Tetfund Sponsored Kwara State Polytechnic Journal of Research and Development Studies
Vol. 5. No. 1 June 2017.

DESIGN, FABRICATION AND TESTING OF A BIOMASS DRYER

Uthman, F., Balogun, A.L and Onipede, E.A

Department of Agricultural and Bio Environmental Engineering Technology, Kwara state Polytechnic, Ilorin Kwara state, Nigeria.

Abstract

Drying is one of the major problems in Postharvest Operation. The traditional method of drying (sun drying) is weather dependent and unhygienic as affecting food storage. Bio-mass dryer was designed, fabricated and tested for performance as a solution to drying of Agricultural Produce. The dryer consist of the following operating component parts: a cabinet, blower, tray, heating element, temperature controller, Light Emitting Diode (LED) screen and switch. The factors considered in the study, using groundnut, was weight (50g, 100g and 150g), temperature (55^{0}C, 60^{0}C and 65^{0}C) and each were replicated 3 times. The results show that temperature of 60^{0}C and 65^{0}C favors the drying of the three weights than temperature of 55^{0}C. The time taken for each sample at different weight and temperature differs. Hence, the higher the temperature the lesser the time taken for the groundnut to dry, the higher the weight the higher the time taken for the groundnut to dry.

Keywords: Biomass dryer, Temperature Controller, Design, Groundnut

1. Introduction

Although in many parts of Africa certain crops can be produced throughout the year, the major food crops such as cereals, grains and tubers including potatoes are normally seasonal crops. Consequently the food produced in one harvest period, which may last for only a few weeks, must be stored for gradual consumption until the next season's crop. The principal aim of any storage system must be to maintain the crop in prime condition for as long as possible. (Bala, *et al*, 2003). Drying is the reduction of moisture from agricultural products which is a most important process for preserving agricultural products, since it has a great effect on the quality of the dried product. Drying means preservation of food, fruit and vegetables required not air in the temperature range 45^0 - 60^{0}C for safe drying. When any agricultural is drying under controlled condition at specific humidity as well as temperature, it gives rapid superior quality of dried product (Babagana, *et al*, 2012).

The process of drying involves the application of heat to vaporize moisture and some means of removing water vapor after its separation from the food products. The removal of moisture prevents the growth and reproduction of micro –organism like bacteria and minimizes many of the moisture mediated deteriorative reactions. It is observed that reduction in weight and volume enables the storability of the product under ambient temperatures. Drying of agricultural products such as corn, rice millet beans, sorghum, groundnut, pepper, Okra, yam and plantain chips requires a considerable amount of energy which must be available when the crop is harvested. The application of solar energy in drying of agricultural products has tremendous potential, since it can easily provide the low temperature heating required for drying. Drying processes using solar energy range from traditional open sun drying to solar dryers. The climatic condition during harvest season in some areas may be such that unheated or natural air can be used to reduce the moisture content in the crop to safe storage moisture (Bolaji *et al*, 2011).

Many dryers have been developed, designed and tested. Arinze(1985b) designed and evaluated an indirect crop dryer with an integrated thermal storage system for deep bed drying for grains. Airflow rate of $40kgh^{-1}$ m^{-2} and $5.6m^2$ of collector area per m3 of dryer were recommended. (Akbulut and Durmus,2010) designed, constructed and tested solar dryer of various operation modes indirect mixed, passive active and hybrid for drying agricultural products. The most efficient operation mode was the forced hybrid one, followed by the passive and active modes. 50% reduction in the drying time was obtained using forced hybrid mode.

Bala and Rahman (2009) investigated the performance of solar tunnel dryer for drying mushrooms. The drier is arranged to supply hot air directly into the drying tunnel unit using three dc fans powered by a 40 watt solar module. During the test, the temperature in the drying chamber varied from 37.0^0Cto 66.5^0C and the mushroom were dried from about 89.41% to 6.14% moisture content (w.b) in about 8 hours of effective sunshine drying takes place in two stages. The first one happens at the surface of the drying material at constant drying rate and is similar to the vaporization of water in to the ambient and second stage is according to properties of drying product with decreasing drying rate.

In the olden days natural or open sun drying is used for drying agricultural product, in this method, the crop is placed on the ground or concrete floors where it can reach higher temperature in open sun and left there for a number of days to dry capacity wise. Despite the very rudimentary nature of the process, natural drying or open air drying remain the most common method of solar drying. This is because the energy requirements which come from solar radiation and the air enthalpy are readily available in the ambient environment (Amer, *et al,* 2010).

The purpose of a dryer is to supply more heat to the product than that available naturally under ambient conditions, thus increasing sufficiently the vapor pressure of the crop moisture. Therefore moisture migration from the crop is improved. Natural air drying technique has the problem of contamination, infestation, microbial attack. the required drying time for a given commodity is long direct solar drying. This is the easiest method of drying but due to limitations like reduction in the quality of the product and reduction in the vitamins and nutrient due to direct exposure to solar radiation. There is no control over rate of drying and the rate of drying is very slow. Agricultural products are directly exposed to uneven climate changes and poor solar conditions. Products also suffer the undesirable effects of dust, and atmospheric pollution. Because of these limitations, the quality of the resulting product can be degraded, sometimes beyond edibility. Eradication of this limitation brings about the design and fabrication of a biomass dryer which provide effective technique of product drying (Babagana *et al,* 2012). According to Al-Bosoul (2017) the following parameters should be put into consideration when designing for dryers; amount of moisture to be removed from a given quantity of crops, harvesting period during which the drying is needed, the daily sunshine hours for the selection of the total drying time, quantity of air needed for drying, daily solar radiation to determine energy received by the dryer per day and wind speed for the calculation of air vent dimensions. Considerations should also be given to the source of energy generation. This project is aimed to reduce the moisture content of agricultural crops in order to prolong their shelf life by designing and fabricating a dryer that uses biomass as a source of heat generation.

2. Description of System Design

The biomass dryer consist of three major sections which include solar energy section, biomass stove section and drying chamber section. The dryer has the shape of a home cabinet which is provided with one heated air inlet that comes from outside base of the drying chamber for the heated air existing in the biomass stove. The drying chamber section is 560mm by 570mm in cross section and has an height of 860mm.It has three tray levels and it is filled with a piping system that channels the heated air released from the surface of the pipe to the trays. The chimney has a height of 457mm from the top base of the drying chamber which is located at the center of the drying chamber and also serves as the air outlet. The biomass stove section consist of two sub section i.e. the briquette combustion chamber and a 12v DC air blower which is powered by the solar energy system. The solar energy section consists of a solar panel of 60w with 12v battery as a backup. The solar energy system powers the temperature controller that monitors and controls the temperature to the required drying temperature of the crop involved and also powers the light emitting diode (LED) screen for the displaying of the various activities occurring in the drying chamber. The pictorial view of the Biomass Dryer is as shown in figure 2.1 and 2.2 below:

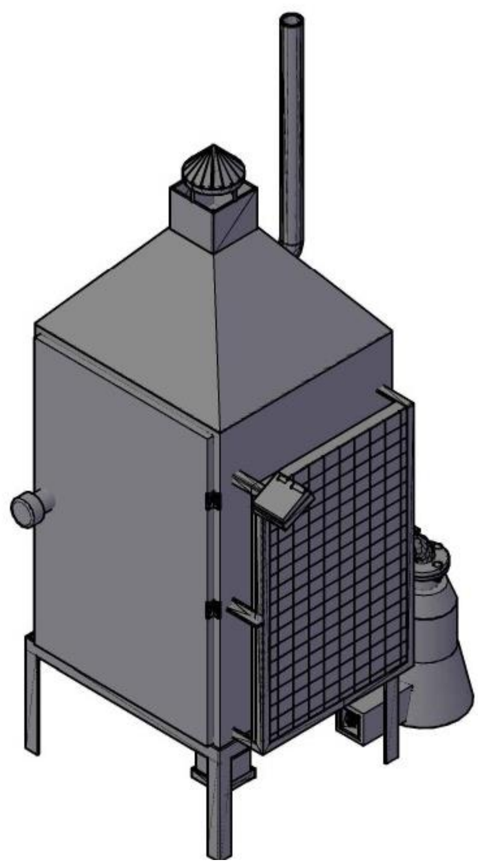
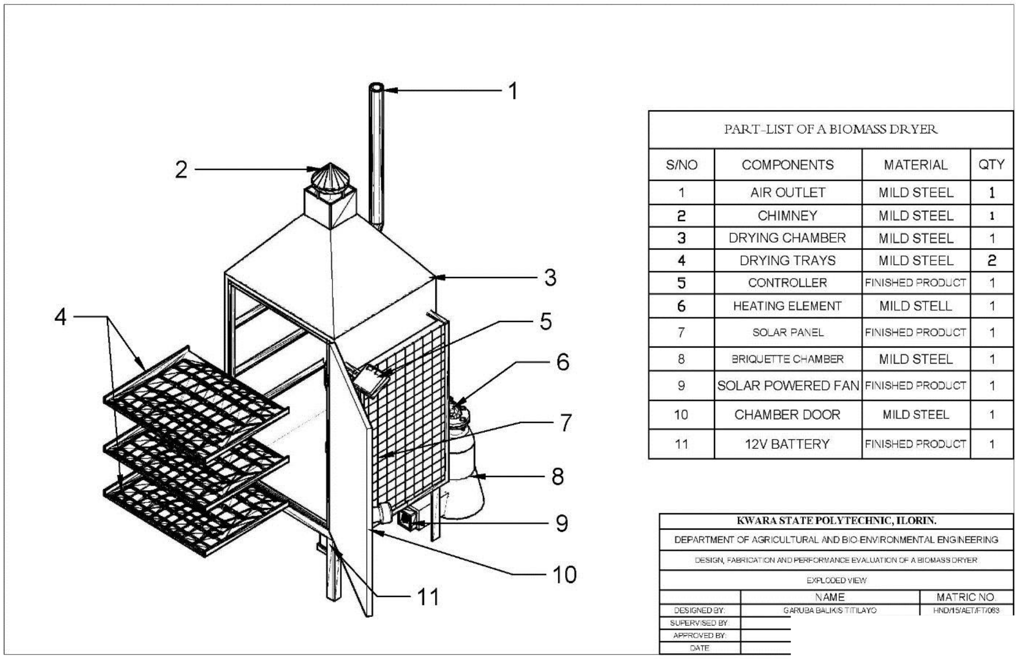


Figure 2.1 Isometric view of Biomass Dryer



S/NO	COMPONENTS	MATERIAL	QTY
1	AIR OUTLET	MILD STEEL	1
2	CHIMNEY	MILD STEEL	1
3	DRYING CHAMBER	MILD STEEL	1
4	DRYING TRAYS	MILD STEEL	2
5	CONTROLLER	FINISHED PRODUCT	1
6	HEATING ELEMENT	MILD STELL	1
7	SOLAR PANEL	FINISHED PRODUCT	1
8	BRIQUETTE CHAMBER	MILD STEEL	1
9	SOLAR POWERED FAN	FINISHED PRODUCT	1
10	CHAMBER DOOR	MILD STEEL	1
11	12V BATTERY	FINISHED PRODUCT	1

Figure 2.2: Exploded View of Biomass Dryer

3 Fabrication of System Design

The following parameters are put into consideration in the design of the dryer; air temperature, air relative humidity, air flow rate, original and final moisture content; crop type and crop maturity. The capacity of drying chamber

$$A = LXB \qquad 1$$

Where A= Area of the drying chamber (mm), L= Length of the drying chamber (mm), B= Breadth of the drying chamber (mm), was fabricated with L=560mm, B=570mm and A= 319.2x10^{3}mm Volume of drying Chamber

$$V = LXBXH \qquad 2$$

Where V=volume of the drying chamber, (mm), L=Length of the drying chamber (mm), B=Breadth of the drying chamber (mm), H=Height of the drying chamber (mm), was fabricated with L= 560mm,B= 570mm, H=860mm and V=274.5x10^6 mm^3 Volume/capacity of drying tray

$$V = LXBXH \qquad 3$$

was fabricated with L =500mm, B=400mm, H= 20mm and V = 4000000mm^3 The amount of Moisture to be removed from the Product, m_w(kg) was calculated using the following equation:

$$m_w = m_p \frac{(m_i - m_f)}{(100 - m_f)} \quad 4$$

where, m_p(kg) = The initial mass of product to be dried (100kg), M_i=initial moisture content of produce, M_f= Final moisture content of produce. According to Wright and Siddique (2003)

M_i =25%, M_f =14%, M_p =100g,

M_w =100($\frac{25-14}{100-14}$)

=12.79 = ~ 13%

Solar Panel Capacity

$$P = VI$$

where, P= power, W, V = Voltage, V, I= Current, A was fabricated with V=17 V, I= 2.9A and P= 49.98 W= 50 W. The drying rate m_{dr}, was determined from the mass of moisture to be removed by solar heater and drying time by the following equation.

$$M_{dr} = \frac{Mw}{Td} \quad 6$$

Where M_{dr}=Average Drying rate, Mw=Mass of moisture content of crop, Td=is time interval of drying.

4. Discussions of Results

Our findings on the weight loss of groundnut dried in the dryer is presented in tables1 to 3.

Table1 Drying Rate of Groundnut at 55^{0}C

Weight (g)	Time (min)	Total water loss (g)	Drying rate (g/min)
50	240	10.0	0.0416
100	300	30.0	0.1
150	360	50.0	0.138

Table 2 Drying Rate of Groundnut at 60^0C

Weight (g)	Time (min)	Total water loss (g)	Drying rate (g/min)
50	210	10.0	0.047
100	240	30.0	0.125
150	330	50.0	0.151

Table 3 Drying Rate of Groundnut at 65^0C

Weight (g)	Time (min)	Total water loss (g)	Drying rate (g/min)
50	180	10.0	0.056
100	210	30.0	0.143
150	270	50.0	0.185

Tables I and 2 revealed the relationship between the treatment applied and the output parameters. It was recorded that the weight of 50g, 100g and 150g was subjected to temperature 55^0C, 60^0C and 65^0C.It was observed that the weight decreased with time and the higher the temperature the higher the drying rate. The time taken for each sample at different temperature differs. The results revealed that as temperature increased, moisture percentage decreases and as drying time increased moisture content decreased as well. Moisture percentage decreased faster at higher temperature than at low temperature. At 55^oC the decrease in moisture percentage was relatively slow. Hence, the more the temperature the lesser the time taken for the groundnut to dry, thus the temperature at 65^0C is more favorable for the drying of groundnut.

5. Conclusions

A Biomass dryer was fabricated and tested in the department of Agricultural and Bio-environmental Engineering, Kwara state polytechnic, Ilorin. Based on the result obtained from the experiment, the following conclusions were drawn. The time spent in drying is a major factor that was considered. An average 3 hours, thirty minutes is enough to dry groundnut at temperature of 65^0C, 4½hours is enough to dry groundnut at temperature of 60^0C and 6 hours is enough to dry groundnut at temperature of 55^0C. The higher the temperature, the faster the drying rate. The biomass dryer is recommended for farmers (large or small) scale, industrialist, institution laboratories and domestic use. The biomass dryer is recommended for producers and sellers of groundnut.

References

Akbulut, A and Durmus, A (2010), Energy and Exergy Analysis of Thin Layer Drying of Mulberry in a Forced Solar Dryer Energy ,Vol.35,Pp 1754-1763.

Amer, B.M.A., Hossain, M.A. and Gottschalk, K. (2010) Design and Performance Evaluation of a New Hybrid Solar Dryer for Banana. Energy Conversion and Management., 51, 813-820.

Arinze, (1985b).Design and Performance Evaluation of a Commercial Size Natural Convention Solar Crop Dryer, Nigerian Journal of Solar Energy,Vol.4,Pp.106-115.

Al-Busoul, M. (2017). Design of Fruits Solar Energy Dryer under Climatic Condition in Jordan. Journal of Power and Energy Engineering, 5,123-137.

Babagana,G;,Kiman and Murtala,.(2012). Solar Dryer –An Effective Tool for Agricultural Products Preservation. Journal of Applied Technology in Environmental Sanitation,2(1),Pp 31-38.

Bala, M and Rahmah,M.F. (2009) Solar Drying of Mushroom Using Solar Tunnel Dryer. Proceedings of the International Solar Food Processing Conference Pp 1-11.

Bolaji,B, Olayanju, T and Falade,T.O (2011). Performance Evaluation of a Solar Ventilated Cabinet Dryer.The West India Journal of Engineering .Vol 33 ,Pp12-18.

Siddique, A.B and Wright, D. 2003 Effects of Different Drying Time and Temperature on Moisture Percentage and Seed Quality (Viability and Vigour) of Pea Seeds (`).Asian Journal of Plant Sciences, 2:978-982