Modified Solar Dryer with Desiccant Material for Agricultural Products

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Abstract— **The food preservation is very important in all over. Most of the food products are obtained from agricultural so it is essential that preservation of food for long time therefore the moisture removal from agricultural products is also important. Solar Drying process is traditional process which is used for removing the moisture from agricultural grains. Drying is possible only during sunshine hours. So that time required for drying is longer.**

In this paper the objective is that, it can also dry the agricultural products in off sunshine hours. In off sunshine hours drying is operated by solid desiccant material which is also the adsorbent. The moisture removal rate of solid desiccant is increase by 25% and time required for drying is minimised. In short drying efficiency of system increased approximately as compare to conventional process.

***Keywords*:- solar dryer, desiccant drying, thermal efficiency, forced convection.**

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I. Introduction

In the majority of Indian states, agriculture represents the biggest part of economy.60-70% population is employed in agriculture. Despite these large numbers, national food production still does not meet the population. The lack of appropriate preservation and storage system caused considerable losses. Solar drying is the most wide spread method of food preservation. There are some drawback relating to traditional method of drying [8]. Non uniform and insufficient drying also leads to deterioration of the product during storage.

Various type of solar dryer are developed and tested for their performance. Normally the storage systems are developed to store the thermal storage by using thermal energy which includes sensible heat storage, latent heat storage chemical. As the properties is available in sand, silica, concrete it can be store heat energy and liberate to the atmosphere by temperature gradient same all these properties are also available in solid desiccant which is aim of our experiment. The drying potential in desiccant material is shows the required the mechanism of thermal storage for solar drying. In this process removing moisture from the air and become its dry and realize by adsorption in desiccant unit by solar energy

Though silica gel has got moisture absorption capacity its dust particles have shown to be carcinogenic and make it unsuitable for direct food processing application so that solid desiccant material is suitable. The composition of desiccant is 60% bentonite,10% $CaCl_2$, 20% vermiculite, 10% cement gives high moisture removal rate and this desiccant material use as a grain drying application.[7]

Experimental Setup

Construction:

It consist of forced convection solar dryer with solar flat plate collector, centrifugal blower, dying chamber consisting of solid desiccant material staked at the top, a reflective mirror for increase the solar radiation rate on the desiccant bed. The schematic diagram of the experiment shown in figure..

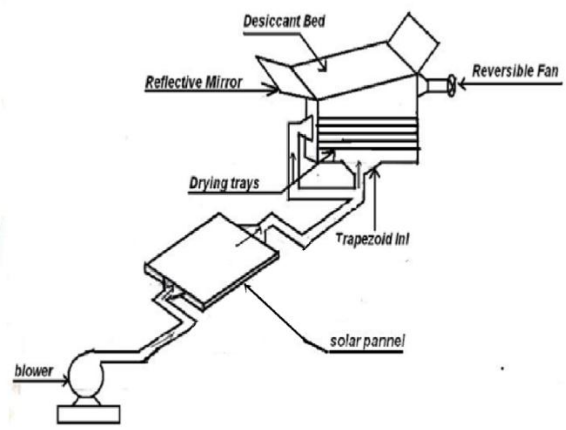

Fig. Solar dryer with desiccant bed [7]

The solar flat plate collector has a dimension of 2m×1m. a 0.5m thick acrylic glass placed on collector. 0.5mm thick copper plate with black wash is placed inside the collector as a absorber plate. The mild steel frame is made up of glass wool as an insulating material a double glazing with an air gap of 50mm is provided with an inclination of 30̊. 2.5 inch pipe is provided for flow of air from collector to the drying chamber. The drying chamber is simply box consisting of trays inside it with the dimension of 0.5m×0.5m×1m having a hole at bottom side for connecting the 2.5inch pipe.

Working:

A blower forced the air through duct at a rate of 400m3/hours after that this air is goes into the collector. During sunshine hours the rays of sun are radiate on the solar panel. The total solar radiation impinging on the glass cover a part of rays is reflected back to the atmosphere and the remaining transmitted inside the cabinet. In this cabinet maximum amount of heat is generated. That much amount of heat is sufficient to heat the air.

This heat inside the collector heats the air by law of convection. Then due the density gradient hot air have a lesser mass than cold air thats why it flow up side so that negative pressure is generated inside the collector for that purpose to maintain the negative pressure at an certain limit pressure relief valve is provide which is operated manually whenever required.

The hot air flow from collector to the drying chamber and heated the products which kept for drying the hot air removes moisture content in the products. This process is known as dehumidification. And latent heat is liberated at to the atmosphere from top opening of chamber at normal pressure and temperature this process is done during sunshine hours. At off sunshine hours the drying is done by solid desiccant which is placed on corrugated plate. This desiccant adsorbs heat during sunshine hours and emits the heat off sunshine hours. At night time desiccant material acts as sun for heating or drying products.

EXPERIMENTAL CALCULATIONS & EQUATIONS

The experiments performance and drying characteristics are calculated by following equations [1]:

1) Initial moisture content (Mo) :-

$$Mo = \frac{Wo - Wd}{Wd}$$

2) Final moisture content (Mf) :-

$$Mf = \frac{Wwet - Wd}{Wd}$$

3) Moisture Ratio (M R):-

$$MR = \frac{Mt - Me}{Mo - Me} = e^{-kt}$$

4) Drying rate :-

$$\frac{dM}{dT} = -k(Mt - Me)$$

Where ,

Wo =initial weight of product in (kg)

Wd = dry weight of product in (kg)

Ma = mass flow rate of air (kg/s)

Md = mass of desiccant (kg)

Mw = mass of moisture evaporated in time 't' (kg)

Me = equilibrium moisture content (kg water/kg dry matter)

Mf =final moisture content (kg water/kg dry matter)

Mo= initial moisture content (kg water/kg dry matter)

Mt= moisture content at any time of drying (kg water/kg dry matter)

MR=moisture ratio

k =drying constant (s -1) (k=0.5921)[4]

Results And Calculations

Sample calculation of grapes dryin]

For 500 grm of grapes having initial moisture

1)Initial moisture content (Mo) :-

$$Mo = \frac{Wo - Wd}{Wd}$$

$$Mo = \frac{500 - 375}{375}$$

2) Final moisture content(Mf) :-

$$Mf = \frac{Wwet - Wd}{Wd}$$

$$Mf = \frac{450 - 375}{375}$$

$$Mf = 20\%$$

3)Moisture Ratio (M R):-

$$MR = \frac{Mt - Me}{Mo - Me}$$

$$MR = \frac{28 - 26.66}{33.33 - 26.66}$$

$$MR = 0.20$$

4) Drying rate :-

$$\frac{dM}{dT} = -k(Mt - Me)$$

$$= 0.5921(28 - 26.66)$$

$$\frac{dM}{dT} = 0.7934$$

Further five Readings are shown in Table 1.1

Readings With Desiccant Bed:

Table 1

No.	Weight(grm)	Mo(%)	Mf(%)	MR	Dm/Dt
1	500	33.33	20	0.20	0.7934

2	600	34.39	21.2	0.212	0.7846
3	700	31.57	18.2	0.182	0.7732
4	800	32.76	19	0.199	0.7894
5	900	33.92	20.12	0.2012	0.8028

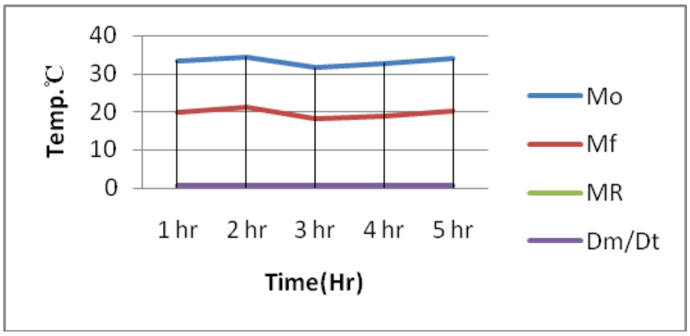

Fig.2. Graph shows variation in temperature profile of Mo,Mf,MR,Dm/Dt over the time of day (With Desiccant drying)

<u>Without Desiccant (Conventional Drying):</u>

No.	Weight(grm)	Mo(%)	Mf(%)	MR	Dm/Dt
1	500	41.66	24	0.24	0.681
2	600	40.25	22.7	0.227	0.674
3	700	41.98	22.98	0.229	0.667
4	800	42.78	23.76	0.237	0.654
5	900	42.89	25.89	0.258	0.668

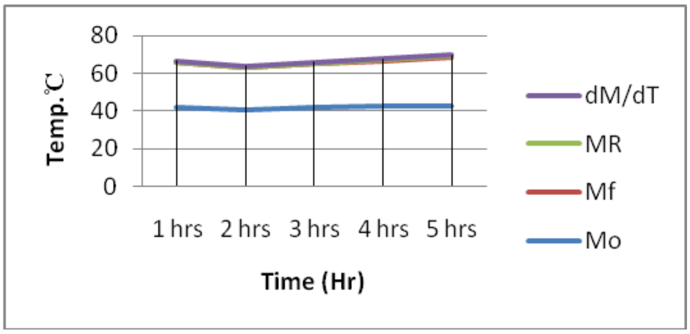

Fig.2.Graph shows variation in temperature profile of Mo,Mf,MR,Dm/Dt over the time of day (with convevtional drying)

CONCLUSION:

From result it can be conclude that the thermal efficiency of the system is increases by 15% as compare to the conventional drying system and the time required for the drying is less. The drier with copper absorber plate enables to maintain consistent air temperature inside the drier. The grapes was dried from initial moisture content 90% to the final moisture content about 10% and 11%(wet basis) in bottom and top tray respectively. It could be concluded that, forced convection solar drier is more suitable for producing high quality dried grapes for small holders.

Uniform drying in all the trays were achieved with good quality in terms of colour, when compared to solar drying. Taste of the dried grapes (plums) is good. The desiccant material is stable even after continuous operation. The dryer can be used for drying various agricultural products. It can reduce drying time and improve quality of the dried product.

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