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Design, Construction and Experimental Evaluation of a Double Slope Solar Dryer in Kano, Nigeria

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ABSTRACT

This paper involved designing a double slope indirect cabinet type solar dryer. Good method of preservation such as drying is required to keep the crops at the right or safe moisture, content needed, this dryer is designed purposely to attain this safe, moisture content of the crops (tomatoes), which 'is an improvement of the traditional methods of sun drying which is not controlled. A special consideration is focused on the required design parameters based on Kano climate. The dryer generates higher air temperature and consequently low air relative humidity, which are both conducive to improve drying rates and lowered final moisture contents of the dried products.. Over 50% savings in time can be achieved by using solar crop dryers as against the traditional sun-drying.

KEYWORDS: *Moisture content, double slope, Relative humidity, Solar constant and solar altitude*

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NOMENCLATURES / NOTATIONS

SYMBOLS	NOTATIONS
I_{SC}	Solar constant, normal incidence intensity at average earth-sun distance
I_0	Radiation intensity beyond earth's atmosphere
δ	Solar declination
I_d	Diffuse radiation
I_{ND}	Direct normal solar intensity
β	Solar altitude
m	Air mass
a, ρ, τ	Absorptance,,Reflectance and Transmittance for solar radiation.

σ	Stefan-Boltzmann constant (has value of 5.67 x 10-8W/m2k4)
T	Temperature
W_1	Quantity of the crops to be dried
M_1	Initial moisture content of the crop
M_f	Final moisture content of the crop
H	Latent heat of vaporization
T_{ab}	Mean ambient temperature
T_{max}	Maximum allowable drying air temperature
T_d	Drying air temperature
ϕ	Ambient relative humidity
V_a	Mean ambient air velocity
R	Monthly average daily global radiation
η_c	Assumed collector efficiency
L	Latitude of a place the drying is taking place
θ	Tilt angle of the collector
A_c	Collector area of the solar collector
n	Drying period (days) of the crop

h

Chimney height

D_2

Chimney diameter

I. INTRODUCTION

Many sources of raw energy have been variously proposed or used for the generation of power. Only a few sources-fossil fuels, nuclear fission, and elevated water are dominant in application today. A more complete list of sources would include fossil fuels (coal, petroleum, natural gas); Nuclear (Fission and fusion); wood and vegetation ;elevated water supply; solar; winds; tides; waves; geothermal ;muscles (man and animal); industrial; agricultural and domestic waste; oceanic thermal gradients; oceanic currents. Historically, wood, elevated water and wind were predominant. These sources were superseded in the industrial era by fossil fuels, with nuclear energy the most recent addition. Features for acceptability include reliability, flexibility, portability, size, bulk, weight, efficiency, economy, maintenance and costs. The plant for transportation service must be self-contained. [1] The energy situation facing the world today is [hat utilization of fossil fuels (Coal, Petroleum, Natural Gas) is at it peak. The world's energy need at present, supplied by fossil fuels is about ninety percent (90%) of its total energy needs. This energy source, which took millions of years to form, may be essentially depleted very soon. The use of fossil fuels resources has its attendant effects on the environment; we are therefore faced with too many questions such as;

i. Do we continue to use the fossil fuels resources disregarding the consequences on the environment (Depletion of ozone layer)?
ii. Do we continue to use the fossil fuels resources until it gets depleted completely?
iii. Should we choose complex centralized energy production method?
iv. Should we use simpler widely dispersed energy production method?
v. Which sources of energy should be emphasized for increase efficiency?
vi. How can we rely on current energy sources and provide for integrated energy planning?

The combined answer to the above questions is to look for alternative since we must take the responsibility of our existence here on earth, and this decision will affect energy use for generations. Solar energy is fast becoming an alternative energy source. It is because of the high rate of depletion of the environmental energy sources. It is preferred to other alternative sources of energy because it is abundant, inexhaustible and non-polluting. Equally it can be tapped at relatively low cost and has no associated dangers of fire or other hazards. Therefore the use of solar energy and its applications ', for rural development cannot be overemphasized. It is estimated that "the areas of the world lying between latitude 35° North and 35° South of the equator and which have at least 200 hours of bright sunshine per year are ideal for the utilization of sun's energy. From the standards, Nigeria is well endowed with abundant solar energy, being located between latitude 4° and 14" North of the equator. Solar energy plays a vital role in domestic needs for energy such as cooking, water heating, air conditioning and refrigeration, generation of electricity as well as drying. [2]

II. SOLAR RADIATION INTENSITY

In space at the average earth-sun distance, 150rnillion km, solar radiation intensity on a surface normal to the sun's rays is 1353±21W/m^2. This quantity is called solar constant I-sc, undergoes small (±2percent) periodic variations, which affect primarily the short-wave portion of the spectrum. Since the earth's distance varies throughout the year, the intensity beyond the earth's atmosphere Io also varies by ±3.3percent as shown in table 1.1 below.

TABLE 1.1 ANNUAL VARIATIONS IN SOLAR DECLINATION AND SOLAR RADIATION INTENSITY BEYOND THE EARTH'S ATMOSPHERE [1]

DATE	Jan.1	Feb. l Nov.	Mar. l	Apr. 1	May 1	June 1	July1
Declination, deg	-23.0	-17.1	-7.7	+4.4	+15.0	+22.0	+23.1
Ratio, Vise	1.033	1.029	1.017	1.000	0.983	0.971	0.96

Intensity, Io	443.4	441.6	436.5	429.2	421.9	416.7	415.0
(W/m^2)	1398	1392	1376,	1353	1330	1314	1308

The great seasonal variations in terrestrial solar radiation intensity are due to the earth's tilted axis, which causes solar declination 5 (the angle between the earth's equatorial plane and the earth sun line) to change from 0° on March 21 and September 21 to -23.5 on December 21 and +23.5 on June 21. In passing through the earth's atmosphere, the sun's radiation is partially and selectively absorbed, scattered and reflected by water vapour and Ozone, air molecules, natural dust, clouds and manmade pollutant. Some of the scattered and reflected energy reaches the earth as diffuse or sky radiation I_d.. The intensity of the direct normal radiation I_{DN} depends upon the clarity and the amount of perceptible moisture in the atmosphere and the length of atmospheric path, which is determined by the solar altitude p and expressed in terms of air mass m which is the ratio of the existing path length to the length when the sun is at the Zenith. Except at very low solar altitudes, m =1.0/sinβ. Hence solar radiation falling on a body can undergo three processes;

i. Absorption, α

ii. Reflection, ρ and

iii. Transmission, τWhere $\alpha + \rho + \tau = 1$

In the case of a black body, it is a body that absorbs all radiation falling upon it. It is also a perfect emitter and the energy it emits is a function of its temperature i.e. $E = \sigma T^4$. For a body that is not black, it is termed gray body and it emits less energy, i.e. $E_g = \varepsilon \sigma T_g^4$. These properties a, p and τ are all functions of the wavelength. [I

III. AVAILABILITY OF SOLAR ENERGY

The utilization of solar energy in a particular location to determine the economic and performance of systems requires essentially the knowledge of the availability of solar radiation at that location. Detailed information on the availability of solar energy is needed for its efficient utilization. The total energy production of the sun amounts to 3.68 x 10 watts but from the sun-earth geometry, only the small fraction of this energy is intercepted by earth. The earth and atmosphere receive on continues basis about 1.73 x 10 watts of the radiant energy from the sun an amount, which is over 500 times greater than the other sources of the earth's energy. This energy is reduced due to the absorption and scattering in the terrestrial atmosphere with the result that the energy received on the earth's surface is made up of both direct and diffuse components. It is estimated that areas of the world lying between 35°N and 35 S of the equator are ideal for the utilization of the sun's radiant energy. From this standard, the geographical location of Nigeria places it within a moderately high Sun Belt of the world. [3]

IV. AVAILABILITY OF SOLAR RADIATION IN NIGERIA

Accurate measurement of solar radiation in Nigeria is fairly recent and the results from scattered measurement centers in Nigeria have been put together and compiled into solar radiation maps for the twelve months of the year. The highest man irradiation value of over30MJ/m day occurs are observed generally in the semi-arid North in April while the lowest value of about 12MJ/m day occur in the more humid and forest regions of the South from July to September. Country with minimum levels of insolation occurs in the rainy seasons from May to October while maximum level of insolation occurs in the dry season from November to April.The actual number of hours of sunshine for Nigeria is about 3000 per year. The solar energy available from this is sufficient for all solar energy base technology in almost any part of the country.

V. APPLICATION OF SOLAR ENERGY TO CROP DRYING

Harvested agricultural products must be stored dry to prevent attack and destruction by microorganisms and fungi. At some stages of food preparation, drying is also necessary. With the availability and characteristics of solar energy mentioned above, it is clear that it could be utilized to effect drying of food products. This energy can be used in drying agricultural products so. as to enable storage without spoilage- This method of drying has been in practice since the beginning of agriculture. The main advantages of this system of drying are hygienic, efficient and most importantly are its control during the drying process. [3]

VI. CROP DRYING REQUIREMENTS IN NIGERIA

Both rain-fed and irrigation agricultural production is practiced in Nigeria and over 75% of the total crop produced is grown during the rainy season. Irrigated product is practiced mainly in the Northern Nigeria. Maize Millet, sorghum, Soya beans, groundnut and rice are the most common grains grown in Nigeria. The tubers include yam, cassava, Irish and sweet potatoes and the common vegetables are tomatoes, onions and pepper. Because preservation facilities are insufficient, the prices of these commodities can fluctuate during the year. Most of these crops may require drying after harvest for short or long term preservation. The needs for crop drying are more serious in the middle belt and southern parts of Nigeria where the relative ambient humidity is relatively high during the harvest season. This makes it extremely difficult dry crops, naturally in the field. In Northern Nigeria, over 95% of the planted grains dry down naturally in the field before final harvest, usually under favorable conditions such good sunshine and low relative humidity. However, supplementing heating for drying may be required for early harvested crops.

Tomato is the most widely used and important vegetable in Nigeria and it is mainly produced in the Northern and Western Nigeria through irrigation schemes. During both the dry and wet seasons harvest, tomatoes are abundant an cheap but because preservation facilities are poor, the price of this commodity can be five times higher at the end of the harvest both in Southern and Northern Nigeria. Cutting into slices and drying can adequately preserve tomatoes. Other crops grown both in North and South that may be preserved by drying include yam, cassava, pepper, groundnut and okro. Solar drying can-be applied to all these crop-drying needs. [3]

VII. SUN DRYING PROBLEMS

The general practice of drying agricultural products or .crops in several developing countries is sun drying and the sun is the source of .energy, for drying. Generally sun drying applies to the spreading of the crops in the sun on a suitable surface, hanging crops from eaves of a building, trees etc and drying on the stalk by standing in stocks or bundles. Although sun drying requires little capital or expertise, it has many limitations and problems. Loss of moisture is usually intermittent and irregular and the rate =of drying is generally low, thus increasing the risk of spoilage during the drying process. The final moisture content of the dried product can be high because of low air temperatures and high relative humidity, which can result in crop spoilage during subsequent storage. Contamination by dust, infestation by insects and rodents, theft or damage by birds, the need for relatively large areas of land or surfaces to spread crops are also problems associated with sun drying. Improvement in the sun 'drying techniques by solar dryers would allow maximum utilization of solar radiation and other climatological factors, a reduction in the various forms of contamination and hence an improvement in the quality of product and a reduction in drying time for agricultural products. [3]

VIII. METHODOLOGY

The method OF carrying out the project will depend on the absorption of the solar energy by the solar dryer. This amount of energy and other parameters will be determined in the design analysis, which includes the following;

i. Tilt angle of the solar collector (G)
ii. Collector area (A_c)
iii. Air inlet area (A_1)
iv. Drying period (n)
v. Total dryer energy
vi. Chimney height and
vii. Chimney diameter

The construction of the double slope solar dryer will be based on the
design parameters to investigate the effect of drying the domestic crop (tomatoes, pepper, okro, etc). The dryer will equally be used to rest the drying rate of these products, colour changes of the agricultural products.

IX. LITERATURE REVIEW

SUN DRYING

Sun drying is one of the mankind's oldest preservative or techniques. The traditional technique or practice of crops drying is to spread crops on the ground, thus exposing it to the effects of sun, wind, rain, animal, insects and dust etc. the logic of this is inescapable; the sun supplies an appreciable and inexhaustible source of heal to evaporable moisture from the crop and the velocity of the wind to remove the evaporated moisture is, in many locations, at least the equivalent of the air How produced in a mechanical dryer. Even today, sun drying of agricultural products remains the most common drying method in. tropical developing countries. It is first employed when the crops are standing in the field prior to harvest. For instance, maize cob may be left on the standing plant for several weeks after maturity. Although not requiring labour or other inputs field drying may render the grains subject to insects' infestation, prevent the land being prepared for the next crop and is vulnerable to theft and damage from animals. Drying in the Field may also be carried out after harvest with the harvested crops laid in stocks with, the grain, maize cobs or .panicles raised , above the ground and exposed directly to the sun. [6] Drying on fiat exposed flat surface is the most common way of drying crops after harvesting and threshing. For drying small amounts on the farm, crops may be spread on any convenient area of land. Contamination with dirt cannot be easily avoided with this method, and the need for moving the crops for under cover in the event of rain is one of the major problems encountered with sun drying. However, it is still by far, the most widely practiced agricultural processing operation. [5]In Nigeria, over eighty percent (80%) of the harvested products are sun dried. That is why even in rainy weather, though drying will be slow, every effort is made to prevent wet freshly-harvested products from overheating with deterioration in quality by spreading on floors rather than let them remain in heaps, sacks with more spoilage. Above all, sun drying (i.e. direct drying of crops from the sun) has devastating effect on the crops taste, colour, and nutritive value which are the vitamins, toughness and shrinkage of the crop especially when drying harvested crops like tomatoes, pepper. [5]

SOLAR DRYING

An improved technology in utilizing solar energy for, drying materials or agricultural products is the use of solar dryers where air is heated in a solar collector and then passed through the beds of the products, [9]. However, it differs from sun drying in that a simple structure, such as flat plate solar collector is used to enhance the effect of isolation and minimize loss of the collected sun energy to the surroundings. Solar drying preserves crops by removing enough moisture from the crops to prevent decay and spoilage. Water content of properly dried agricultural product varies from5 to .25 percent depending on the crop. Successful drying depends on the following;

i. Enough heat to draw out moisture, without cooking the food.
ii. Dry air to absorb the release moisture and
iii. Adequate air circulation to carry off the moisture. [8]

Solar drying of agricultural products removes moisture as quickly as possible at a temperature that dose not seriously affect the flavour, texture and colour of the products as in the case of sun drying. The fact' '•"remains the same that if the temperature is too low in the beginning, microorganisms may grow before the product is adequately dried. On the other hand, if the temperature is too high, and the relative humidity is too low, the product may harden on the surface. This makes it more difficult for moisture to escape but with solar drying, such is eliminated as in the case of sun drying. The higher temperatures attainable are also deterrent to insects and microbial infestations and drying in an enclosed structure enhances protection against dust, insects, animals and theft. The benefits derived from solar drying cannot be overemphasized. Dried solar foods are tasty, nutritious, light, easy-to-prepare and easy-to- store and use. The energy input is less than what is needed to freeze or can, and the storage space is minimal compare with what is needed for canning jars and freezers containers, The nutritional value of the dried crops is minimally affected by drying. For instance, vitamin A is retained during drying. The dried products are equally high in fiber and carbohydrates and low in fat, making them healthy food choices. Solar drying makes provisions for complete drying of the crop, which eliminate the problem of mold. [7]

X. REVIEW OF PAST/PRESENT WORKS IN SOLAR DRYING

A number of commercially research works on solar drying has been going on in Nigeria, more than twenty years mostly in Universities and Polytechnic colleges in the Department of Agricultural/Mechanical engineering. Some of the work has been published in journals or conference proceedings but other work remains unpublished although it has been documented as project reports.,Ofi (1982) constructed and evaluated a solar dryer using a flat plate collector. Although he did not dry any crop, with it, he obtained a drying chamber temperature that was about 50 above the ambient under maximum sunshine conditions. He calculated an overall efficiency of 30%.Awachie (1982) used a solar hot box to dry fish, coconut and maize. He obtained air temperature of 45-50 C in the chamber during the wet seasons and above 50 C during the dry seasons. Pie reported that 0.74kg of coconut lost 0.l43kg of moisture within twenty-four (24) hours and that uncut fish were fully dried in less than 72 hours, withabout 50 C of the moisture lost within the first 25 hours..Arinze (1985) has successfully designed a commercial solar dryer for maize and other cereals that will be suitable for the Northern part of Nigeria..B. Garba, A. T. Atiku and A. S. Sambo (1993) fabricated two passive solar dryers at Sokoto Energy Research Center. The two dryers were tested for two different dates, 16/3/93 and 18/3/93 with potato chips and tomatoes slices. Potatoes chips and beef cuts look 2 /^ days each to dry, while tomato slices took 3 days and onion slices took 4 days..Before 1980, some experimental solar dryers were tested at the Universities of Nigeria Nsukka and Ife. In 1980, the design and evaluation were reported for a solar dryer with a concentrator type of collector in which shelled maize and slice plantains were dried (Igbeka 1980). Latter, a flat plate collector was used to heat air for drying maize on cob and sliced okro (Igbeka 1982) and this dryer was modified as a solar dryer/storage system by Araoye (1984) with very satisfactory results.Globally, successful solar drying initiatives have been carried out. Fruits of the Nile in Uganda are working with hundreds of women to dry pineapples, mangos, chillis and banana for export..In Kenya GTZ played a key role introducing the technology. Most of the work is with simple direct lowest cost type solar dryers. Such simple designs use frames made of wood inside which screen traysare laid. An ultraviolet resistant plastic film is used as a cover..KIRDI is actively working with institutions and women's groups in developing improved dryers for processing of fruits, vegetables, and cereals in a commercial basis.work by chancellor (1965) and Soemardi (1979) has demonstrated that paddy can be dried from 24 to 26% moisture to 14% moisture at depths of 50 to 100mm at the rate of3.3kg/m h for stirred paddy and1.9kg/m h for unstirred paddy. The grain can reach temperature as high as 60° C under clear skies. In the rate of the drying, such can be extremely high.

XI. CLASSIFICATION OF SOLAR DRYERS

Drying implies the partial removal of water from the material, but when fuel fired equipment is used in the process, then the term dehydration is often applied. Condition essential to both drying and dehydration includes the supply of heat energy to evaporate the water and a supply of air to carry away the water vapour produced. In open air solar drying, the heat is supplied by direct absorption of solar radiation by material being dried. The vapour produced is carried away by air moving past the material, the air motion being due to either natural convection resulting from contact with the heated material or to winds. In dehydration using fuel heat, the material being dried is placed in an enclosure and heated air is blown past the surface of the surface of material to remove moisture. Solar dryers make use of solar radiation, ambient temperature, and relative humidity. Heated air is passed naturally or mechanically circulated to remove moisture from materials placed inside the enclosure, [10].

XII. TESTING

During testing, two sets of experiments were

1. NOLOADTEST
2. DRYING TEST

XIII. NO LOAD TEST

During this test the dryer was mounted east west. The solarimeter for measuring solar radiation was placed close to the dryers. The thermometer were use to measure the inlet air temperature, the absorber plates temperature and the inlet air temperature. The readings were tabulated at intervals of 30 minutes. The result were tabulated as follows:

TABLE 4.1 NO LOAD TEST DATA

DATE	TIME	I(W/m2)	Tl(°C)	T2(°C)	T3(°C)	T4(°C)
09/09/05	12:00PM	776.6	34.5	66.0	60.0	33.0
09/09/05	12:30PM	848.8	33.0	68.0	62.0	35.0
09/09/05	1:00PM	830.8	33.0	65.0	63.5	34.0
09/09/05	1:30PM	803.7	32.0	63.5	64.0	32.0
09/09/05	2:00PM	758.5	31.5	60.0	64.0	33.0
09/09/05	2:30PM	776.6	32.0	56.0	66.0	34.0
09/09/05	3:00PM	695.3	33.5	48.5	65.0	35.0
09/09/05	3:30PM	650.2	33.0	45.0	60.0	33.0

09/09/05	4:00PM	605.0	32.0	43.0	63.0	31.0
09/09/05	4:30PM	478.4	31.0	44.0	62.0	31.0

KEY

I = Solar radiation (W/m^2)
T1 = Air healer inlet temperature for slope 1 and 2 (°C)
T2 = Absorber plate temperature for slope 1 (°C)
T3 = Absorber plate temperature for slope 2 (°C)
T4 = Drying chamber temperature (°C)

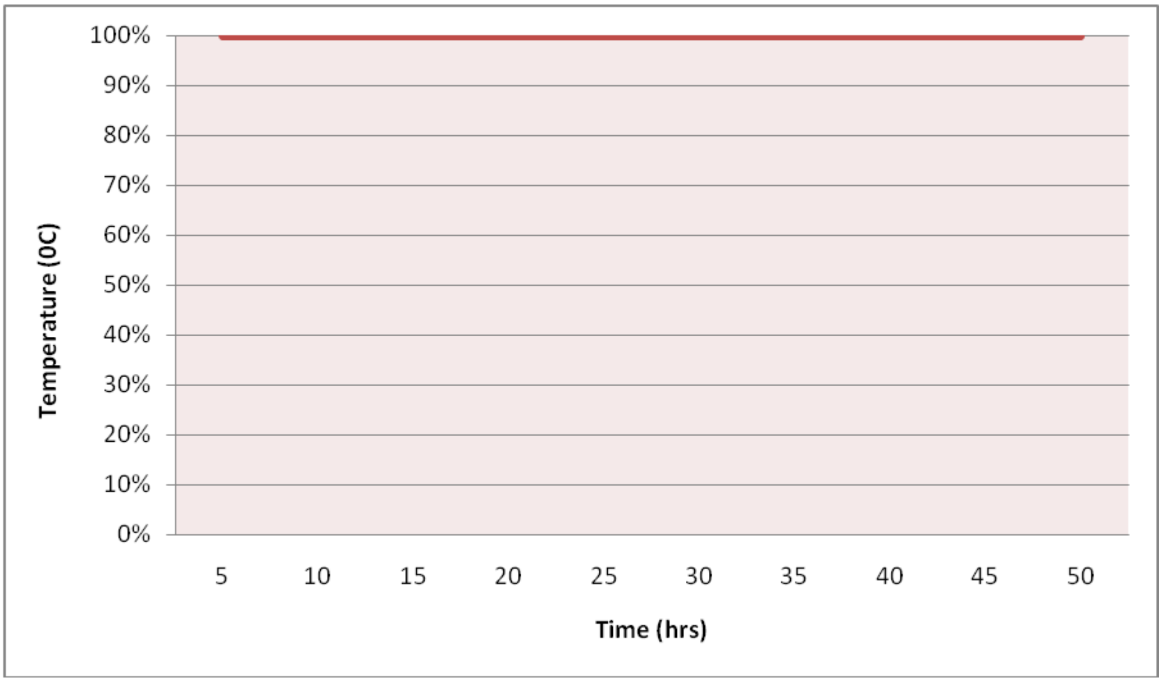

Fig. 4.1: Variations of Temperatures with Time

XIV. DRYING TEST / LOAD TEST

The set up of this experiment is similar to that, outlined above. One crop (tomato) was dried and the weight variation was carefully monitored.During the process of drying, the product was weighed at regular intervals of three hours each day starting from 09/09/05 at 5.00pm to "12/09/05 at 3.00pm, the crops undergoing solar drying were left in position in the dryer.
The results were tabulated as follows:

TABLE 4.2 DRYING TEST DATA

DATE	TIME	WEIGHT (kg)
09/09/05	5.00pm	2.08
10/09/05	9.00am	1.70
10/09/05	12.00pm	1.45
10/09/05	3.00pm	1.10
10/09/05	6.00pm	0.95
11/09/05	9.00am	0.89
11/09/05	12.00pm	0.77
11/09/05	3.00pm	0.65
11/09/05	6.00pm	0.55
12/09/05	9.00am	0.40
12/09/05	12.00pm	0.34
12/09/05	3.00pm	0.25

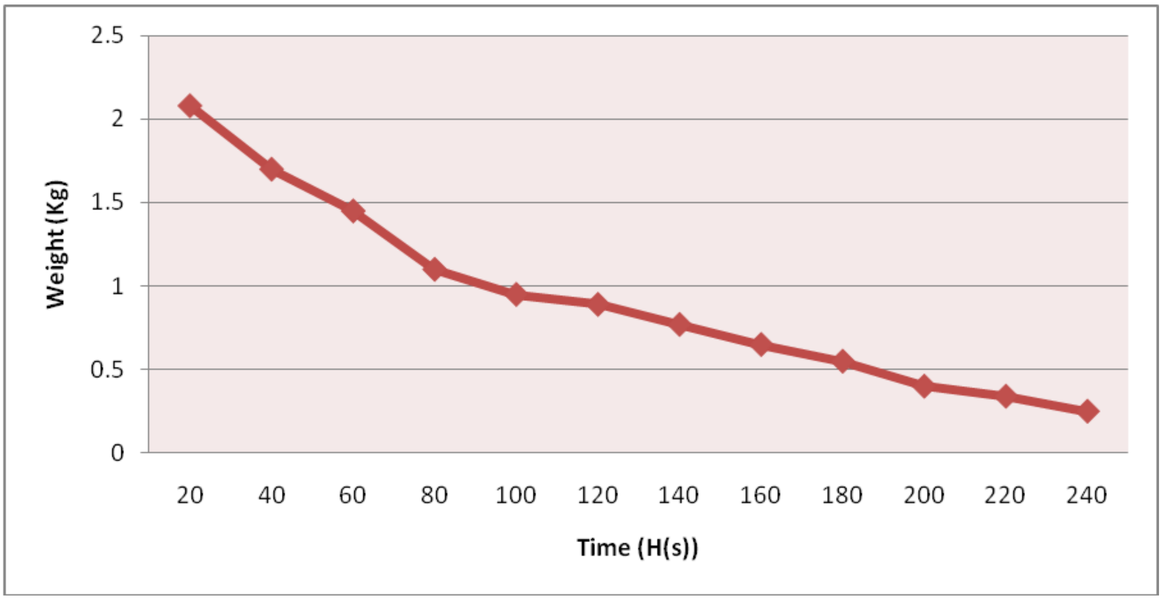

Fig. 4.2: Variations of Weight with Time

DISCUSSION OF RESULTS

(a) NO LOAD TEST

The no load test was conducted on the dryer. The test was carried mainly to observe the temperature variations of different parameters in the dryer. In this test, variations in absorber plates temperatures, drying chamber temperature and inlet temperatures for both slopes were monitored. The performance curves for all these parameters are as shown in figure 4.1.It can be seen from table 4.1 that the solar radiation increases with time until it reaches a maximum of848.8W/m^2 at 12.30pm and then decreases with time.

Figure 4.1 indicates that;

i. T_1increases from 31°C to 45°C and then fluctuates slightly
ii. T_2 increases with time until it reaches its maximum value of 68^{0}1 12.30pm.
iii. T_3 equally increases with time until it reaches it maximum value of 66°C at 2.30pm.
iv. T_4 increases with time to a maximum temperature of35°C and fluctuates.

(b) DRYING TEST

The drying test was conducted with the crops loaded. The test was carried to determine the rate at which the crops were dried and the weight variations of the crops with time. The curve of this test was shown in figure 4.2 the solar dryer was tested with fresh tomatoes from 09/09/05 to 12/09/05.

It can be seen from the figure 4.2 that the weight decreases rapidly with increase in time from 2.08kg to 0.25kg in 70 hours.

TABLK 4.3 COST ANALYSIS

ITEM	SIZE	QUAT1TY	AMOUNT
Melai sheet	1350x475 mm	2	800:00
Glass	1135x435mm	2	1,600:00
Plank		2 sheets	1,000:00
Plywood		2 sheets	3.000:00
Glue gum	1 Litre	ITin	150:00
Nails	2 inch	1 Lab	150:00
Electrodes		Half dozen	100:00
Black paint		2 Litres	300:00
Wire gauge		3 yards	240:00
Pair of hinge		3	150:00
Handle		3	60:00

TOTAL = N7,450:00
Labour, 10% of the cost = N 745
Grand total cost of the dryer = N 8,202:00

XV. CONCLUSION AND RECOMMENDATIONS

Solar energy, which is sufficiently abundant in most developing countries and in Nigeria particularly, can be used to provide heat for various applications in homes, industries, and agriculture. Some low temperature energy system, such as those ones applied in crop drying and food processing is highly recommended to conserve fossil fuels. Crop drying is necessary in Nigeria and inmost developing countries, for both long and short-term crop preservations. Double slope solar dryer was successfully designed, constructed and tested. It essentially consists of double air heater made up of22gauge Steel sheet absorber plate of 1.3 x 0.475m in size. The plate was covered with outer casing. The sides of the casing were made of plank wood. The bottom covers were made of plywood and the top transparent covers were made 3mm thick glass, 1.135 x 0.435m.The drying chamber contains two porous trays for loading and unloading the crops. The inlet air openings are located at the bottom sides of the both air healer while the outlet opening is located at the chimney on top of the drying chamber. This dryer was tested with fresh tomatoes only due to short period of lime. Two types of test were conducted, i.e. the NO LOAD TEST and the DRYING TEST. For the NO LOAD TEST, maximum plates temperatures were 68 (^{0}C and 66^{0}C for slope 1 and 2 respectively and a maximum drying chamber temperature of35 (^{0}C.During the DR.YING TEST, the double slope solar dryer was tested with fresh tomatoes with initial weight of 2.08kg the weight of the fresh tomatoes dropped to 0.25kg with some of the sliced tomatoes completely dried while some were yet to be completely dried in 70 hours.

The results of the experimental tests on solar crop drying indicated that solar crop dryers performed satisfactorily in drying various agricultural products under varied weather conditions. The solar dryers have considerable advantages over the traditional uncontrolled sun-drying methods in terms of faster drying rate and handling convenience. Over 50% savings in time can be achieved by using solar crop dryers as against the traditional sun-drying. Further, by using solar dryers, harvesting at higher moisture content is possible without fear of spoilage. An intensive campaign is needed for adoption of solar crop drying technique for short and long term crop preservation in Nigeria and other tropical developing countries. With the adoption of solar dryers technological method, and with successful combination of the modern food preservation and processing methods, the spoilage of our agricultural products will become a thing of history.

RECOMMENDATIONS

i. Owing to the limited time of the project, the dryer was tested for a short period of lime with only one crop. Therefore long-term test should be carried to cover different times of season with different crops.
ii. Even though the dryer operates on natural air circulation, afan may be incorporated at the air inlet to increase airflow and hence decrease drying time.
iii. Owing to the fact that the air can pick up more moisture only when its relative humidity is low there is a need to construct a device that will reduce the relative humidity of the air before entering into air heater.
iv. For further research work, there is a need to use metallic drying chamber, which will equally contribute immensely to the required energy for drying the crops.

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