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Design and Construction of an Electric Maize Dryer

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ABSTRACT: An electric maize dryer was design and constructed at Mechanical engineering department, Adamawa State Polytechnic Yola Adamawa State. In Nigeria, maize corn drying is done in dry season because of low humidity of atmospheric air and adequate sunshine majority of the maize corn is harvested in the rainy season and farmers cannot dry the fresh maize corn rather they sell them at very cheap prices to corn roasters and for other delicacies, this study is aimed at designing and fabricating a maize con on cob dryer that will efficiently help the farmers in drying their harvested maize. Ripped maize corns with husks were bought from the market and preserved to retained its moisture content, dehusked and thereafter, dried to a given percentage moisture content of 15%. This was done by laboratory dryer. The drying rate data was generated and the high rate of 2.0g/hr was used afterwards to design and fabricate the corn cob dryer. From the results, drying of a sample of maize corn cob by the laboratory dryer took a period of three days and six hours to reach the 15% moisture content (wet basis) needed. A test run was carried out on the fabricated dryer and seventeen hours was used to dry a sample of maize corn- on-cob to the same 15% moisture content. This implies that design data is satisfactory as its application in the fabrication of the dryer resulted inan increased flow rate of air in the dryer thereby increasing the rate of drying at the same drying temperature of 40^{o}C.

Keyword: Maize, dryer, moisture content, drying rate, drying temperature.

I. INTRODUCTION

Maize is one of the most important grains in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic and nutritional value. Maize is one of the most important cereal crops cultivated in the rainforest and the derived savannah zones of Nigeria. Maize has been in the diet of Nigerians for centuries, initially produced at subsistence quantity and has gradually become one of the most important crops.

Cereal grains have been and will continue to be a major source of food for humans and animals throughout the world. Amongst all cereals, the most important is the maize grain. (Leonard et al, 1963). Maize corn and products can be used for various purposes; human food, alternative medicine, chemicals, bio fuels, ornamentals, fodder, to mention but a few (Leonard, Warren H., andJohn H. Martin). Maize crop is intensively and extensively cultivated in all the geo- political zones of Nigeria. Early maize is planted between late March and late May while the late maize is planted between August and September. The harvest time for the early maize is usually between late July and September. During this period, corns are harvested fresh and cannot be preserved by drying owing to the unavailability of sunshine during the rainy season. It is usually roasted or cooked fresh. This practice does not encourage maize farmers as they would sell the maize corn at a give-away prices and this does not guarantee returns on their investment. In addition to this, dried maize grains will guarantee food sufficiency during the scarce period. Notably, corn of high moisture content does not store very well and is usually vulnerable to damage due to deterioration, molds, and insects during the period ofstorage.

However, open air-sun drying as practiced in most rural areas often yields poor quality dried corn, since the product is not protected against dust, moisture, wind, rodents as well as other domestic animals while carrying out the drying. As

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a result, they are often contaminated with pathogens. Another common practice in maize corn-on-cob drying is drying over a fire place. This has its own problems as the maize grains are contaminated with smoke. Moreover, the temperature of drying is not properly controlled such that grains become dead after drying. There are various research works that have been carried out on grain drying (Zare et al, 2006; Mellmann, et al 2011; Adzimah and Seckley, 2009). These works were silent on drying and dryer design for maize corn-on- cobs.

Whitefield 2000). This research project will address these problems associated with postharvest handling of maize corn-on-cobs, in particular drying, by designing and fabricating electrically operated tray dryer that will be simple but very robust inoperation. Maize corns are usually stored when dried to certain percentage moisture content. In Nigeria, maize corn drying is done in dry season because of low humidity of atmospheric air and adequate sunshine. However, it is a common place to see peasant maize farmers dry their maize corn-on-cobs over fire place, butthispracticecontaminatesthe driedmaizecornwithsmokeandusually small quantity of maize corn-on-cob are dried. The reverse is the case during the rainy season. Unfortunately, bulk of the maize corn is harvested in the rainy season and farmers can not dry the fresh maize corn rather they sell them at very cheap prices to corn roasters and for other delicacies. To give value to farmers and also to guarantee maize corn sufficiency during scarce period, it becomes necessary that a simple but robust corn-on-cob dryer should be designed and fabricated to assist farmers have good returns on their investment especially during post-harvest handling of maize corn during rainyseason.This project when completed will encourage maize farmers by giving them good returns on their labour and enhance maize cornproduction and will provide Nigerian populace with a cleaner dried maizegrains and also attract foreign exchange for Nigeria as cleaner dried maize can beexport.

Design Equation

The following equations were applied in design calculations used in fabrication of the tray dryer for maize corn-on-cobs.

i. Rate of vaporization of moisture is given by:

$$\frac{dw}{dt} = \frac{-h_a(T_a - T_d)A}{\lambda} \quad (1)$$

Where $\frac{dw}{dt}$ = Rate of evaporation of moisture, h_a is the heat transfer coefficient of air, $T_a$is the inlet temperature of air, T_d is the temperature of the drying chamber, A is the total area of the drying surface and λ is the latent heat of vaporization. $\lambda = \frac{9729\,Cal}{mol}$,

$T_a = 65^0C, T_d = 40^0C, A = 1.25m^2$ and drying rate of 2.0g/hr

Heat Transfer

$$\frac{dQ}{dt} = h_a(T_a - T_d)A \quad (2)$$

ii. Mass Flow Rate

The mass flow rate of air into the drying chamber is given by:

$$h_a = \frac{8.8G^{0.8}}{De^{0.2}} \quad (3)$$

Where h_a Heat transfer coefficient, G is the mass velocity of air and De is the equivalent diameter of the air flow

iii. Fan capacity

This selection is based on the speed of the motor to generate an air flow that will enable the dryer to give an optimum performance. The selected fan capacity is 1000rpm synchronous speed tallying with the 960rpm nominal speed.

iv. Heat loss prevention by lagging

The wall of the dryer was insulated with fibre glass put between the mild steel and aluminium. The mild steel is to prevent outside temperature alteration on drying, the fibre glass for the prevention of heat loss through lagging and finally, the aluminium sheet for heat loss prevention from the inner chamber of the dryer.

v. Temperature of the drying chamber.

Considering the drying data generated, drying at 40^0C gives an agricultural product that is viable for the next planting season. So, the drying chamber is maintained at a constant temperature of 40^0C, since the dryer is to dry samples of maizecorn-on-cob

vi. Drying time

During design data generation, a sample of maize corn-on-cob took a period of three days and six hours to dry to a moisture content of 15%wet basis and 18%dry basis. But the drying period for the maize corn-on-cob the dryer can contain is fifteen hours.

vii. Percentage Moisture

Moisture is a word used commonly to describe any volatile liquid or vapour involved in drying; i.e., it is not used selectively to mean only water. The quantity of moisture present in a

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material can be expressed either on the wet basis or dry basis and expressed either as decimal or percentage. The moisture content on the wet basis is the weight of moisture present in a product per unit weight of the wet material, represented as;

$$M_{wb} = \frac{W_o - W_d}{W_o} \quad (4)$$

While the moisture content on the dry basis is the weight of moisture present in the product per unit weight of dry matter in the product and represented as,

$$M_{db} = \frac{W_o - W_d}{W_d} \quad (5)$$

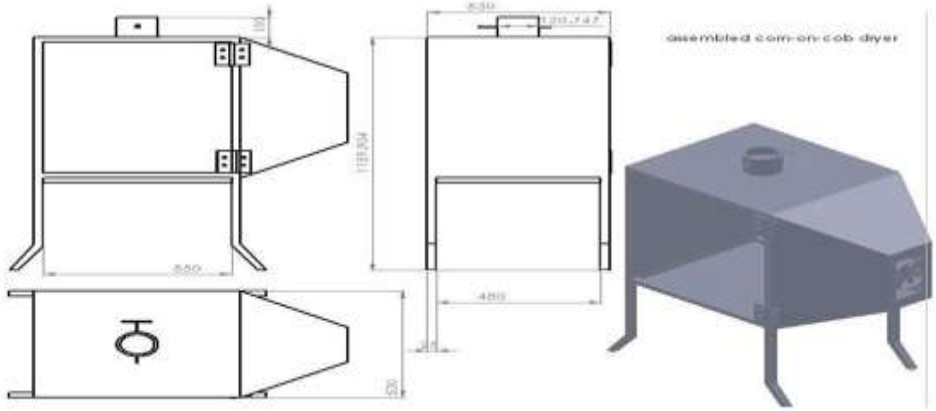
$$\text{Percentage } M_{wb} = M_{wb} \times 100, \quad (6)$$

$$\text{Percentage } M_{db} = M_{db} \times 100. \quad (7)$$

Description of the Machine

This corn-on-cob tray dryer is a drying machine whose temperature is controlled by a thermo stating device that disconnects the heating element. The air temperature at the heating chamber is 65^0c, and the air temperature at the drying chamber is 40^0c at a velocity of 120rpm for a suction radial fan covered with a mesh size 30µmm, to prevent dirt and debris being sucked into the drying chamber.

The dryer consists of a heating chamber, drying chamber, and with a chimney at the top. It is double walled and has single door. It is wheeled with rollers for portability and mobility. It is kept in an open space for easy exchange of air. The corn dryer is censored such that it is with low moisture content hence, it is therefore only corn cub dried in their flower stalk in the farm that can be dried with the machine. This is so because, if it is fed with fresh (immature) corn cub, cooking may take place and the aim will be defeated.



II. RESULT

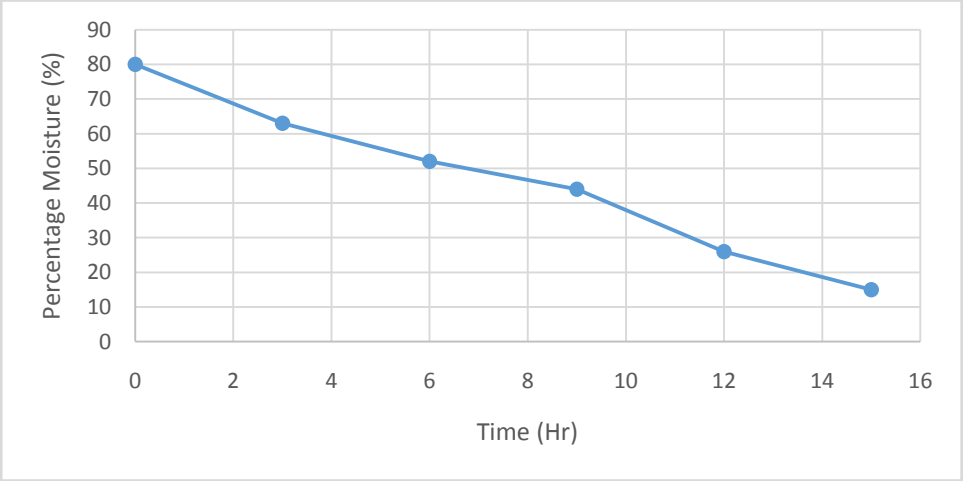


Figure 1. A graph of percentage moisture of the maize cob against Time

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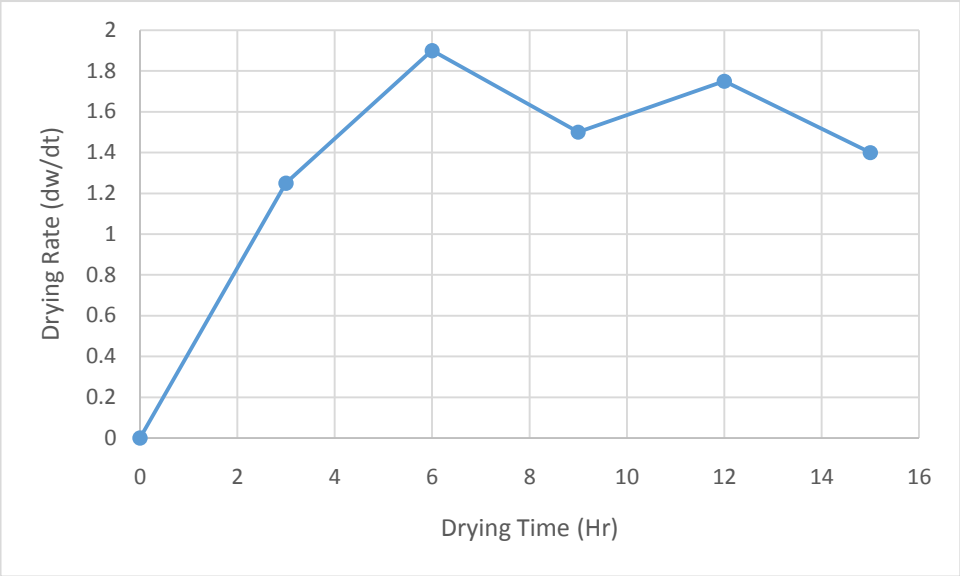

Figure 2. Drying rate of maize cob against Time.

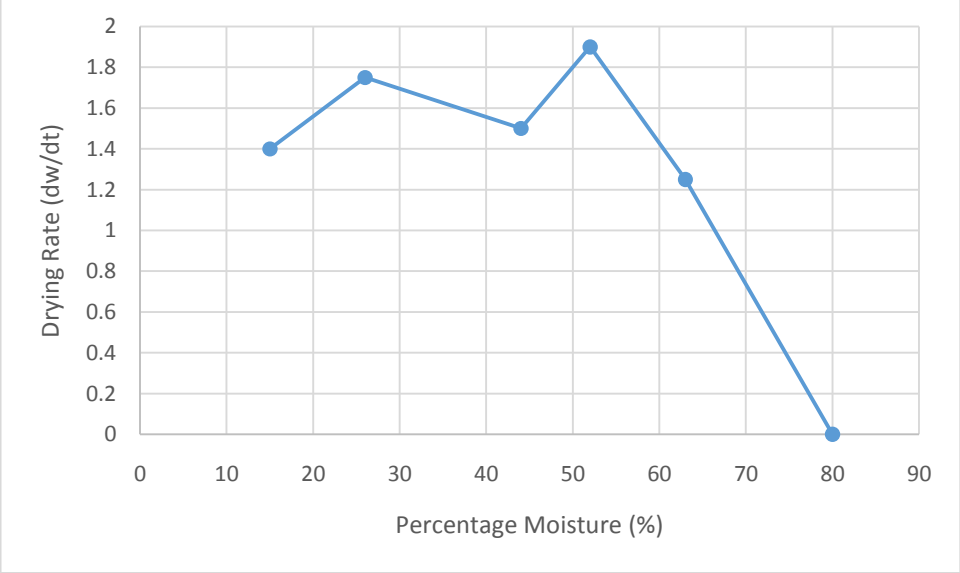

Figure 3. Drying rate of maize cob against percentage moisture.

III. DISCUSSION

From the results gotten above, there are areas of similarities and differences between each figure and those obtained from literatures. It was observed that unavailability of constant power supply during drying affects the drying rates of the corn-on-cob, as the rate curve tends to deviate from their normal patterns which are shown in sudden rise and fall of the drying rate cures. This pattern can be attributed to the hygroscopic in nature of maize; it will always absorb moisture from its surroundings and causing the drying rate to fluctuate. It is also observed that the corn-on-cob sample attains only a falling rate period it has no much moisture init.

Comparing the drying times of the laboratory dryer and the fabricated one, it took about three days and six hours to dry a maize corn-on-cob using laboratory dryer while about 40 maizes corn-on cobs were dried just in about 17 hours. That is to say that there is a remarkable improved in time of drying and can be used by maize farmers in drying maize corn-on cob after harvest.

IV. CONCLUSION

Since the fabricated corn-on-cob dryer gives a faster drying rate for maize, rural farmers

should endeavour to use a dryer whose fan has a very high flow rate of air. Because it has higher efficiency and saves time and gives higher prevention against diseases, insects and pests, which causes deterioration in food quality.

RECOMENDATION

In designing of a corn-on-cob dryer, the following should be considered thoroughly;

i. Power supply should be made available, steadily to ensure an accurate result.
ii. A well matured corn-on-cob should be used for the drying, to avoid undue shrinking of thegrains.
iii. Rural farmers should seek assistance from the government as the project requiresfunding.
iv. The corn-on-cob drying should be done thoroughly to avoid mould growth.
v. A very sensitive weighing balance should be made available to avoid error in the weight of thecorn-on-cob.

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