Design and Construction of Electric Corn Dryer

Engr.O. R Ayodele
Mechanical Engineering Department.
Rufus Giwa Polytechnic, P.M.B 1019, Owo.
Ondo State, Nigeria
olakunle_ayodele@yahoo.com

Prof. I. O Oluwaleye
Mechanical Engineering Department.
Ekiti State University, P.M.B 5363,Ado,
Ekiti State, Nigeria
fccadoekiti@yahoo.com

Engr. S. O Adepo
Mechanical Engineering Department.
Rufus Giwa Polytechnic, P.M.B 1019, Owo.
Ondo State, Nigeria
adeposegun@yahoo.co.uk

***Abstract*—This paper presents the design and construction of electric corn dryer, the design parameters are: a drying chamber, heating element, paddle fins, electric motor, frame, and reduction gearbox. The frame was fabricated from (40 x 40 x 3) mm angle iron bar with dimension (540 x 450 x 905) mm. The drying chamber is cylindrical and has diameter of 200 mm and is 520 mm long. The fan housing consists of three (03) fan blades and electric heating element (1500) W. The function of the reduction gearbox is to reduce the electric motor speed of 2800 rpm to a shaft speed of 2.635 rpm. The mass of corn to be dried which constituted the load on the dryer was 5 kg. The inlet temperature of air in which corn would be viable varied from 50 ^{0}C to 70 ^{0}C. When the dryer was operated without loading of corn in 30minutes, the temperature in the drying chamber rose to 117 ^{0}C, which is expected to give higher drying rate than the natural sun drying and open-fired drying methods.**

Keywords—Electric Energy, Corn dryer, drying temperature, local construction, gearbox)

INTRODUCTION

Most of the corns produced today are being dried through solar energy (Sun dried). That is, the energy from sun intensity is used to remove the moisture content of the grain to considerable and desirable level. However, the major constraint with sun drying is the occasional disruption of drying by weather and climate changes. Maize, also referred is a corn with the scientific name of (*Zea mays*), is a valuable crop. It is a cereal grain widely grown for food and livestock feed. Corn has been of importance in the life of people since 4500 years ago [11]. Maize is a warm weather crop growing in average temperature of 21^{0}C - 35^{0}C.

Traditional drying, which is frequently done on the ground in the open air, is the most widespread method used in developing countries because it is the simplest and cheapest method of conserving foodstuffs. Some disadvantages of open air drying are: exposure of the food stuff to rain and dust, uncontrolled drying; exposure to direct sunlight which is undesirable for some foodstuffs, infestation by insects, attack by animals [13].

Corn is harvested at the peak of the rainy season, making preservation difficult and causing most of the grains to perish. This results in scarcity in the supply of the grains which leads to subsequent hunger and malnutrition. Meanwhile corns are routinely seen dumped in villages and major cities during the peak of harvest. Therefore, it is necessary that corn are properly dried and stored to yield better quality grains and ensures availability and viability.

In the late 15th century and early 16th century, maize spread to the rest of the world after it was originated from South America. Maize ranks with wheat and rice as one of the world's chief grain crops. Corn plant consists of rigid stem, rather than hollow one like most other grasses. The average height is 2.4 m and the leaves, which grow alternately, are long and narrow. The demand for corn is so paramount that the farmers grow two or more plantation per year, since corn can be processed into variety of food products [17]. Hence, the drying calls for a controlled technique.

Drying is a dual process of heat and mass transfer of moisture from the interior of the product to the surrounding of air [9]. Beneth [3], stated that the term drying from the industrial stand point is understood to represent the removal of liquid from a solid by thermal means. Drying also means the removal of water from a suspension or solution of a liquid [1]. Mclean [14] revealed that drying involves the abstraction of moisture from the product by heating and the passage of air mass around it to carry away the release vapour. It is a process of heat and mass (moisture) transfer. The process of heat transfer requires the application of hot ventilating air to the grain to evaporate the moisture by converting it into water vapour while the mass transfer involves the mixing of water vapour with the drying air and its eventual transportation outside the dryer [10]. It can also be defined as a process of moisture removal due to simultaneous heat and mass transfer [7].

For the past years, empirical research has been achieved on modern technology to produce high quality seed. On this scientific technology, the use of mechanical drying has been introduced. Mechanical drying uses air and supplementary heat, for instance electric dryer uses fan and heating element. The heating element generates heat while the fan produces air, which carried and spread air throughout the chamber. Transferring of moisture content from corn surface to the air around is the first step in corn drying which is known as "constant rate period". The next step is the movement of moisture content from the inside of the corn to corn surfaces which is also called the "falling rate period". The amount of moisture which can be removed from corn is depended upon the condition of the corn and the condition of amount of air moving around the corn [6].

MATERIALS AND METHODS

The electric drying system which includes the frame, heating element, drying chamber, electric motor(1h.p), paddle fin, thermostat, reduction gear box and the fan.

The Frame: The cabinet serves as the frame structure of the dryer where all other components are attached. It has a rectangular shape and constructed with size (40 x 40) mm mild steel iron. The dryer has two sections: the dryer compartment and the supporting stand.

The Heating Element: The heater supplies heat for the drying of the corn and will be electrically powered.

The Drying Chamber: The drying chamber/drum is the part of the dryer where the corn to be dried are fed and drying takes place. The drum/drying chamber is positioned centrally in the cabinet which is cylindrical in shape made with mild steel plate because of its heat transfer properties. The corn is fed through the hopper into the drum/ drying chamber.

The Paddle Fin: This is incorporated in the drying chamber for effective distribution of uniform heated air to the corn.

The Thermostat: This maintains and regulates the temperature within specified range in the drying chamber.

Reduction gear box: The function of the reduction gearbox is to reduce the electric motor speed of 2800 rpm to a shaft speed of 2.635 rpm.

The Fan/Blower: The fan aids in heat distribution by sucking ambient air from the surrounding to the heater housing and discharging heated air to the drying chamber. An axial flow fan with three blades is used to ensure proper distribution of heat to the drying chamber.

DESCRIPTION OF THE DRYER

The dryer consist of a cabinet containing a drum in which the corns to be dried are poured through the hopper as shown in plate 1.1. After the corn were loaded, the hopper closed and heated air of about 50 ^{0}C to 70 ^{0}C is blown across the corn from the heater housing through electrical heating element and fan. Both heater and fan terminals are connected to electricity. The heat being supplied by the heater is controlled by a thermostat which turns off the machine if inlet temperature exceeds the actual temperature required for drying with the aid of a thermocouple attached to the wall of the drying chamber. There is a shaft joined with paddles that passes through the centre of the drum. A sprocket is fixed to this shaft and then connected to the reduction gear box through a chain drive and in turn connected to a pulley on the electric motor that was positioned outside the cabinet. During the drying process the gear box with the aid of an electric motor produce drive to the stirrer continuously. After drying, the discharge pot plate is opened where the dried grains are discharge to the receiving tray.

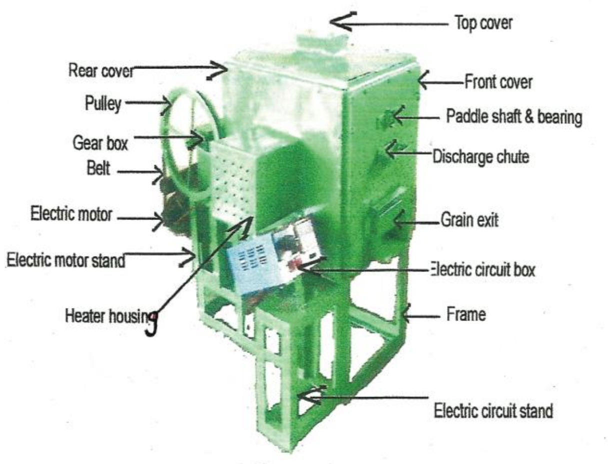

Plate 1.1 Component parts of the corn dryer.

COMPONENTS DESIGN

(i) Design of the drying chamber

Load capacity of the machine = 5 kg

Density of corn= 684kg/m^3
Brooker *et al;* [4]

$$\text{Volume of corn} = \frac{Mass\ of\ corn}{density\ of\ corn} \qquad (1)$$

Hall, [9]

$$= \frac{5}{684} = \underline{0.007309\ m^3}$$

Volume of drum (V_D) = Volume of corn (V_c) $= \pi R^2 L_D$ = 0.007309 m^3

$$L_D = \frac{0.007309}{3.142\ x\ 0.1\ x\ 0.1}$$

= 0.2327 (Approx. 0.300 m)

Volume of drum (V_D) = $\pi R^2 L_D$

= 3.142 x 0.1^2 x 0.300

= 0.0094 m^3

where,
V_D = Volume of drum.

L_D = Length of drum.

R_D = Radius of drum.

(ii) Design of the frame

Let the distance between drum, tray and surrounding be 0.100m

Height of drying compartment = Height of drum + tray + distance between drum and tray (2)

= 0.200 + 0.156 + (0.100 + 0.100 + 0.100) = 0.656 m

Let the length of support be 0.250m, then

Total height of cabinet = Length of support + Height of drying compartment (3)

= 0.656 + 0.250 = 0.906 m

Width of cabinet=Drum diameter + distance btw drum and wall on both sides of the frame (4)

= 0.200 + 0.100 + 0.100 = 0.400m

Length of cabinet = Length of drum + distance between cabinet walls

= 0.400 + 0.07 + 0.07 = 0.540 m

(iii) Design of heater

Volume of drying compartment = (Length x Breadth x Height)

= (0.656 x 0.400 x 0.300) m^3 = 0.0787 m^3

Bulk density of corn = 684kg/m^3

Total mass of corn = Bulk density x volume

= 684kg/m^3 x 0.007309m^3

= 4.999kg = 5 kg

Moisture content = $\frac{M_w - M_d}{M_w}$ x 100 (5)
Brooker *et al;* [4]

where,
M_w = Mass of wet corn,

M_d= Mass of dry corn

From the moisture content table, optimum moisture content for corn when harvested = 32 %

Table 1.1

Cereal	Maximum moisture during harvest %	Optimum moisture at harvest %	Usual moisture at harvest %	Required for safe moisture storage ……………………. 1 year	5 years
Sorghum	35	30-35	10-20	12-13	10-11
Corn	35	28-32	14-30	13	10-11
Oats	32	15-20	10-18	14	11
Barley	30	18-20	10-18	13	11
Rice	30	25-27	16-25	12-14	10-12
Wheat	38	18-20	9-17	13-14	11-12

Moisture contents for various grains [5].

$$\frac{4.999 - Md}{4.999} = \frac{32}{100}$$

M_d =3.402kg

Mass of water = 4.999 - 3.402 = 1.596 kg

Quantity of heat required to remove moisture content:

$Q = M \, x \, L$ (6)
Brooker *et al;* [5].

where,
M = Mass of water, (kg)

L = Specific latent heat of vapourization of water, (kJ/kg)

Q = Quantity of heat, (J/s)

Q = 1.596 x 2256 = 3600.58 kJ

Power = $\frac{Q}{t}$ (7)
Mubeen, [15].

where, t = time (s)

$$= \frac{1.596 \times 2256}{80 \times 60} = 0.7512 \text{ kW}$$

From the above calculation a heating element of about 1500 Watt should be used.

(iv) Determination of shaft diameter

The shaft diameter was selected from the formular:

where,

S_s= Allowable combine shear stress for bending and torsional = 40MN/m^2

K_b=1.5, K_t=1.0, M_t=27.1 Nm, M_b=104.4 Nm (for gradually applied load on rotating shaft).

K_b = Combined shock and fatigue factor applied to bending moment.

K_t= Combined and fatigue factor applied to torsional moment.

K_t = Combine shock and fatigue factor applied for torsional moment 1.0 to 1.5 for heavy shock to 1.5

S_s= allowable shear stress for type of shaft.

$$D_s^3 = \frac{16}{\pi S_s}\sqrt{\{K_b M_b)^2 + (K_t M_t)^2\}} \quad (8)$$

$$D_s^3 = \frac{16}{\pi \; x \; 40 \; x \; 10^6}\sqrt{\{(1.5 \; x \; 104.4)^2 + (1.0 \; x \; 27.1)^2\}}$$

D = <u>27.3 mm</u>

Thus 30 mm diameter was selected.

(v) Insulation of the covers

Different materials are available for insulation but considering the drying temperatures, availability and cost of insulating material, fibre glass has been chosen for installation.

For heat transfer by conduction, the rate of heat flow (Q) is directly proportional to the area (A) as well as the temperature gradient $\frac{dT}{dx}$

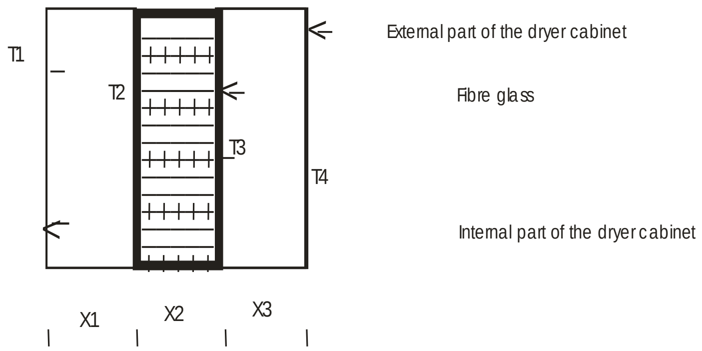

Fig. 1.1 Temperature profile of the drying cabinet

Using Fourier heat conduction equation which according to [8], is expressed as

$$Q \propto A\frac{dT}{dx} \quad (9)$$

where,

K_1 is the constant of proportionality characterizing the thermal conductivity of the material of the inside wall i.e metal sheet = 43 W/mk, [18].

Hence,

$$Q = K_1 A\frac{dT}{dx} \quad (10)$$

Integrating both sides in the appropriate limits of equation (10), we obtain

$$Q \int dx = KA\int dt \quad (11)$$

From equation (10) the rate of heat flow is expressed as

$$Q = \frac{K_1 A(T_2 - T_1)}{\Delta x_1} \quad (12)$$

Rearranging the equation,

$$T_2 - T_1 = \frac{Q(\Delta x_1)}{AK_1} \quad (13)$$

Similarly, heat flow through the insulating material is given by

$$Q = \frac{K_2 A(T_2 - T_3)}{\Delta x_2} \quad (14)$$

K_2 is the thermal conductivity of the insulating material fibre glass which according to [18] = 0.04W/mK

So that

$$T_2 - T_3 = \frac{Q(\Delta x_2)}{K_2 A} \quad (15)$$

where,

Heat flow by conduction through the outside wall of the chamber is given by

$$Q = \frac{K_3(T_3 - T_4)}{\Delta x_3} \quad (16)$$

From where,

$$T_3 - T_4 = Q\frac{\Delta x_3}{K_3 A} \quad (17)$$

where,

K_3 according to [18] is the constant of proportionality characterizing the thermal conductivity of the material of the outside (metal sheet) = 43 W/mK

Adding up equations (13), (15) and (16), we obtain,

$$T_1 - T_4 = Q\frac{\Delta x_1}{K_1 A} + Q\frac{\Delta x_2}{K_2} + Q\frac{\Delta x_3}{K_3} \quad (18)$$

$$\frac{Q}{A} = T_1 - T_4\left(\frac{\Delta x_1}{K_1} + \frac{\Delta x_2}{K_2} + \frac{\Delta x_3}{K_3}\right) \quad (19)$$

Equation (19) gives the expression for the rate of heat transfer by conduction from inside wall of the chamber i.e the rate of heat loss from the chamber. Also, the thickness of insulation used was calculated using the expression obtained by re-arranging equation (19)

$$\Delta x_2 = \left(\frac{Ak_2}{Q(T_1 - T_4)} + \frac{K_2}{K_1 \Delta x_1} + \frac{K_2}{K_3 \Delta x_3}\right) \quad (20)$$

Quantity of heat per second = 1500 W (From previous calculation, equation (7)

Assume a loss of 4% of the quantity of heat produced

$X_1 = X_2$ = 1cm

4% of the quantity of heat produced per second =q = 60 W (21)

Equating (21) and (12), we have

$$60 = \frac{43}{0.01}(50 - T_2)$$

T_2 = 49.99 ^{0}C

From equation (14), we have

$$60 = \frac{43}{0.01}(T_3 - 20)$$

T_3 = 20.01 ^{0}C

Also from equation (16)

$$X_1 = \frac{0.04}{60}(49.99 - 20.01)$$

= 0.019 m

Fibre glass 0.019 m thick should be used as the insulating material to achieve a minimal heat loss of 4 % from the drying chamber.

(vi) Length of chain required

Length of chain (L) = K x p

Shiegly and Mischke [19].

$$K = \frac{(T_1 + T_2)}{2} + 2\frac{x}{p} + \frac{(T_1 + T_2)^2}{2} + \left(\frac{p}{x}\right) \quad (22)$$

where,

T_1 = Number of teeth on the smaller sprocket

T_2 = Number of teeth on the larger sprocket

p = Pitch of the chain, and

x = Centre distance between the pulleys, (mm)

$$K = \frac{(14 + 42)}{2} + 2\frac{200}{10} + \frac{(42-14)^2}{2\pi} + \frac{10}{200}$$

$$= \frac{(14+42)}{2} + 2\frac{200}{10} + \frac{(42-14)2}{2\pi}\left(\frac{10}{200}\right)$$

= 74.23 mm

But $L = K \times p$ = 74.23 x 10

= 742.3 (Approx. 745mm)

(vii) Length of belt required

$$(L) = \pi(R_2+R_1) + 2x + \frac{(R_2-R_1)^2}{x} \quad (23)$$

Shiegly and Mischke [19].

where,
R_2 and R_1 = Radius of the largest & smallest pulleys
x = Distance between the centres of two pulleys
L = Total length of the belt.

$$L = 3.142\ (150 + 25) + 2(200) + \frac{(150-25)^2}{400}$$

= 1027.9 mm (Minimum)

From table A1.1 the nearness standard pitch length is 1102 mm for which the normal length is 1067mm –A 42 V- belt will be used. [15]

(vii) Design of receiving trough tray

The receiving trough tray is rectangular in shape, made of mild steel and positioned below the drying chamber. After drying, the dried corn will pass through the slotted path of the drum and transferred to the tray.

Volume of receiving trough tray = Volume of drum

Volume of receiving trough tray =Length x breadth x height

Volume of drum $= \pi R^2 L_D$ = 3.142 x 0.1^2 x 0.300 = $0.0094m^3$

$$L \times B \times H = 0.0094m^3 \quad (24)$$

0.3 x 0.2 x H = $0.0094m^3$

$$H = \frac{0.009m^3}{0.3 \times 0.2} = 0.156\ m^3$$

Volume of receiving trough tray = 0.3 x 0.2 x 0.156 = $0.0094m^3$

(viii) Power drive and Transmission

The power transmission is in two stages:

(i) from the electric motor pulley (driver) to the driven pulley on gearbox shaft and
(ii) from the driver sprocket on the gearbox to the driven sprocket on the stirring shaft.

A pulley of 50 mm diameter is mounted on the electric motor (2800 rpm))and connected to the input shaft of the gear box having a pulley of 300 mm diameter with the aid of an A-belt tensioned appropriately. This will reduce the input speed by ratio 6:1 and the required input speed to the gear box will then become 467 r.p.m

From the above information, the speed of driven pulley on gearbox can be calculated using the relation:

where,
N_1 = speed of the electric motor.
N_2 = speed of the input side of gearbox.
D_1 = diameter of the pulley on the electric motor.
D_2 =diameter of pulley on the output side of gearbox.
N_3 = speed of output side of the gearbox.
N_4 = speed of the paddle/stirrer shaft.
D_3 = diameter of small sprocket on output side of the gearbox.
D_4= diameter of pulley on the paddle/stirrer shaft.

$$\frac{D_2}{D_1} = \frac{N_1}{N_2} \quad (25)$$

Badmus and Adeyemi, [2].

$$N_2 = \frac{50 \times 2800}{300} = 467 \text{ rpm.}$$

Speed of the output side of gearbox at ratio 1:63 from the gearbox.

$$N_3 = \frac{N_2}{63} = \frac{467}{63} = 7.407 \text{ rpm}$$

Speed of the paddle/stirrer shaft at ratio 1:3 of the gearbox.

$$N_4 = \frac{N_3}{3} = \frac{7.407}{3} = 2.469 \text{ rpm.}$$

Power requirement for rotating the paddle/stirring shaft and gearbox shaft

Power requirement for gearbox shaft, (P_{gb})

P_{gb} = Torque x Angular velocity of gearbox shaft (26)
Jones [12]

Torque, $(\tau_{gb}) = W_{sp}+W_{pu}+W_{gb}+W_{wg}) \times R_{bpu}$ (27)
W_{sp} = Weight of smaller sprocket on output side of gearbox = 4.1 N
W_{pu}= Weight of bigger pulley on input side of gearbox = 18.3 N
W_{gb} = Weight of gearbox pinion shaft = 10.6 N
W_{wg}= Weight of worm gear = 11.0N
R_{bpu} = Radius of bigger pulley on input side of gearbox = 0.150 m
τ_{gb} = (4.1 + 18.3 + 10.6 + 11.0) x 0.150 = 6.6 Nm

Angular Velocity $(\omega_{gb}) = \frac{2\pi N_{gb}}{60}$ (28)

Where, N_{gb} = Speed of gearbox shaft .

= $\frac{2 \, x \, 3.142 \, x \, 466.7}{60}$ = 48.8791 rad/s.

P_{gb} = 6.6 x 48.8791 = 0.3226 kW

Also the power requirement for rotating the paddle/stirring shaft with full load (P_{ps}) is as follows:

P_{ps} = Torque x Angular velocity, of paddle/stirring shaft, (29)

But torque (ĭ) = total weight x radius of the bigger sprocket.

$(ĭ_w) = (W_c + W_{pd} + W_{sp}) \, x \, R_{bsp}$ (30)

where,

W_c = Weight of corn = 5 x 9.81 =.49.05 N.

W_{ps} = Weight of paddle/stirrer shaft = 78.7 N.

W_{bsp} = Weight of bigger sprocket = 21.2 N.

W_{bsp}= Radius of bigger sprocket = 0.100 m.

$ĭ_{ps}$ = (49.05 + 78.7 + 21.2) x 0.100 = 15.895 Nm.

Angular Velocity ($\acute{\omega}_{ps}$) = $\frac{v}{r} = \frac{2\pi N}{60}$ (31)

where, N = Speed of paddle/stirrer shaft

$\acute{\omega}_{ps}$ = $\frac{2 \, x \, 3.142 \, x \, 2.469}{60}$ = 15.5152 rad/s.

P_{ps} = 15.895 x 15.5152 = 0.2466 kW

The power required for rotating the paddle/stirrer and gearbox shaft ($P_{p/g}$)

$(P_{p/g}) = P_{ps} + P_{gb}$ (32)

= (0.3226 + 0.2466) = 0.5692 kW.

A 1 h.p (0.746 kW) electric motor is recommended for rotating the paddle/stirrer shaft and gear box.

Plate 1.2 shows the design work for the entire output of the stirrer: the electric motor, pulley, gear box, and sprocket.

Plate 1.2 Arrangement of electric motor, gear box and paddle/stirrer shaft.

The need of the gear box is to reduce the speed of the paddle fins/stirrer so that the corn can receive uniform distributed heated air. The preferred size of a reduction gear box locally available and to augment for the final output speed of 7.90 r.p.m has the following specification:

Pitch of pinion shaft = 6 mm

Number of teeth on worm gear = 63 teeth

Pitch circle diameter (P.C.D) of worm gear = 165 mm

Pitch circle diameter (P.C.D) of pinion shaft = 30 mm

Ratio of pinion shaft to worm gear = 1: 63

Output speed of gear box = $\frac{1}{63}$ = 0.01587 r.p.m

Total output of gear box from electric motor = 0.01587 x 498.33 =7.90 r.p.m

Furthermore, a sprocket of 42 teeth is mounted on the output shaft of the stirrer and connected to a 14 teeth sprocket on the output shaft of the gear box with the aid of a chain tensioned appropriately. This will reduce the input speed by ratio 1:3 and the required input speed to the stirrer will then become 3 rpm.

Then the final output of shaft speed = (Output of gear box) x (Output of stirrer)

= 7.90 x 0.333 = 2.635 rpm

CONSTRUCTION OF THE DRYER

The dryer components as shown in plate 1.1 were measured, machined, bolted, welded and assembled. Figure 1.2 shows the isometric view of the corn dryer according to the design specification. The component parts of the dryer are:

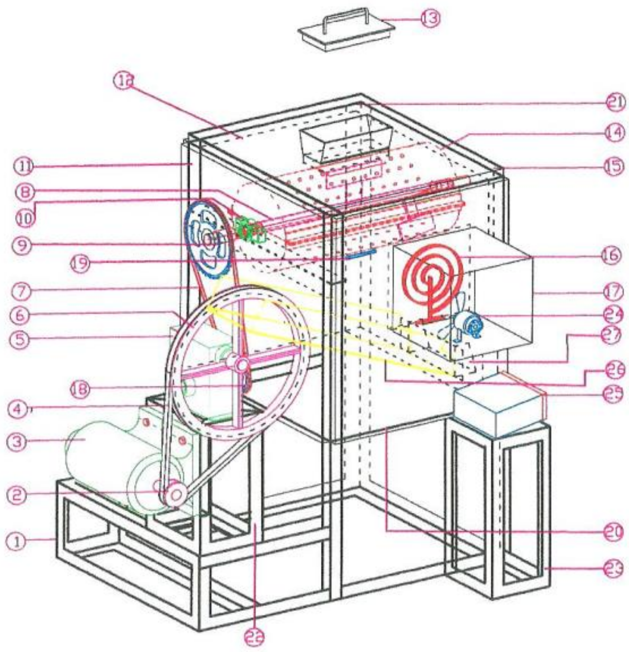

Fig. 1.2 CAD Isometric view of the developed corn dryer

(1) Frame, (2) Small pulley (Driven), (3) Electric motor, (4) Belt, (5) Gearbox,(6) Big pulley (Driven), (7) Chain, (8) Paddle/stirrer shaft, (9) Big sprocket (Driven)(10) Bearing case, (11) Left side cover, (12) Rear side cover, (13) Lid, (14) Drum/drying chamber,

(15) Right side cover, (16) Heater,(17) Front cover, (18) Small sprocket chain, (19) Thermocouple, (20) Bottom cover, (21) Top cover, (22) Electric motor holder, (23) Switch control holder, (24) Electric fan, (25) Electrical box regulator, (26) Discharge trough tray and (27) Discharge chute

THE BLOCK DIAGRAM OF POWER SUPPLY IN THE DRYER

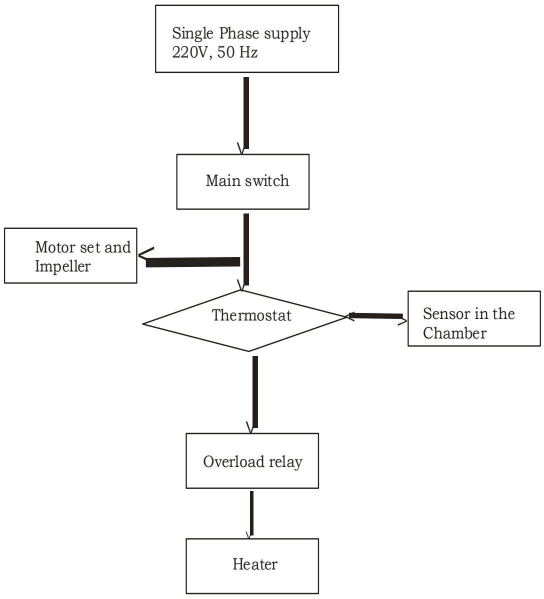

Fig. 1.3 The block diagram of power supply in the dryer.

EXPERIMENTATION AND TESTING

No-load Test.

A no- load test was conducted for the thermal profile in order to determine the maximum temperature the heater with capacity 1500W would give and also the time it will take the heater to reach these temperature at different fan speeds. Mujumdar [16], opines that the drying period may be significantly shortened by blowing air through the drying chamber when air is heated. In reference to this, an axial fan consisting of three (3) blades with speed 1400rpm (speed I) 1420rpm (speed II) and 1440rpm (speed III) was used. These fan speed were obtained by Tachometer.

RESULTS AND DISCUSSION

Results

The results are presented in Table 1.2 under No-Load condition of drying, temperature of the heated air from the heated source (1500W) inside the drying chamber were measured at three speeds I, II, III (1400, 1420 and 1440) rpm respectively at an interval of 2minutes for about 34minutes.

Table **1.2**

Time (min)	Temperature of drying chamber ^{0}C)		
	Speed I (1400) rpm	Speed II (1420) rpm	Speed III (1440) rpm
0	28	28	28
2	41	38	33
4	56	48	42
6	68	58	51
8	77	66	58
10	83	73	64
12	88	79	69
14	93	84	73
16	97	88	76
18	101	91	79
20	104	94	82
22	107	97	84
24	109	99	86
26	112	102	88
28	114	104	89
30	117	107	92
32	117	108	92
34	117	108	92

Temperature data under no load test of heater at different fan speeds

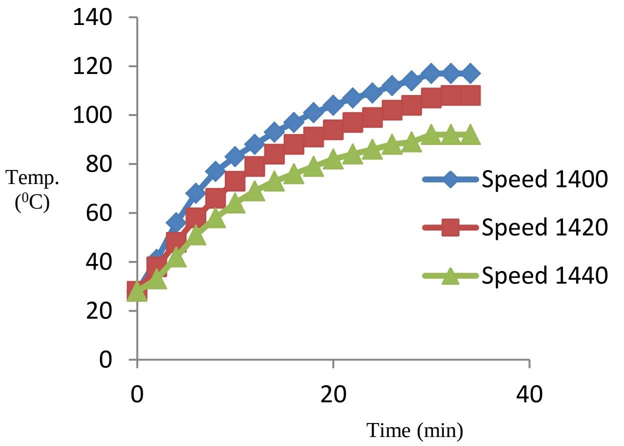

Fig. 1.4 Temperature profile under no-load with the heater at different fan speeds.

DISCUSSION

During No-load condition, it is observed that maximum temperature increases with fan speed I (1400 rpm). However, the maximum temperature decrease with fan speed III (1440 rpm). Heater (1500 W) at fan speed I (1400 rpm) gave the highest drying chamber temperature, while fan speed III (1440 rpm) gave the lowest drying chamber temperature. Thus, these figures can be used to predict the temperature of the heated air in the chamber at a specific drying time under No-load.

CONCLUSION

As a means of arresting the occurrence of post-harvest losses of corns in the farm due to local methods of preserving it, a corn dryer was designed and fabricated. It consists of a frame, drying chamber, fan/blower, paddle fins was subjected to no-load testing of the dryer.

From the results, heater (1500 W) at fan speeds I (1400 rpm), II (1420 rpm), and III (1440 rpm) attain the maximum drying chamber temperatures 117 ^{0}C, 108 ^{0}C, and 92 ^{0}C respectively in 30, 32, and 30minutes. This suggests that this drying system capable of supplying as high as 117 ^{0}C drying chamber temperature, could be a substitute for local drying methods especially in poor weather conditions.

REFERENCES

[1] Adzimah, K.S and Seckley, E {2009}: “Improvement on the Design of a Cabinet Grain Dryer”, *America Journal of Engineering and Applied Science* 2 (1). Pg. 217 -228. ISSN 1941 – 7020.

[2] Badmus,N and Adeyemi,A (2004): Design and Fabrication of a small scale whole Piniapple Fruit Extractor. Proceeding of the Nigerian Institution of Agricultural Engineers (A division of the Nigerian Society of Engineers), Vol.26, pg. 287– 291.

[3] Bennett, A.S., C.J. Bern, T.L. Richard and R.P. Anex.(2007). “Corn Grain Drying using Corn Stover combustion and CHP systems”, *Transaction of the ASABE*. 50(6): 2161-2170.

[4] Brooker, Brooker, D.B; Baker-Arkema, F.W and Hall C.W (1973): “Drying Cereal Grain”,*2nd Ed. New York. John Wiley and Sons*. Pg. 173 - 269.

[5[Brooker, D.B; Baker-Arkema, F.W and Hall C.W (1974): “Drying Cereal Grains”,*The AV1 Publishing coy; Inc. West port Connecticut USA,*Pg. 256.

[6] Brown R.B, G.N Fulford, T,BDaynard and A.G Meiering and L Otten (1979): “Effect of Drying on Grain Corn Quality”,*Cereal Chem.* 56(6): 529-532.

[7] Ertekin, C.; and Yaldiz, O.(2004): “Drying of Egg- plant and Selection of a suitable Thin Layer Drying Model”,*J. Food Engineering*. 63: 349-359.

[8] Frank, P.J and David, P.D (2002):” Fundamentals of Heat and Mass Transfer”, *Fifth Edition, John wiley and Sons (Asia) pte, Ltd; Singapore,* Pg 5 - 7.

[9] Hall, C.W. (1980): “Drying and Storage of Agriculture Crops”,*AVI Publishing Company, Inc. Westport, Connecticut, U. S A,* Pg. 134.

[10] Hall, A.S; Holowenko, A.R and Laughlin, H.G (1980): “Theory and Problems of Machine Design”,*Schaum’s Outline Series, McGraw-International Book Company, Singapore.* Pg.113- 130.

[11] Kiniry JRC, Tischler W, Rosenthal D, Gerik TJ (1992): “Non Structural Carbohydrate Utilization by Sorgtium and Maize shaded during Growth. Crop Science”, 32: 131-137.

[12] Jones, G. D (1982): Engineering and mechanical Science. Thomas Nelson and son Ltd, Waston road Causeway Bay,Hong Kong. Pg. 113 - 115

[13] Madhlopa A, Jones S AKalengaSaka J D (2002): “A Solar Air Heater with composite Absorber Systems for Food Dehydration. Renewable Energy”, 27; pg.27 – 37.

[14] McLean, K A (1980): “Drying and Storage of Combinable Crops”,*Farm press Ltd; Ipswish, Suffolk, United Kingdom,* Pg. 37.

[15] Mubeen, A (1998): “Machine Design”,*Khanna publisher, 2-BNath Market, Naisarak Delhi-110006* , Pg. 698 – 730.

[16] Mujumdar, A.S (2006): “Principles Classification and Selection of Dryers”,*Handbook of Industrial Drying, Ed; Mujumdar, A.S; Taylor and Francis Group, Part I,* Chapter 1, Pg.29 – 58.

[17] SahayK. M and Sangh K.K (1994): “Unit Operations of Agricultural Processing”,*Vikas Publishing house PVT Ltd. Bhopal,* Pg.38 – 55.

[18] www.Engineeringtool.com (2010): “Thermal Conductivity of some Materials”,*Accessed* 15th March, 2010.

[19] Shiegly, J.E and Mischke, C.R (2001): “Machine Design”,*McGraw-Hill, Singapore.* 4th Edition Pg. 356 – 360.