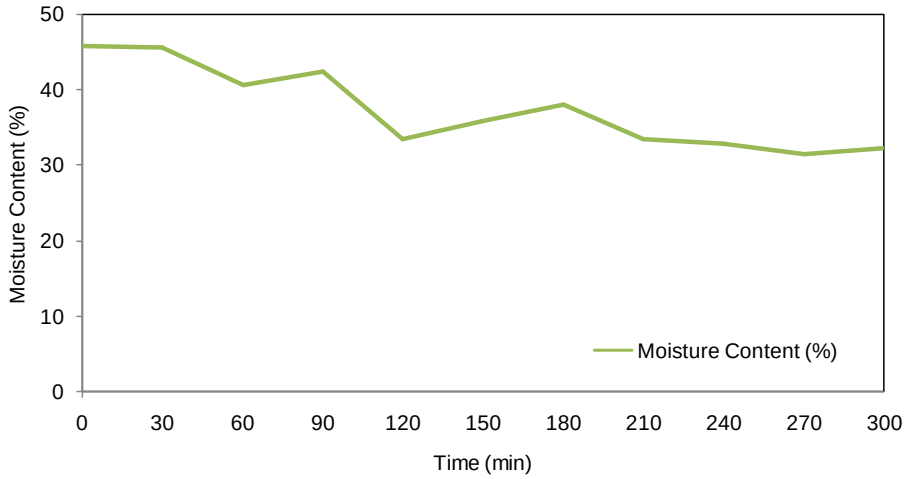

Figure 31. Moisture content of the cassava products vs. Drying time

The initial moisture content of pressed cassava mash was determined to be 45%. this gradually decreased to 30% towards the end of the drying period. It was observed that the design of this particular bin dryer had a very high propelling fan attached to the blower system. Hence, upon drying

to almost 30%, particles begun flying about and were no longer stationary for the heat coming from the burner to further dry them. Consequently, drying was carried out for 6 hours.

Modifications and Testing of modifications to bin and flash

Based on the technical evaluation of the bin dryers in Ghana, technical modifications to the existing dryers have been identified. Furthermore, a new design for bin dryer has been proposed. For the existing bin dryers, at least 50 mm thickness lagging of the walls and floors of the bin dryer will increase the temperature reaching the products by at least 20 °C (Figure). A further control and reduction of the blower fan speed especially the drying moisture between 25 and 12 % for the cassava products will reduce the drying time by at least 1 to 2 hours making energy saving costs. Current bin dryer control systems have constant fan blower speeds which blow the generated heat too quickly through the product without allowing ample time for the products an absorb the generated heat. To achieve this, a control system would be integrated to regulate the speed of air through the product.

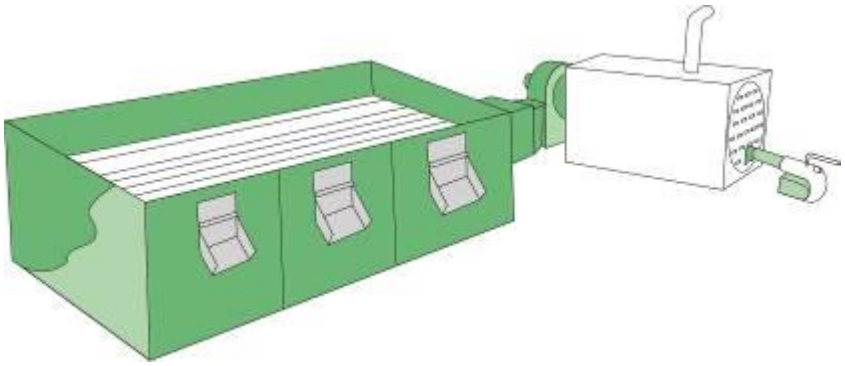

Figure 12. Surfaces of the bin dryer that require lagging

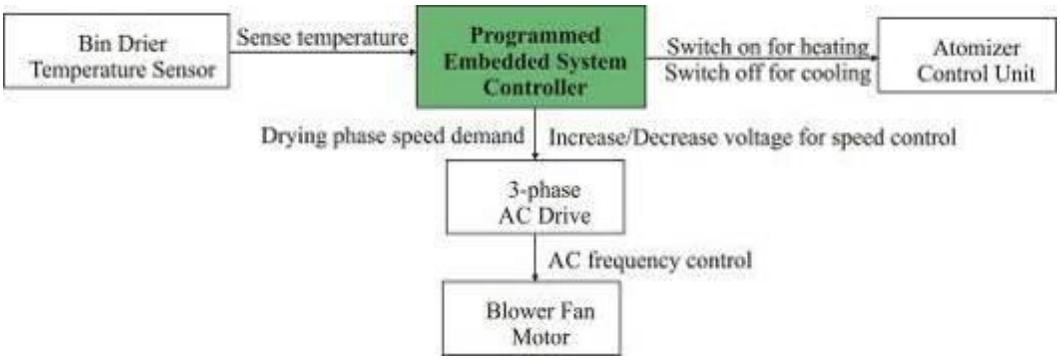

Figure 13. Embedded system with AC motor drive for control of blower fan speed according to desired product drying temperature

6.0 Conclusions

From the evaluation of the bin dryers, a total drying time of about 8 hours was needed to dry sliced cassava chips of weight 510 Kg from moisture content of 58 % to 12%. For grated and pressed cassava of weight 350 kg, a total time of 6hrs was needed to dry the products from moisture content 47% to 12% using the bin dryers in Ghana. With regards to the technical components of the bin dryers assessed in Ghana, the present heat exchangers were inefficient, losing about 50% of the generated heat from the burner. Heat losses from the walls and floors of the dryers were high. To improve efficiencies, it is proposed that the assessed bin be lagged with insulation material of at least 50 mm thickness to reduce heat losses. A proposed control system for regulation of the blower fan speed especially at lower drying moisture contents of the cassava products will increase the drying efficiencies, reduce drying time and cut down cost of energy for running the bin dryers.