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DESIGN AND DEVELOPMENT OF STATIC SOLAR DRYER

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ABSTRACT

Natural draught is a process where the moisture reduction occurs naturally due to atmospheric pressure. This static solar dryer has an enclosed structure with dimensions 1000*800*760 mm. It has a unique body structure with 3 sides covered with 1.2 mm polycarbonate sheet and the other side have GI sheets fabricated followed by power coating on all sides except the three with transparent sheets. There are four trays on which the goods for drying will be kept. Our sole aim of this dryer is to dry perishable goods at an accelerated rate than drying under open Sun. The expected outcome of our research and project is to reduce the moisture from 90% to as low as 23%. The highest temperature recorded inside the solar dryer is 84 °C when the surrounding atmospheric temperature was 34 °C.

Keywords: Heptagonal structure, Natural Draught, Moisture reduction, Perishable goods.

I. INTRODUCTION

The life of perishable goods is limited due to water content in the system, for this drying is the correct method. Drying and preservation of agricultural item have one of the oldest uses of solar energy. The traditional method, still widely used throughout the world, that is open drying where diverse crops, such as fruits, vegetables, cereals, tobacco, grains, etc. are scattered on the ground and regularly flipped until it dries sufficiently. There are many disadvantages of open sun drying such as large space for drying and longer drying time is required. This led to the innovation of various types of drying processes in devices like electric dryer, fire wood fuel dryer, solar dryers, and oil fuel dryers.

Applications like drying of fruits, vegetables and spices can be carried out in this solar dryer. Recent developments of direct solar dryer for drying of cereal grains, fruits, vegetables and spices in the rural areas of the tropic and sub tropic regions are critically examined in terms of drying performance and product quality. There are uncertain rise and shortage of fuels increases the demand to search alternative source of energy. Solar energy can attract the researcher because it sustainable and renewable in nature. This is largely due to its abundance in direct as well as indirect form. It has been observed that use of direct solar dryer under natural draught reduces moisture in very less time as well as drying rate is very fast than the traditional drying process.

II. METHODOLOGY

As life of perishable goods is limited, need for drying those goods arises here. Drying and storing of edible goods is a traditional method for increasing the life of them. But this conventional methods of drying in open sunlight consumes more time for the drying process. Thus, due to solar dryers, this heat and mass transfer rate can be achieved maximum. Our parameters to build a dryer are that it should be economical, sustainable and efficient. So we have selected Indirect type – natural circulation Solar Dryer. Material selection is a step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals.

While designing, one must keep in mind the parameters as said earlier. There are many different types of design for solar dryers in the market. Some of them are like a rectangular box, or a prism. We have designed a heptagonal structure. Analysis is the next important step after design. We analyzed our design in Ansys, carrying out stress, strain and deformation analysis. While manufacturing any product, its performance is evaluated on the basis of materials and quality assurance. Six Sigma and Kaizen methods are implemented for this evaluation. This gives us an idea about the end results of the project that we will be manufacturing.

After all the design and analysis, moving on to fabrication. Manufacturing includes production of components and parts and then fabricating / assembling them together. Last step of the project is finally presenting it. Before presentation several trials are taken.

III. MODELING AND ANALYSIS

This static solar dryer consisting of two heptagonal rings made up of Sq. pipe 0.75 inch having material of MS. 3 sides of the solar dryer are covered with 1.2 mm polycarbonate sheet. Other sides were completely closed with 0.6 mm G.I. sheet and 1.2 mm G.I. sheet. The inside surface of the back door is covered with 0.6 mm Al sheet which is working as a reflector. This entire body is coated with black powder coating. Four trays are made of 1.2 mm MS perforated sheet of dimensions 632*488 mm.

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Figure 1: 3D Model

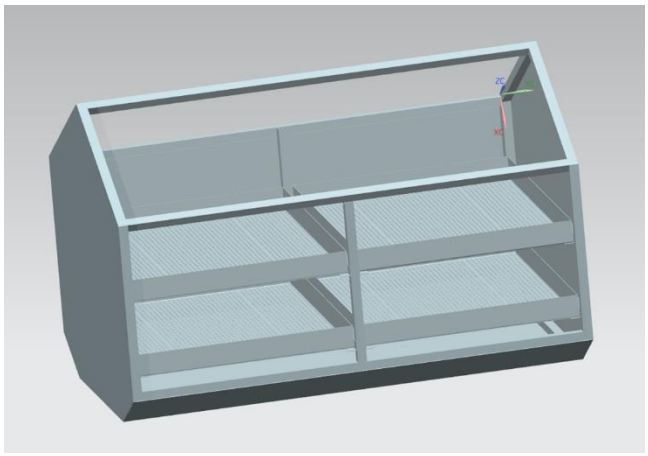

Figure 2: Static Solar Dryer

Analysis of trays

1. **Stress Analysis.**

Here,

For Perforated Sheet

Dimensions = 632*488

Thickness = 1mm

Permissible Stress = 250 MPa

Now,

Load = 10 Kg = 100 N

Actual Stress after load applied = 55.957 MPa

Hence,

Permissible Stress > Actual Stress

Therefore, Design is Safe.

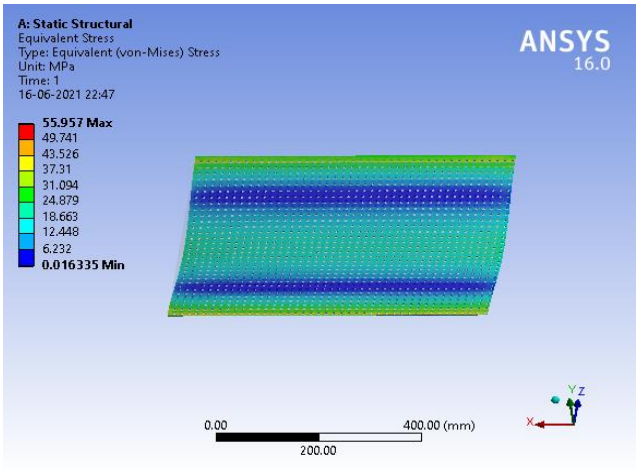

Figure 3: Stress analysis in Ansys

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2. Strain Analysis and Deformation analysis:

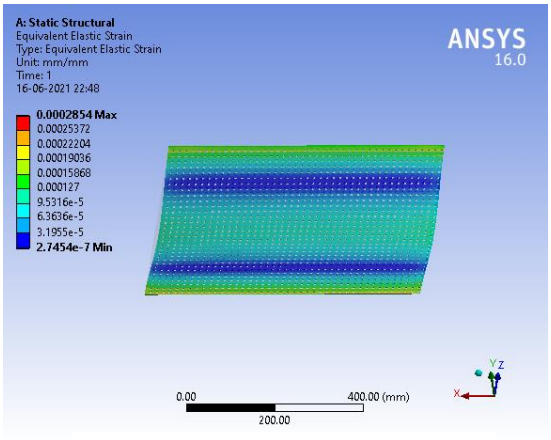


Figure 4: Strain analysis in Ansys

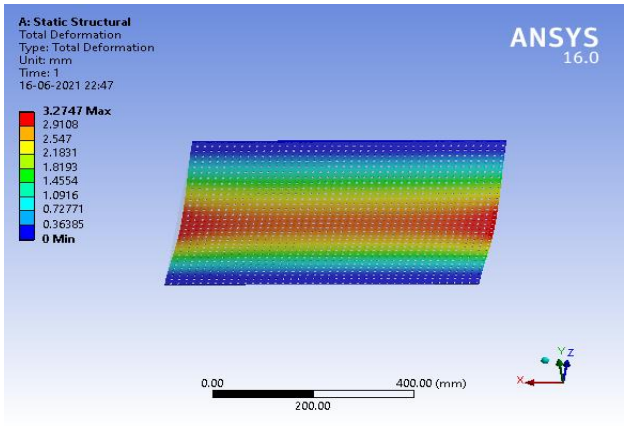


Figure 5: Deformation analysis in Ansys

Parameters	Minimum	Maximum
Stress	0.016335	55.957
Strain	2.7454e-7	0.0002854
Deformation	0	3.2747

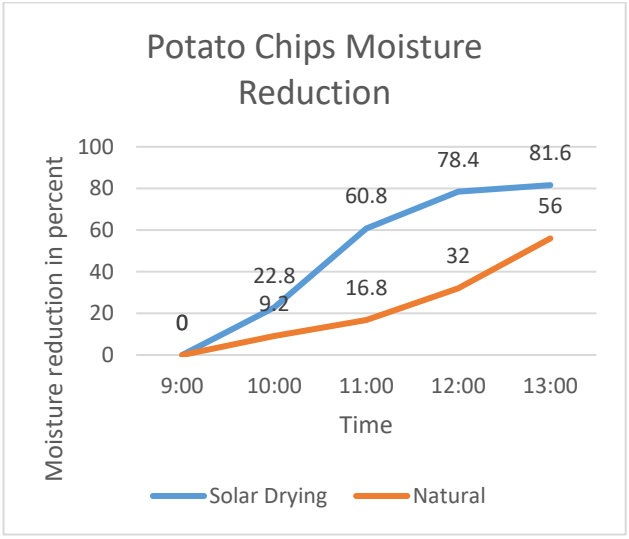
IV. EXPERIMENT

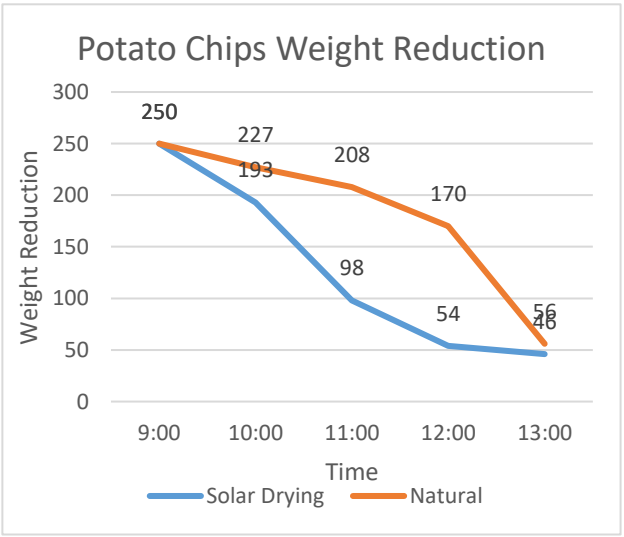
We performed experiment with four products viz., Potato Chips, Carrot, Ladyfinger, Cluster beans.

1. Potato Chips

Table 2: Potato Chips Readings

Sr.no.	Time	Temperature		Weight gm		Moisture %	
		Tn	Ts	Wn	Ws	Mn	Ms
1	9:00	24	48	250	250	0	0
2	10:00	30	68	227	193	9.2	22.8
3	11:00	33	80	208	98	16.8	60.8
4	12:00	33	80	170	54	32	78.4
5	13:00	33	74	110	46	56	81.6

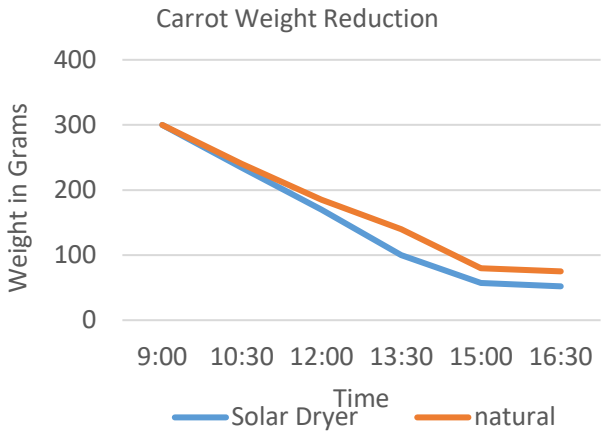


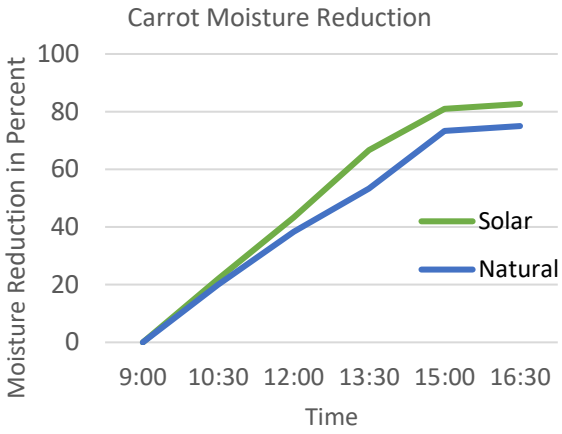


2. Carrot

Table 3: Carrot Readings

Sr.no.	Time	Temperature		Weight gm		Moisture %	
		Tn	Ts	Wn	Ws	Mn	Ms
1	9:00	23	52	300	300	0	0
2	10:30	28	66	240	234	20	22
3	12:00	32	76	185	170	38.33	43.33
4	13:30	32	78	140	100	53.33	66.66
5	15:00	31	66	80	57	73.33	81
6	16:30	28	60	75	52	75	82.66

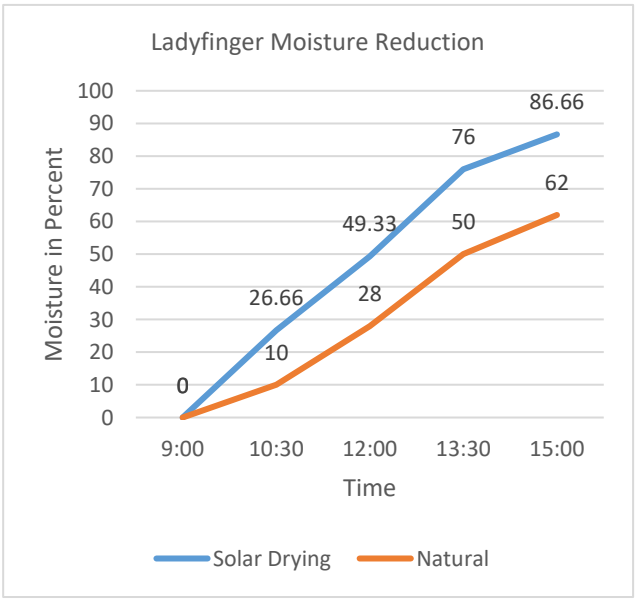


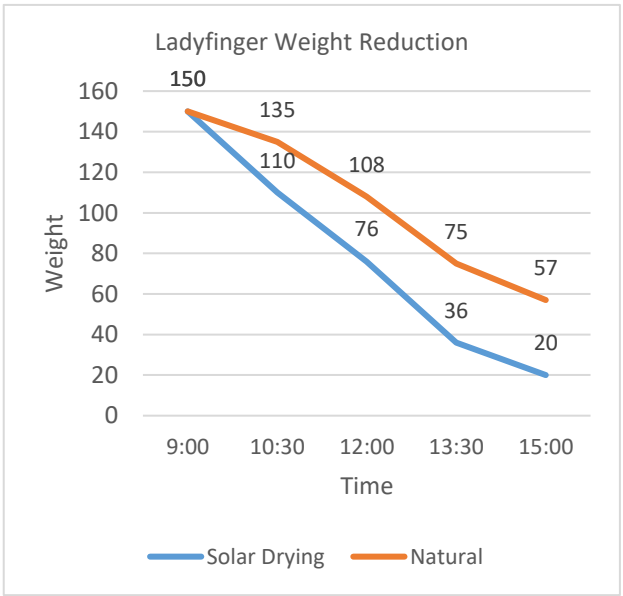


3. Ladyfingers

Table 4: Ladyfinger Readings

Sr.no.	Time	Temperature		Weight gm		Moisture %	
		Tn	Ts	Wn	Ws	Mn	Ms
1	9:00	23	52	150	150	0	0
2	10:30	28	66	135	110	10	26.66
3	12:00	32	76	108	76	28	49.33
4	13:30	32	78	75	36	50	76
5	15:00	31	66	57	20	62	86.66
6	16:30	28	60	51	Dried	66	Dried





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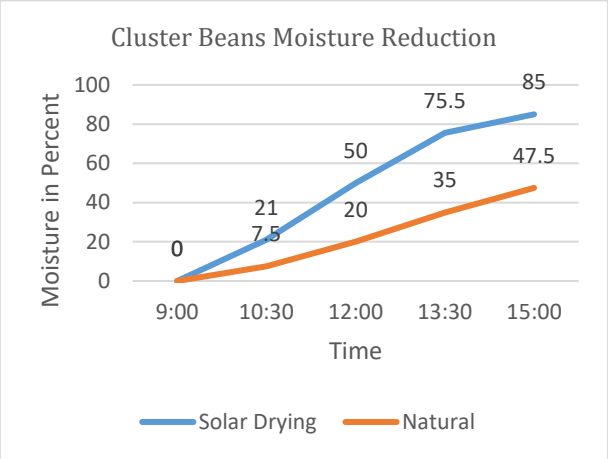
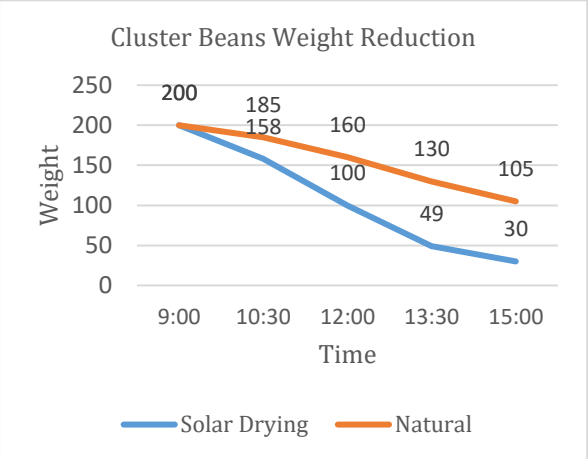
4. Cluster Beans

Table 5: Cluster Beans Readings

Sr.no.	Time	Temperature		Weight gm		Moisture %	
		Tn	Ts	Wn	Ws	Mn	Ms
1	9:00	23	52	200	200	0	0
2	10:30	28	66	185	158	7.5	21
3	12:00	32	76	160	100	20	50
4	13:30	32	78	130	49	35	75.5
5	15:00	31	66	105	30	47.5	85
6	16:30	28	60	100	Dried	50	Dried





V. RESULT AND DISCUSSION

Figure 6: Before and After of Potato Chips in Static Solar Dryer

What we understood through this experiment was the rate of drying under static solar dryer was very much more than open drying and also the time taken by solar dryer was least with good quality product without any dust particles and a good taste. The moisture of the products was fully removed and shape of the products was also good compared to open drying. The weight reduction was fast in solar dryer than natural dryer.

VI. CONCLUSION

The solar energy source is utilized to operate solar food dryer. The study concluded that time required in drying the vegetables was comparatively higher in open sun drying than solar dryer. The drying method had an effect on the chemical content of the vegetables (protein, ash, fat, crude fiber and carbohydrate). The solar energy costs us nothing just sunlight is which is a free of cost and also it is a non-finishing source of energy. The highest temperature recorded inside the tray was 84°C at normal ambient temperature and even more at higher ambient temperature. The moisture removal rate or drying rate is an important performance parameter for a dryer. Substances like potato chips dried within 2 hours in the solar dryer whereas it usually takes a day in the natural open drying. It is portable and mobile, can be kept anywhere as per convenience and it consumes less space.

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