Design of Experimentation process for grains and herbs drying process using Conical Solar Dryer

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Abstract :Drying is one of the methods used to preserve food products for longer periods .The objective of this work is to develop a conical solar dryer in which the grains are dried by forced convection, the air passing through the aluminum plate present in the collecting tank heated due to high temperature of plate due to trapped heat by glass .The other problem arise is orientation of sun which is eliminated by conical solar dryer containing four drying chamber so that orientation of sun does not become the issue]1][2 .[This paper presents an experimental investigations and Sequential classical experimentation technique has been used to perform experiments for various sizes of green herbs at different weather conditions to establish model for moisture removal rate for drying operation .This paper also reports the experimental procedure to establish mechanical properties using specially designed instrumentation during experimentation.

Keywords *:Conical Solar dryer, forced convection, Green Herbs, Instrumentation*

I. INTRODUCTION

The disadvantages of open sun drying need an appropriate technology that can help in improving the quality of the dried products and in reducing the wastage .This led to the application of various types of drying devices like solar dryer, electric dryers, wood fuel driers and oil-burned driers]3 .[However, the high cost of oil and electricity and their scarcity in the rural areas of most third world countries have made some of these driers very unattractive .Therefore, interest has been focused mainly on the development of solar driers]4,5 .[One basic disadvantage of forced convection dryers lies in their requirement of electrical power to run the fan .Since the rural or remote areas of many developing countries are not connected to the national electric grids, the use of these dryers is limited to electrified urban areas .Even in the urban areas with grid-connected electricity, the service is unreliable .In view of the prevailing economic difficulties in most of these countries, this situation is not expected to change in the foreseen able future .The use of natural convection solar dryer could boost the dissemination of solar dryers in the developing countries .Therefore, experimental performance of solar dryer has been evaluated in this project.

This project presents the design, construction and performance of a solar conical dryer for food preservation .In the dryer, the heated air from a separate solar collector is passed through the perishable food item .The results obtained during the test period revealed that the temperatures inside the dryer and solar collector were much higher than the ambient temperature during most hours of the day-light .The temperature rise inside the drying cabinet was up to 74 %for about three hours immediately after 12.00h)noon .(

II. PROBLEM CONSTRAINTS

Drying processes play an important role in the preservation of agricultural products] 6 .[They are defined as a process of moisture removal due to simultaneous heat and mass transfer . The purpose of this project is to present the developments and potentials of solar drying technologies for drying grains, fruits, vegetables, spices, medicinal plants .The traditional method of drying, known as 'sun drying, involves simply laying the product in the sun on mats, roofs or drying floors .Major disadvantage of this method is contamination of the products by dust, birds and insects –Some percentage will usually be lost or damaged, it is labor intensive, nutrients loss, such as vitamin A and the method totally depends on good weather conditions .Because the energy requirements -sun and wind - are readily available in the ambient environment, little capital is required .This type of drying is frequently the only commercially used and viable methods in which to dry agricultural products in developing countries .The safer alternative to open sun drying is solar dryer .This is a more efficient method of drying that produces better quality products, but it also requires initial investments .If drying conditions such as weather and food supply are good, natural circulation solar energy, solar dryers appear to be increasingly attractive as commercial proposition.

III. CONSTRUCTION OF CONICAL SOLAR DRYER

The experimental set-up of an indirect forced /natural convection solar dryer consists of a flat plate solar air collector, conical drying chamber and four drying trays .The schematic diagram of the experimental set-up is shown in fig 1 .A 1 mm thick heating plate)made up of Aluminum (sheet painted with dull black paint is used as a collector plate to absorb incident solar radiation .The solar air collector was fixed along all direction .The radiation collector heating plate)made up of Aluminum (plate is placed inside the solar collecting tank such that the air can flow over and below its surface and get heated .The heated air temperature is measured with the help of temperature sensors LM35 .The sensor LM35 can measure the temperature variation from -550C to 1250C . The heating plate)made up of Aluminum (plate is hinged on four column frame which is placed on the bottom of the collecting tank.

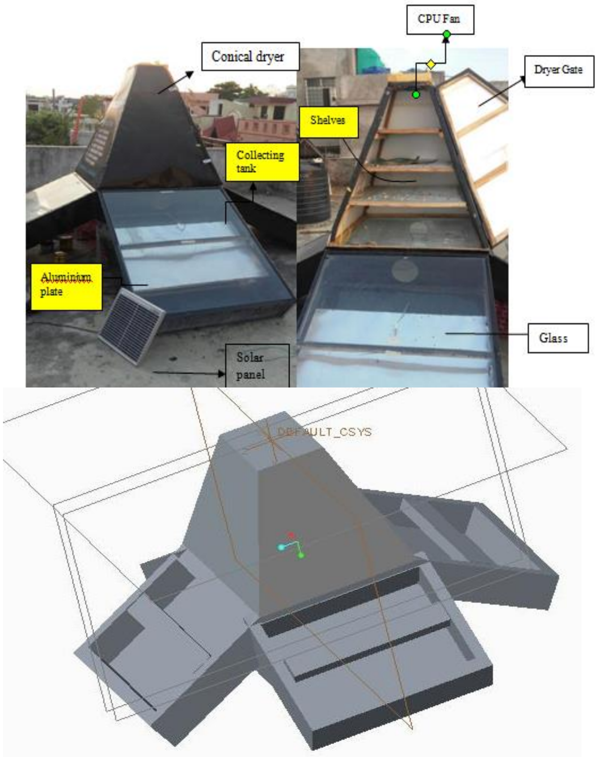

Fig.1 :Experimental Setup of Conical Solar Dryer

The collecting tank is the important part of the system .It is made of tin having rectangular dimensions and is open from the top side of it .It has rectangular cross section inlet having a net placed over it of dimensions 900mm x 210mm at its lower end to provide air inlet .It also has the exhaust outlet of diameter 160 mm .On the opposite side where the blower is fixed so that blower can provide forced convection .The anemometer is used to measure the air velocity at the outlet of blower .Different air velocities are required for different vegetables and green herbs, so the regulator is used to regulate the speed of the blower.

The glass having thickness 6 mm is used as a transparent cover for the air collector to prevent the top heat losses and to trap the heated air by providing packing .It is mainly used for allowing the radiation from sun to enter the solar radiation collecting tank .It is placed above the heating plate)made up of Aluminum (plate at about 15 mm height on the collecting tank for free circulation of air coming from inlet .Thermocol is used as insulating materials which is used to reduce heat losses from solar dryer .The insulation material is stick on the outer surface of the solar radiation collecting tank with the help of fevicol and covered with black color plastic tape and also used inside the wooden box to maintain the inside temperature of heating chamber .

The wooden box is used for receiving the heated air from the blower at the bottom which take up the moisture of the vegetables on the shelves inside it and provided with circular vent at the top to pass-out the exhaust air .A temperature sensor and humidity sensors are placed inside the wooden box to measure temperature and humidity inside the wooden box .The solar panel is placed on the top of the wooden box which generates electricity to run the blower .The whole system is placed on the fixed stand made of Aluminum .

Table 1 :Details of drying chamber

Sr .No.	Parameters	Values
1	length	900 mm
2	Breadth	900 mm
3	Height	1100 mm
4	Material	M.S .Steel)2 mm thick(
5	No .of Shelves	3
6	Volume of drying chamber	8.91m^3

Table 2 :Details of solar collector assembly

Sr.No.	Parameters	Values
1	Length	900 mm
2	Width	1200 mm
3	Height	210 mm
4	Absorber plate	0.1 mm Aluminum sheet
5	Surface treatment	Black paint coating
6	Glass	Clear glass of thickness 6 mm
7	Insulation	Thermocol
8	Frame	Made of Mild Steel
9	Collector slope)β(	Fixed at 30° with horizontal
10	Airflow area)at inlet and outlet(	0.189 m^3 & 0.0016m^3
11	Distance between cover and absorber plate	50 mm
12	Blower	120mm dia., 2500rpm CPU fan

IV. WORKING

Solar dryer)shown Fig .1 (is dependent on the availability of sunlight, air movement, humidity and food which is to be dried .So, firstly we have to select the most suitable area or region where this solar dryer should be placed for the maximum output .The solar radiation collecting tank has to collect maximum radiation coming from sun, so collecting tank is placed along all the four side at 30° from horizontal.

The weight of the vegetables or herbs is taken, which is to be dried are placed on the trays inside the M.S .Steel box .After this the door is closed to provide packing so that heated air should not skip .The connection of solar panel to the blower is engaged .The blower starts rotating and creates partial vacuum inside the collecting chamber, which sucks air from the surrounding.

When the air from the surrounding enters in the solar radiation collecting tank through the rectangular cross section at the lower end, which passes over and below the collecting surface and gets heated due to the solar radiation incident on the collecting plate .This air gets heated to a maximum temperature and is trapped due to the glass packing .This heated air is made to pass through the exhaust via blower run by solar panel at the top side of the solar radiation collecting tank to the wooden box inlet .The heated air is passed in the wooden box through a pipe connecting the collecting tank and the wooden box .When the heated air is made to flow over the vegetables, it will take up the moisture until it is virtually fully saturated, that is absolute humidity has been reached.

The M.S .Steel box is fully insulated from inside because the capacity of the air to take up the moisture is dependent on its temperature .The higher the temperature, the higher will be the moisture take up .There is also an exit at the top of the wooden box for air outlet .The temperature of aluminum plate in the solar radiation collecting tank and inside the M.S .Steel box was taken after a particular interval of time .After the drying process which may range from 1 to 2 days, the weight of the dried food is measured.

Drying will also be considered in integrated, herb processing operations with technologies and entrepreneurship combined to create successful business that will create many entrepreneurs in suicide hit /drought hit areas of Vidharbha.

V. INSTRUMENTATION FOR MEASUREMENT OF INPUT AND OUTPUT PARAMETERS AND EXPERIMENTAL PROCEDURE

A. The experimental measurements:

Three thermocouples)LM35-Precision Centigrade Temperature Sensors (have been positioned to measure the air temperature at the inlet, middle portion and outlet portion of the air heater with accuracy of ±1 .Other thermocouples have been placed on trays in order to measure the temperature of trays .To measure ambient temperature one more thermocouple placed outside the dryer in air .Humidity is measured with the help of hydrometer placed at the stand of dryer chamber .Air velocity or flow rate of air at the inlet position of the drying chamber was measured by anemometer .All the readings are recorded and delivered to computer via USB port using specially designed electronic Kit and recording software shown in fig .2

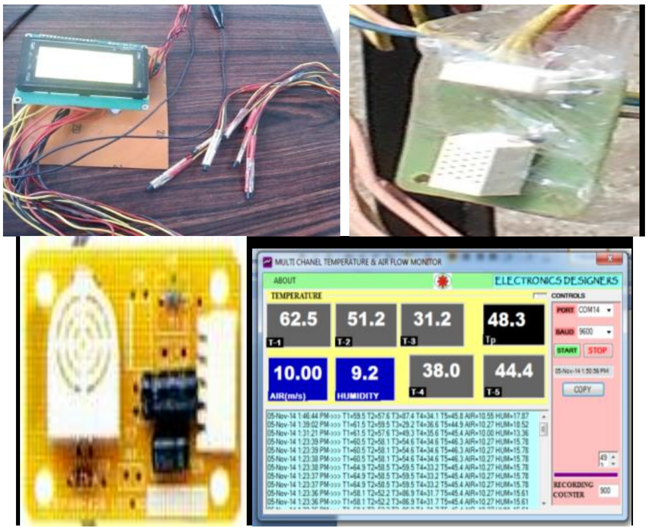

Fig .2 :Anemometer, Electronic Circuit along with thermocouples, humidifier and window of software for measurement of temperature, humidity and air velocity.

B. Construction & Working of Instrumentation System for Experimental Setup:

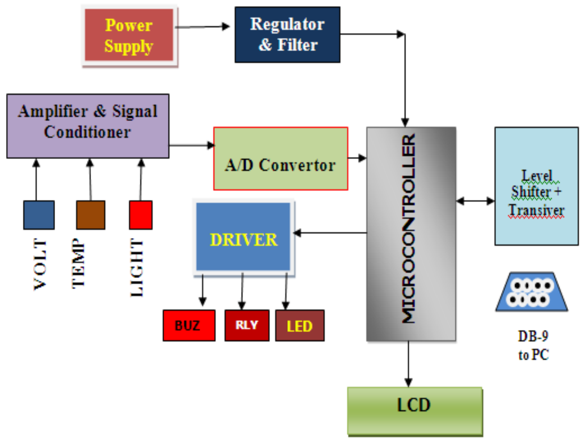

Fig. 3 :Block Diagram of Instrumentation System

1. Construction:

The microcontroller is main part of the whole circuit .The potential transformer, current transducer, humidity sensor, oil temperature and oil level of transformer .The 5V of supply is being given to the microcontroller, MAX232, and the various sensors .And the 12V is given to the driver IC2803 to operate the relay .The relay is here is used as a switch where it will only connects the contactor in case of normal condition or disconnects in case of abnormal condition.

a) Major components of instrumentation system are:
b) PIC)Peripheral Integrated Controller(
c) Regulator IC)7805(
d) Driver IC)ULN2003(
e) Precision Centigrade Temperature Sensors)LM35 (
f) Proximity Sensor
g) Transformer

h) MAX232)Interfacing IC(
i) LCD 16 x 4

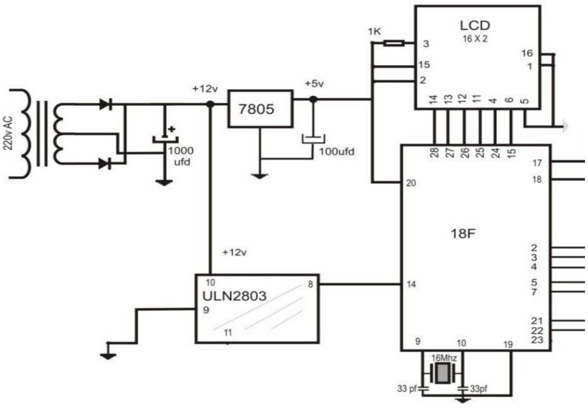

Fig 4 :Circuit Diagram of Instrumentation System

2. Working:

The above block diagram)fig.3 (represents the actual block diagram of the monitoring of Multiple Data of Temperature, Humidity and Air Flow .It consists of various blocks such as microcontroller, measurement devices and sensor unit along with interfacing IC .The parameters to be analyze for monitoring are Humidity, Air Flow, temperature within the solar dryer unit by using microcontroller which is further connects with a PC or laptop this collected data will further save to analysis .As shown in the fig. the power transformer is used to step down the voltage of 230V single phase to 12V . The 12V supply is being rectified to 12V by using the full wave rectifier .This rectified supply is regulated to 5V .This 5V of supply is need for the working of microcontroller, MAX232 IC, and the various equipped sensors .The P.T .are energized by the line conductors .The LCD used to display the monitored parameters on the solar dryer unit itself .The driver IC is used as a current booster to amplify the current from the microcontroller, used to drive the relay.

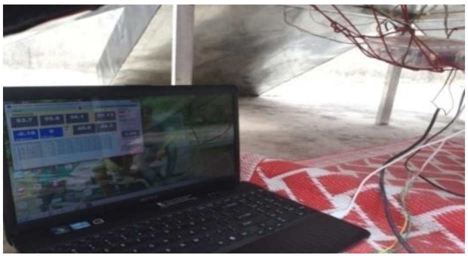

Fig. 5 :Instrumentation System while reading generation

In experimental set up no direct measurement of parameters was possible so indirect measurements are used, as electric voltage signals are used to measure the parameters . Fig. 4 shows designated instrumentation system .Fig.5 specify the instrumentation while generating the readings .The calibration of the designing instrumentation system was carried out by using measuring instruments in Measurement laboratory of the institution.

VI. EXPERIMENTAL PROCEDURE

The design of experimentation has given a road map of how the experimentation is planned .But implementation of experimental plan and conduction of actual test run requires a systematic detailing of execution .

A. The detailed procedure for the test run is as under:

1) For Solar drying of various types of herbs, seven to eight types of herbs like Neem)Sweet and bitter(, Spinach, Methi, Karela, Chilli, Coriander, Tulsi, Amla Sour and sweet)Broken and chips(, Potato)chips (and Green peas should be selected one by one on each day of experimentation.
2) Before starting of experimentation any one crop was selected and its weight is measured on weighing machine for proper selection of crop in proportion.
3) The experiment was conducted according to location at Nagpur, Central India)latitude 21°06 'N and Longitude 79°03'E (and the orientation of the solar collector has been fixed towards the south direction, inclined at an angle of 31°.
4) Air velocity or flow rate of air at the inlet position of the drying chamber was measured by anemometer.
5) Humidity, Temperature of collector plate, ambient temperature and dryer chamber)box (temperature was recorded during experimentation using hydrometer and thermocouples)which are already placed inside heat collector chamber, air and dryer .(
6) During experimentation time of drying, length of day and date of experimentation was recorded during experimentation.
7) At the end of experimentation weight of dried crop is measured and difference of Weight and dry crop is calculated, to evaluate moisture loss during experimentation.
8) Similar experiments were repeated by changing collector plate material .Initially GI Steel sheet, then aluminum and then copper plate were used during experimentation .
9) Fig .6 and fig .7 Shows products /green herbs dried during experimentation .Table III :Sample readings of solar drying process.

)a) (b(

)c) (d (

Fig. 6 :.Samples of potato)a (Before drying in dryer)b (before drying in open atmosphere)c (after drying by dryer)d (after drying in open atmosphere

Fig. 7 :.Spinach)a (Before drying)b (after drying in dryer)c (after drying in open atmosphere

Table 3 :Sample readings of solar drying process

Time	T∞ċ	Tp1	Tp2	Tp3	Tp4	Tp5	Air Velo)m/s(	Humi dity (%)
10:00	31.6	52.6	55.1	53.7	53.7	44.9	12.9	12.71
12:00	36.2	56.1	61.0	62.0	59.5	50.2	13.5	7.87
2:00	35.6	66.4	77.1	75.6	64.9	51.7	12.2	7.07
4:00	34.1	60.6	70.2	67.8	55.5	51.2	12.5	8.96
Mean	34.37	58.93	65.85	65.5	58.4	49.5	12.76	9.15

B. Comparison Chart of moisture removal rate:

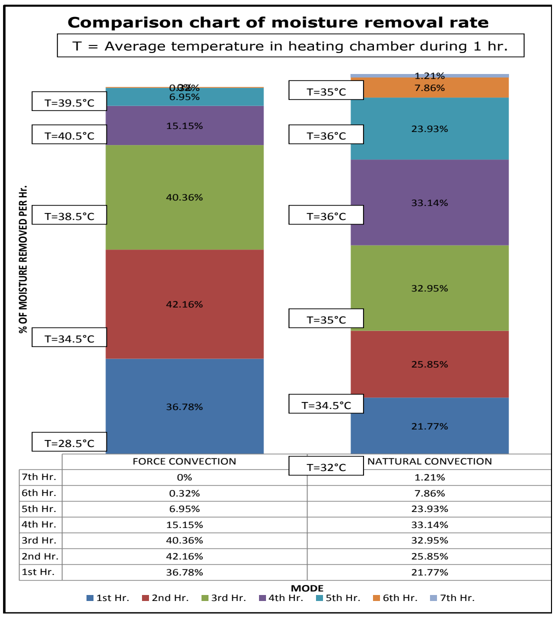

Fig 8 :.Comparison chart of moisture removal rate

Fig. 8 shows comparison of moisture removal rate using Natural and force convection] 10.[

POTATO CHIPS –Weight Before Drying =612 gms

Weight After Drying =88 gms

Total Moisture Lost =85 %

C. Sample Calculations of Solar Drying Process:

Sample Calculations of Solar Drying Process for forced convection

1) Convective heat and mass transfer coefficient from crop to air)h(

h is Calculated using relation $(Nu) = \{\frac{h.Dh}{K}\}$.....(1(

Where Dh is hydraulic dia in m,and K is thermal Conductivity of heating medium in W/m^{2o}C.

T_∞ = Ambient Temperature.

T_{p1} = Temperature of aluminum plate at initial point = 50.4075°C

T_{p2} = Temperature of aluminum plate at at Mid point =51.56°C

T_{p3} = Temperature of aluminum plate at End point = 52.6825°C

T_{box} = Box Temperature=46.3175

Average T_∞ =34.375°C

Average Tp =51.55 °C

Average T_{box} =46.3 °C

Film temperature) =Tp +T / (∞2 =42.9625°C

For 42.9625°C

v =kinematic viscosity =17.30 x 10^{-6} m^2 /sec

Pr =Prandtl number =0.67759125

Cp =Specific heat =1005 J/kgk

k =thermal conductivity=0.0275807375 w /mk

R_{ed} =Reynolds number =u.Dh/v

u = Air velocity =6.0175 m /sec.

Dh =Hydraulic diameter =4 Ac/P

Ac =Cross-section area of inlet =0.0735 m^2

P =Perimeter of inlet =1.61 m

Reynolds no =63689.19 > 2300

Hence flow is turbulent

For turbulent flow

Nu =0.023 Re$^{0.8}$ pr$^{0.4}$

=137.2042

Nu =h Dh /k

h =20.723 watt /square meter kelvin

2) *Heat energy required for drying crop)Q(*

Q is calculated using relation

$(Q) = \{h.A_p.(t_p - t_\infty)\}$ ……..(2(

Where Q is heat flow in watts,A_p -Cross section Area of heating plate, tp&$t_\infty$is Temperature of plate and ambient in ^{o}C resp.

Q =h As)Ts -T(∞ …………)3(

= 332.7112 watt

For both sides of plate

Q =332.7112 x 2

=665.422 watt

3) *Efficiency of heat collector plate*)η_c (

η_c is Calculated using relation$(\eta_c) = \{\frac{Q}{I.\ A_s}\}$] 7)-------[4 (

ω = hour angle) =h-12 (x 15 =0

Where, h is time

We calculate for 12 p.m .

h =12.00

Declination)δ:(

This is the angle between the sun's direction and the equatorial plane and is given by,

δ =23.45 sin]0.9863)284 +n] [(7)------------[5(

where,)n (is the day in the year which varies from n =1 to n = 365.

δ =declination angle) for n =301 for 28th October, 2015] (7[

- =14.10 º

Angle of incidence

Cos)θi=(Sinδ*Sin)Φ-β+(Cosδ*Cosω*cos)Φ-β] (7… [.(6(

Where,

) φ =(21.1º is the latitude of the location.

β =slope angle =31.1 º

Cos)θi = (0.9974

Solar heat flux I =Ig x Cos)θi (

Where,

Ig is global heat flux in W/m^2.

θi is the angle of incidence .

Ig =796 W/m^2]7) [at 12.00 hrs .for October Month from Data Book(

I =Ig x cosθ_I= 796*0.9974 =793.95 W/m^2

Efficiency of aluminum plate)η = (Q /IA$_S$ =0.4482 ….(7(

=44.82 %

Dryer efficiency calculations]7[

$\eta_d = \frac{\Delta M * L}{I_c * A_s * t}$……… (8(

Where)L (is the latent heat of vaporization of water)KJ/Kg(,)ΔM (is difference of the mass of the crop before and after drying, Ic is global heat flux in W/m^2, Surface Area of the heating plate)A$_s$(, m^2 and)t (is the time of drying in sec .For effective four hours duration

$= \frac{0.58*2257*1000}{793.95*0.9348*3600*4}$

=0.0887 i.e .8.87%

% moisture Loss)PML(

PML is calculated using relation(%ML) $= \left(\frac{M_{ci}-M_{co}}{M_{ci}}\right)$ ….).9(

Where, Mci =mass of crop sample before drying and Mco = mass of crop sample after drying .

Table 4: Sample reading of mass of crop after and before drying

Material	Mass of crop before drying	Mass of crop After drying	Moisture Loss	%of Moisture Loss, %M= ML/Mci
	M_{ci} in Kg	M_{C0} in Kg	ML in kg	%M
Neem_bitter	1	0.42	0.58	58
Neem_sweet	0.8	0.33	0.47	58.75
spinach	1	0.32	0.68	68
Methi	1	0.26	0.74	74
Tulsi	0.55	0.21	0.34	61.81
Karela	0.73	0.33	0.4	54.79
Karela	0.75	0.38	0.37	49.33
Chilli	0.828	0.486	0.342	41.30
Chilli	0.75	0.455	0.295	39.33
Coriander	0.927	0.182	0.745	80.3
Amla Sour)Broken(	0.525	0.166	0.359	68.3
Amla Sweet)Broken(	0.365	0.162	0.203	55.6
Amla)Chips(	0.73	0.3	0.43	58.9
Potato)chips(	1	0.652	0.348	34.8
Green Piece	0.9	0.4	0.5	55.5

Table 5 :Sample observations sheet of solar drying process

SN	Material	Amb. Temp , ta	Plate Temp ., tp	Box . Temp ., tb	Film Temp, tf	Tem pDiff erenc e ΔT	Hu midi ty, H
1	Neem_bitter	34.38	51.6	46.32	40.35	11.9	31.4
2	Neem_sweet	29.11	46.4	41.36	35.24	12.3	37
3	spinach	34.08	50.9	46.02	40.05	11.9	16.9
4	Methi	36.49	53.5	48.55	42.52	12.1	31.7
5	Tulsi	34.23	51.5	46.5	40.37	12.3	35
6	Karela	32.48	49.7	44.68	38.58	12.2	25.2
7	Karela	31	48.1	43.14	37.07	12.1	25.4
8	Chilli	32.55	49.5	44.48	38.52	11.9	19.1
9	Chilli	39.9	56.8	51.89	45.89	12	19.4
10	Corrainder	28.68	45.9	40.83	34.75	12.2	11.4
11	Amla Sour)Broken(	32.23	49.3	44.37	38.3	12.1	26.8
12	Amla Sweet)Broken(	30	46.9	41.99	36	12	28.6
13	Amla)Chips(	30.83	47.6	42.67	36.75	11.8	25.8
14	Pottato)chips(	31.1	48.2	43.19	37.14	12.1	24.7
15	Green Piece	32.43	49.2	44.67	38.55	12.2	27.6

VII. IDENTIFICATION OF VARIABLES AFFECTING THE PROCESS:

The term variables are used in a very general sense to apply any physical quantity that undergoes change]9 .[If physical quantity can be changed independently of the other quantities, then it is an independent variable .If the physical quantity changes in response to the variation of one or more number of variables, then it is termed as dependent or response variable . The variables affecting the effectiveness of the phenomenon under consideration are shown in Table VI .

TABLE VI ::Dependent and Independent variable with units and symbols solar drying Operation

S.N.	Variables	Symbol	Unit	Dependent / Independent
01	%moisture Content %)M(	PML	%	Dependent
02	Mass of air flow	m_a	Kg/S	Dependent
03	Convective heat transfer coefficient from crop to air	h	W/m²°C	Dependent
04	Heat energy required for drying crop	Q	W	Dependent
05	Efficiency of heat collector plate	η_c	%	Dependent
06	Efficiency of dryer	η_c	%	Dependent
07	Velocity of air	v_a	m/s	Independent
08	Ambient Temperature	t_∞	°C	Independent
09	Temperature inside the heating Chamber	t_p	°C	Independent
10	Temperature inside the drying chamber	t_b	°C	Independent
11	Film Temperature $t_f = t_p + t_\infty/2$	t_f	°C	Independent
12	Relative Humidity	H	%	Independent
13	Dynamic Viscosity of air at temp .t_f	μ_a	NS /m²	Independent
14	Thermal Conductivity of air at temp . t_f	K_a	W/m°C	Independent
15	Specific heat of air at temp . t_f	C_{pa}	J/Kg°C	Independent
16	Density of air at temp .t_f	ρa	Kg/m³	Independent
17	Length of heating Plate	L_p	m	Independent
18	Width of heating Plate	B_p	m	Independent
19	Thickness of heating plate	T_p	m	Independent
20	Thermal Conductivity of heating Plate	K_P	W/m°C	Independent
21	Specific heat of heating Plate	C_{pp}	J/Kg°C	Independent
22	Thermal diffusivity of heating Plate	α_p	m²/s	Independent
23	Specific Density of heating Plate	ρ_p	Kg/m³	Independent
24	Volume of heating Chamber	V_{hc}	m³	Independent
25	Volume of drying Chamber	V_{dc}	m³	Independent
26	Solar heat flux	I	W/m²	Independent
27	Angle of incident	ϴ	rad	Independent
28	Length of Day	N	--	Independent
29	Mass of crop after drying	Mci	Kg	Independent

VIII. CONCLUSIONS

Under this experimental investigation of thermal performance of solar dryer gives the temperature difference of atmospheric air and drying chamber of solar air heater of near about 10 to 17 °C on a moderate sunny day .It is suitable dryer for producing hot air of space heating and agricultural drying applications .From the interaction made with manufacturers of herbal products, solar system designers, literature cited and cursory survey conducted in Vidarbha region of the state of Maharashtra)India (following conclusions have been drawn:

)i (The design data, economic viability and feasibility, low cost of fabrication will help them to start small scale industry.

)ii (The green herb drying process parameters properties of green herbs are established through Theory of experimentation, which was unknown in previously mentioned literature .

The data in the present work is collected by performing actual experimentation .Due to this, the finding of the present study truly represents the degree of interaction of various independent variables .This has been made possible only by the approach adopted in this investigation .

Drying rate:

There was very varying difference in overall drying times between solar force convection dryers, solar natural convection dryer and open sun drying .According to result it is clear that the moisture removal rate is very high in force convection than in natural convection and later in open sun drying .To remove moisture around 80 –85%, the force convection required approximately 5 Hrs, for natural convection it requires approximately 7 Hrs and for open sun drying it requires approximately 7 –8 Hrs.

Final moisture content:

The reduction in moisture content possible by drying in a solar dryer)to 13%, on average (was consistently greater than that obtained by natural convection drying and sun drying)21%, on average .(As explained previously, storage life is dependent in part upon the moisture content and, therefore solar force convection drying could give a product with a much longer storage life than sun drying .The yield however would be slightly less.

Product quality:

According to test carried out, it is clear that the aesthetic look is maintained in solar force convection drying than in solar natural convection drying or in open sun drying]8.[

a (Natural Convection Dried Potato Chips b (Force Convection Dried Potato Chips

Fig. 9 :Comparison between Natural convection and forced convection drying process

It was considered that the food in the solar dryers were, almost without exception, of high quality .However for the food dried in the open sun drying, a possible health hazard might exist because of the relatively large numbers of flies which were attracted into the food .Solar-dried food was judged to be of higher quality than those dried in the open sun drying

In conclusion, it can be said that force convection solar drying gave a better product result than natural convection solar drying and then on the open sun drying .The open sun drying has a major problem with flies and dirt present in the atmosphere which could be a serious health hazard .In the Nagpur, the capacity of these solar dryers would be sufficient to dry part of the individual daily catch .However, a greater capacity would be required for the larger quantities foods.

The findings of the research work is presented to various solar drying system manufacturing industries of Vidarbha region and also the system is demonstrated to farmers of Vidarbha region .An awareness has been created amongst farmers and future entrepreneurs by demonstrating the solar drying system and the product .

For more efficient working of the model, design can further be implemented as follows-:

- Heating coils can be used inside of the solar radiation collecting tank to heat the inlet air which can be run using battery.
- Tubes and V-shaped plate can be used in place of flat plate for increasing the surface area of collector .
- Conical heat collector chambers can be used for increasing the surface area of collector, which also helps to increase drying rate of herbal products.
- For increasing efficiency solar radiation tracking system can be implemented.
- Sand and pebbles may be kept inside the solar radiation collecting tank to hold maximum amount of heat radiation for a long time.

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