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Investigation Of Solar Biomass Hybrid System For Drying Cashew.

Dhanuskodi.S[1]*, R.Sukumaran*[2], Vincent .H.Wilson*[3]

[1]Assocoate Dean, PRIST University Puducherry Campus, Puducherry,
[2]Assisstant Professor, Dept. of Mech Engg., PRIST University,Puducherry Campus
[3]Dean, Engineering and Technology, PRIST University,Thanjavur.

*Corres.author: dhanush_er@yahoo.co.in

Abstract: In the present energy scenario utilization of Solar Biomass Hybrid System proves to be the need of the day. Twenty percent of fossil fuel gets depleted by 2020. Also India is a tropical country and agriculture is one of the important sectors to develop our economy. This paper deals with the research in the area of effective utilization of alternate energy resources for agricultural applications in the rural area. In this investigation a solar flat plate collector supplies hot air for a batch type drier. Suitable draught is provided with a help of a D. C. Fans. Additionally a D.C. Blower is provided for proper circulation of air through a Bio-mass gasifier which supplies heated air in the cloudy days. According to the need either solar air drier or Bio-mass gasifier can be used separately or both can be utilized as an integrated system.

Experiments have been conducted on various solar days for drying various batches of cashew using solar air drier and bio- mass gasifier separately as well as in hybrid mode and the results are analysed and the findings are presented.

Key Words: Flat plate collector, Solar drying, CNS, Moisture removal rate.

I. Introduction.

Need of a solar drying:

The current energy scenario clearly depicts that the available fossil fuel resources and its derivatives may not satisfy the future demands. The need for alternate energy resources is the need of the day. India is a tropical country and we receive solar power throughout the year for most of the days in a year. Utilization of solar power is one of the important areas to be discussed today. Our country is an agricultural country and the utilization of solar power for drying of agricultural produces is a boom to our country's economy. Especially in rainy days without drying facilities a vast amount of agricultural produces gets wasted and it affects the farmer's life. A batch type drier is supplied with hot air heated by a solar flat plate collector or air Heated by a bio mass gasifier[8].

India is blessed with good sunshine. Most parts of the country receive mean solar radiation in the range of 5-7 kwh/m² and has more than 275 sunny days in a year[1].

India is the fifth largest energy consumer. India is experiencing an acute shortage of electric power that is likely to be worsening day by day which stresses the need for deployment of renewable energy resources to extenuate this energy crisis. Since India is a country which is abundant in natural resources the substantial availability of renewable energy sources in the form of solar, biomass, biogas, hydro-power and wind energy can be provide opportunities of sustainable energy based development.

Drying is an essential process in the preservation of agricultural products. Food products, especially fruits and vegetables require hot air in the temperature range of 40-60˚c for safe drying. Drying under controlled conditions of temperature and humidity helps the agricultural food products to dry reasonably rapidly to safe moisture content and to ensure a superior of the product[9].

The main reasons for selecting solar energy for drying may be the lack of availability of conventional energy sources to remote and rural areas or the high cost of transportation of fuel to those areas.

Hybrid solar systems allow for faster rate of drying by using other sources of heat energy to supplement solar heat.

Solar dryers can broadly be categorized into direct, indirect and specialized solar dryers. Direct solar dryers have the material to be dried placed in an enclosure, with a transparent cover on it. Heat is generated by absorption of solar radiation on the product itself as well as on the internal surfaces of the drying chamber[10].

In indirect solar dryers, solar radiation is not directly incident on the material to be dried. Air is heated in a solar collector and then ducted to a drying chamber to dry the products.

Specialized dryers are normally designed with a specific product in mind and may include hybrid systems where other forms of energy are also used. Although indirect dryers are less compact when compared to direct solar dryers, they are generally more efficient..

Solar drying is often differentiated from “sun drying” by the use of equipment to collect the sun’s radiation in order to harness the radiative energy for drying application. Sun drying is a common farming and agricultural process in many countries, particularly where the outdoor temperature reaches 30˚C or even higher.

The dryer can be used for drying various agricultural products. It can reduce drying time and improve quality of the dried product. In the recent years, Indian farmers face a great difficulty in drying the nuts, grains, etc. electrical heating method was widely used to dry the seed coat and remove the **TASTA** of cashews with an expensive electricity cost and power shortage. Hence, biomass gasifier was introduced as an alternative method to solve this problem for drying seed coats of the cashews. We need an A.C blower to circulate air in the gasifier.

Wood chips are one of the sources of biomass renewable energy that can produce gas through gasification. This source has the greatest potential of any renewable energy option for base-load electric power production for electricity generation and heating. High penetration of biomass technologies requires an abundant supply of biomass resources.

At present our solar dryer consisting of 10 aluminium wire screen trays that which is capable of removing 10kg of **CASHEW NUT SHELL (CNS)** per batch.

Nomenclature:

T_I	Collector inlet temperature, °C
T_o	Collector outlet temperature, °C
G	Solar global irradiance, W/m²
Q	Heat energy,kJ
M	Mass flow rate, kg/s
Cp	Specific heat of air, kJ/kg K
Qu	Useful gain of the collector, kW
Ac	Area of the collector
CNS	Cashewnut in Shells
P_{as}	Partial Pressure of the moisture under saturated condition
P_a	Partial Pressure of the moisture

Cashew nut is one of the important nuts which are used extensively in Indian food system. It is widely grown in different regions of India and is commercially important. Which are used for characteristics of fat and vitamins and of preparation of wide variety of dishes. It has bulk demand in the market ranging from 300 to 500 tones of dry cashew nut annually. This product required careful drying before producing them to the market.

The cashew tree is evergreen. It grows up to 12 metres high and has a spread of 25 metres. Its extensive root system allows it to tolerate a wide range of moisture levels and soil types, although, commercial production is advisable only in well-drained, sandy loam or red soils. Annual rainfall needs to be at least 889mm (35 inches) and not more than 3048mm (120 inches). Cashew trees are most frequently found in coastal areas.

The main commercial product of the cashew tree is the nut. In the main producing areas of East Africa and India, 95% or more of the apple crop is not eaten, as the taste is not popular. However, in some parts of South America and West Africa, local inhabitants regard the apple, rather than the nut kernel, as a delicacy. In Brazil, the apple is used to manufacture jams, and soft and alcoholic drinks. In GAO, in India, it is used to distil cashew liquor called “fenny”.

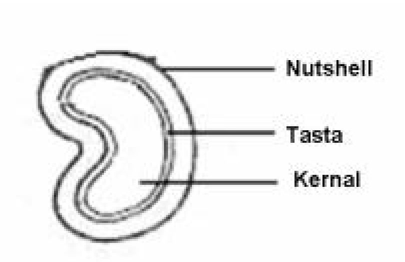


Figure 1: Cashew Nut

All raw nuts carry foreign matter, consisting of sand, stones, dried apple etc. The presence of foreign matter in the roasting operation can be avoided by cleaning the nuts.

The drying chamber of the cashew dryer has 10 aluminium wire screen trays to hold the products. The flat plate solar collector used has a double Plexiglas cover positioned about 5 cm above a matt black painted aluminium absorber sheet. All collector walls except for the transparent glass cover are insulated to 8 cm thickness to reduce heat losses. The solar collector is attached to the back side of the drying chamber at an angle of 15^{o}[11].

A 12W exhaust fan fixed in the inlet of the drying chamber forces the heated air to the drying chamber and rise up through the cashew being dried. The biomass gasifier stove assists drying even when solar radiation is insufficient.

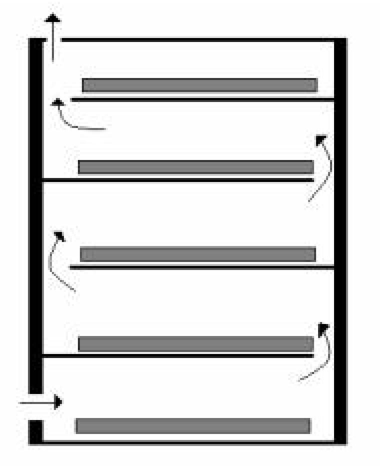


Figure 2:

Technical Specifications:

Cashew Nuts dried in our solar drier in batches of 10 *Kg*. The moisture content per kg of cashew is calculated as 0.04kg. Based on the moisture content the conditions of the air are selected. Depending on the moisture in the product the air supply to the drier decided and accordingly flow rate, temperature, pressure and heat removal rate of air supply decided.

Performance of Solar Collector:

The performance of a flat plate collector can be found by calculating the collector efficiency; the ratio of the heat gathered by the collector to the insulation incident on its surface. The collector efficiency is a function of the air velocity through the collector, the geometry of the air duct, the aborbitivity of the absorption surface and the transitivity of the covers Or collector reference area, m^2.

Efficiency of the collector can be calculated by

η : $Q_u / (A_c * G)$
Ti : collector inlet temperature, °C
To : collector outlet temperature, °C
G : solar global irradiance, W/m^2
Q : heat energy, kJ
M : mass flow rate, kg/s
cp : specific heat of air, kJ/kg K
Qu: useful gain of the collector, kW
Ac : Area of the collector
Qu: m cp (To - Ti)

Heat transfer to the air can be calculated by

Readings have been tabulated to find the collector efficiency and shown in Table. I
Usually it is helpful to present the performance in two different diagrams:

i. Efficiency versus temperature difference between outlet temperature and ambient (Graph 1).
ii. % Moisture Content vs Drying Time (Graph 2).

Calculation of moisture present in the Cashew:

The water present in the Cashew will have water vapour. This water vapour will exert a vapour pressure. The vapour pressure present is directly proportional to the amount of water (Aw) present in the Cashew.

$$Aw = \frac{\text{(vapour pressure of water in the agricultural Produce)}}{\text{(Saturated vapour pressure of water at same temp.)}}$$

When certain solutes are added to food, they lower the water activity by depressing the water vapour pressur.The extent of the depression can be calculated using Raoult's law which states that the partial pressure pA of a component over a solution is the product of the vapour pressure pAS of that component and mole fraction A of that component A.

PA =X * a * PAS

To calculate the performance of drying

The following details are gathered

1) Pressure drop across the flat plate collector, pressure drop across the bio mass gasifier.
2) Temperature distribution across the flat plate collector and bio mass gasifier.
3) Heat transfer needed to remove the moisture from the cashew per batch.
4) The mass, temperature, pressure and heat removal rate of air from the solar flat plate collector if operated alone.
5) The mass, temperature, pressure and heat removal rate of air from Bio-mass gasifier if operated alone.
6) The mass, temperature, pressure and heat removal rate of air from Bio mass gasifier and solar flat plate collector if operated together.

Details of Solar Flat Plate collector.

1) No. of Baffles : 4
2) Inclination of the collector : 15^0
3) Discharge of air through the Collector : $1m^3$
4) Length : 1.87m
5) Breath : 1.10m
6) Depth : 0.225m

Details of Bio-mass Gasifier

1) Capacity of Bio-mass Gasifier :2kw
2) Fuel supplied: :casuarinas

Details of Drier Cabinet

1) Type of products dried :Cashew Nut
2) Mass of product dried For a tray : 1kg
3) No. of tray : 10
4) Total mass of product that Can be loaded for a batch : 10kg

Details of Solar PV pan available

1) Power o/p for a panel:140watt

Blower Details:

1) Type : D.C.
2) R.P.M.: 1750 r.p.m.
3) Power output: 54 W
4) Discharge of air: $0.11m^3$/sec.
5) Volt: 24V (D.C.)

Fig 3 .Photo of Solar Drier

Calculations.

Moisture to be removed per batch of Cashew Nut = 0.4kg
Mass of moisture per kg. of Cashew Nut = 0.04kg
Mass of Cashew Nut per batch = 10.0kg
Moisture removal rate of air From the Cashew Nut per batch= 0.4kg
Rate of Air supply (total) = $0.06m^3$/sec
Pressure of air supply = 3bar
Temperature of air supply = 55^o-75^o

Drying by Solar flat plate collector alone:

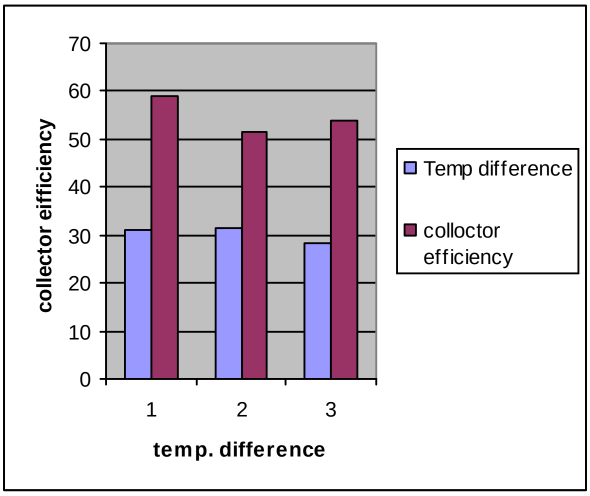
Discharge of air needed : 0.03 m^3 /sec

Drying by Bio-mass gasifier alone:

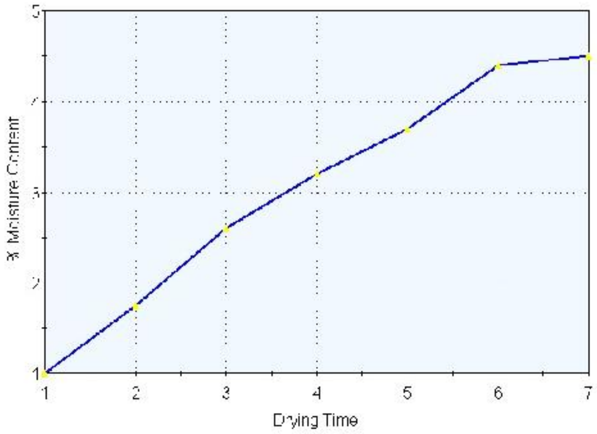
Discharge of air needed : 0.03 m^3 /sec

Performance of Bio-mass Gasifier

i. Mass of fuel burnt/sec. =0.1kg/sec
ii. Calorific value of fuel (CV) = 531kj/kg
iii. Heat output from the Gasifer =53.1kj/kg



Graph 1:temp difference vs collector efficiency



Graph 2:% Moisture Content vs Drying Time

Table 1. Tabular Column to find the efficiency of the collector

Day	T1	T2	T2-TI	den.	Vol.	m=den*V	Cp	Qu	Au*G	Eff.(%)
1	30.9	80	49.1	1.2	0.03	0.036	1.005	1.77	3	59
2	31.5	83	51.5	1	0.03	0.03	1.005	1.55	3	51.66
3	28.5	78	49.5	1.1	0.03	0.033	1.005	1.641	3	54

Table 2 : Tabular Column To Compare Open Sun Drying And Drying With Drier

Drying With Drier/Natural Convection							Open Sun Drying				
Date	Hrs.	Initial Wt. Gms	Final Wt. Gms	Moisture Removd Gms	Moisture Removal Rate Gms./Hr	% Moisture Removed	Initial Wt. Gms.	Final Wt. Gms.	Moisture Removed Gms.	Moisture Removal Rate	% Moisture Removed
1	6	500	482	22	3.6	**4.4**	500	497	3	0.5	**0.6**
2	6						497	490	7	1.16	**1.408**
3	6						490	482	8	1.11	**1.63**
		Total Hrs. Of Drying By Drier= 6 Hrs					**Total Hrs. Of Drying Using Open Sunlight= 18**				
					Time Saved In % :		**12.1**				

Result and Discussion

1.Drying agricultural products with solar drier saves approximately 66% of time when compared With open sun drying.

2.Efficiency increases with increase in temperature difference between inlet and outlet and decreases with increase in mass flow rate.

Conclusion:

Present experimental results prove that bio mass gasifier supplies more heat when compared with solar flat plate collector. Also drying with solar flat plate collector saves time for drying when compared with open sun drying and it is shown in Table 2.Still research has to be continued in the present set up such that efficiency to be improved for solar flat plat collector by optimizing tilt angle, Coating for the surface mirror, installation of booster mirror, supply of air through the collector Using blower, variable speeds for the blower such that heating capacity of the solar flat plate collector to be increased for a best performance by the experimental setup.

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