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Developments of solar dryers, constructing and testing of new dryers with flat and sinusoidal transpired solar collectors.

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Abstract

Men used solar power for drying goods for future use. They dried fish, meat, vegetables and fruits in the same manner. Smoking for drying is also used, but it can cause cancer. Developments of different types of agricultural solar dryers are investigated and the efficiency of solar driers for agricultural products is tested using transpired solar collector. To increase its efficiency the absorbent area of the collector is designed sinusoidal. These driers are designed and built in Materials and Energy Research Center and its efficiency is measured for drying vegetable such as parsley. The experimental result of these two driers shows an efficiency of 26.35% for the drier with sinusoidal collector and 18.82% for the drier with flat collector, that means an increase of 7.53% in efficiency. They are also used to dry different kind of nuts in large scale these dryers have very good efficiency. The only energy beside solar energy used in these dryers is electrical energy to run the fan mounted behind the transpired collector to convey hot air into dryers. Another means of energy could be used to keep the warehouse warm during the night time. These could be heaters operated by electricity, oil, gas or stored solar energy in the form of packed bed system using oil or water as heating fluid agent and medium size packed bed stones to store the day's solar heat for the use at night.

Keywords: transpired collectors, sinusoidal collectors.

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INTRODUCTION

Drying food is an old way of keeping agricultural materials for a long period of time, it started when man saw the seeds dry on the plant were usable later on. So they decided to imitate the idea, and dry cereals using solar power and storing dried goods for future use. They also dried fish, meat, vegetables and fruits in the same manner. Smoking for drying is also used, but it can cause cancer.

Industrialization of drying process of agricultural goods is started during First World War; they began by drying fruits and vegetables using special ovens. Start of First World War was a void reason for drying. In order to prepare enough food for army and transport it on time, and to avoid rotting, adding special vitamins and other additives to prepare soldiers to fight better.
During the recent years, because of high price of oil the use of solar dryers are more economical. New solar dryers have been designed with better efficiency. In this study we have built a dryer with two different types of collectors, and measured their efficiency.

Advantage of drying the agricultural products

There are many ways of storing food. Because of the following reasons, drying is an important way to store food: ◎
1- It is possible to harvest the crop on time to reduce wastage of crop which is caused by wind or hurricane or hot weather or insects.
2-Existence of drying factories makes it possible to plan the harvesting and use the off season cheap workers like students and unskilled workers to reduce costs.
3-It is possible to store the crop for a long time without losing its quality, so it is possible to plan the plantation of crops, and therefore it is economical.
4-It is possible to store and keep crop seed for a long time and prevent them from germination.
5-It causes the reduction of packing and keeping costs, because it can be kept in ambient temperature.
6-It causes the reduction in weight and volume, which results on savings on transportation.

The customary ways of drying agricultural products

The main aim of drying is to reduce moisture of the crop to an extent that prevents it from degeneration, this is called the safe keeping period .This can be done in the following ways:
1-Chemical drying.
2-Freeze drying.
3-Mechanical drying.
4-Thermal drying.
In the process of drying the following tasks should be observed:
5-Quality of crop
1-Chemical and biochemical reactions is reduced to its minimum.
2-Choice of terms in drying conditions should be somehow that moisture is separated easily.
3-the stored food must stay permanent in the period of storage.
4-the dried food should keep its original color.

5-It should be free of pollutions.
6-The economy of process
1-The crop wastage is minimized.
2-The moisturizing should be done quickly.
3-The source of energy should be cheap.
4-To minimize the transportation problem.
5-The drying process should be continuous.
6-Using simple machinery to minimize maintenance and repair costs.

In general the drying period of crop is consists of drying period with steady rate and drying period with falling rate which are explained as:

The benefit of using drying process

One of the oldest ways of using solar energy from the beginning of human life is to dry and store the agricultural products. This way was very elementary and simple and if hygienic methods are used, it is very effective.

In the way that the agricultural products are spread on the floor or on special platform made of concrete or clay to lose their humidity and preventing the growth of bacteria and molds on them. In this way cost of tools and instruments used is very low, but it takes a lot of man power and the drying period is not controllable. In the surveys done before this method is used all over the world and different products like fruits, vegetables, cereals, meat, fish, tea and coffee beans, tobacco, wood are dried in this way. In this simple and ancient way there are some throwbacks, which cause reduction in quality and considerable wastage of product:

1- Cloudy weather and unpredictable in drying season.
2-Pollution caused by insects.
3-Molding and germination of crops.
4-Air pollution.

Using this method drying different products was dried in Iran.

The categorization of solar driers

Driers are categorized with respect of solar radiation pattern as follows:

1-Natural Solar driers:

In this driers solar radiation, ambient temperature, relative moisture and wind energy are used for drying.

Direct solar driers:

In this kind of driers the product is kept in packed chamber with a transparent cover. The thermal energy is produced by solar radiation on product and the area of container. This thermal energy is the cause of evaporation. In addition to this the thermal energy causes the air expansion and circulation to reduce the humidity of product in the packed chamber of the drier. One of these kinds of driers is tent drier. See figure 2. ⚜

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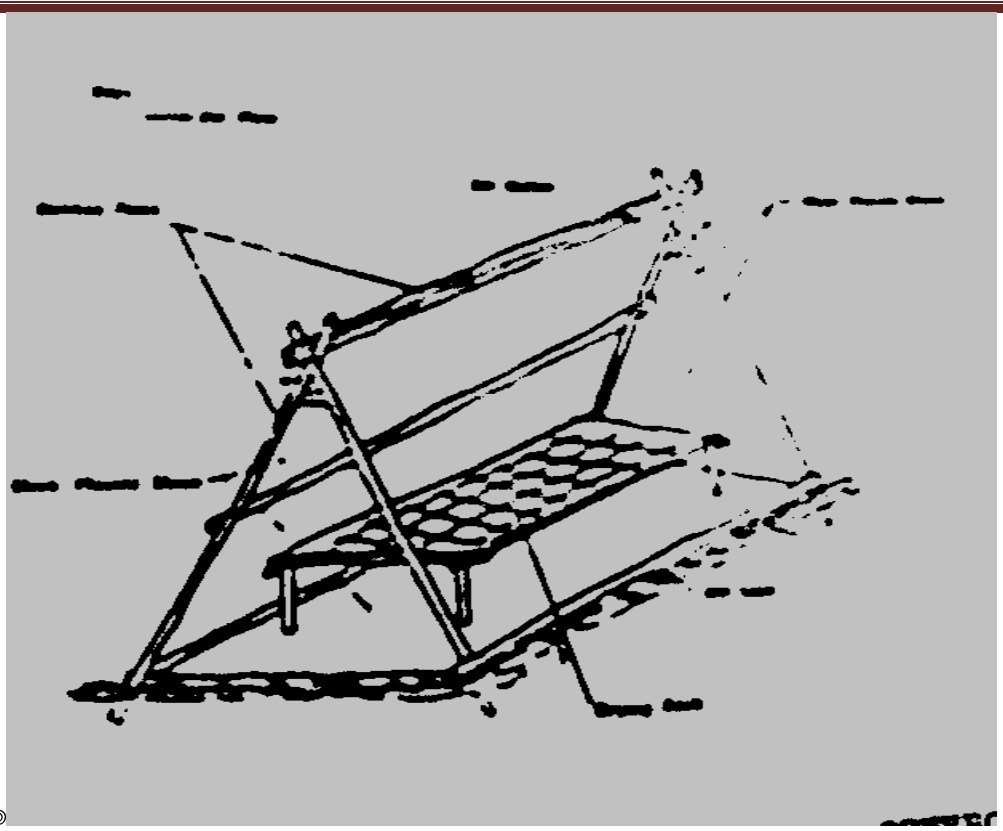

Figure 1: a tent drier

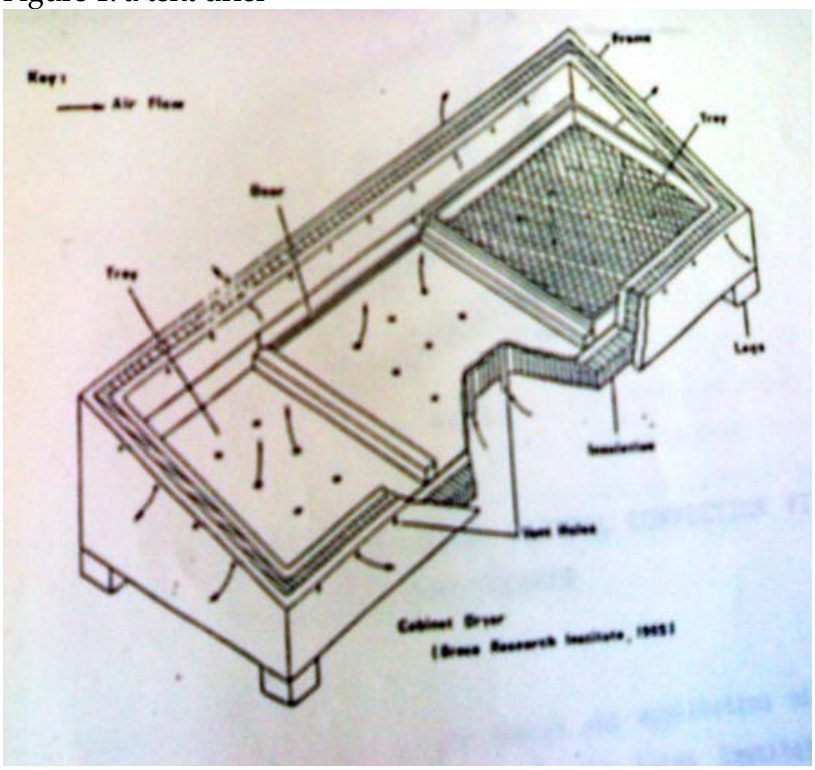

Figure 2: A cabinet drier.

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Indirect solar driers:

In this kind of driers the solar radiation does not effect on the product directly. The air in the solar driers are heated and sent through a channel to the packed chamber to reduce product humidity.

hybrid driers:

In these solar driers in addition of using solar energy other means of energy like oil or electricity is used [Duffie, J.A. and W.A. Beckmann. (1991)]. For example cabinet drier this is showed in figure 3.

Types of solar driers with transpired solar collectors

This collectors use transpired solar collectors which are explained as follows:

1-simple Solar transpired collectors.
2-sinusudale solar transpired collectors.

The sinusoidal transpired solar collector for dryer

These collectors are painted with black matt color; they are cheap and have a high efficiency. They can heat up the outside air and using the suction power of a fan transfer the warm air over the product. The moisture of product is lost in this way (Dymond C. and C. Kutscher).

The experiments using these driers show that their efficiency is improved if they are built in the direction of wind. For example for drying 8 kilo gram of cardamom, one square meter of collector is needed. And to dry 4 kilogram of green paper, one square meter of collector is needed, because its moisture rate is higher (Dymond C. and C. Kutscher). These collectors are made of a sheet of steal which is transpired with high porosity, and they do not need any repairs and they are very resistant to heat and cold. They are painted with black color and connected to the front of the drier. Hot air is transpired from the surface of collector and sucked by the fan to the tray which is filled by the product. They are also installed on the side walls of warehouses.

The American renewable energy laboratory states that the transpired solar collectors are very efficient and cost effective (Dymond C. and Kutscher C. F. (1995). Here in MERC we have built

and tested a variation of this collector, which is sinusoidal transpired solar collector, this have a larger surface area, which makes it more efficient.

Technical features of driers with transpired solar collectors for agricultural products

This kind of driers two main parts:

the heating air section (collector) which is explained before.

the drying container in which warm air is passed over the product to dry it.

The second section is called "evaporation section". Absorption of heat from agricultural products causes it to dry. Of course this process is done when heating energy is absorb, as a result of this heat exchange the moisture of product is evaporated and the product is dried.

When solar radiation radiates to the product directly, a portion of radiation is absorb by the product. In this time the heat inside and outside of product is produced which makes heat transfer in solid to increase (Duffie, J.A. and W.A. Beckmann. (1991)).

The experimental section

Techniques of building drier with flat transpired collector (type one drier)

This is made of following sections:

Collector-the collector is made of a steal sheet with a thickness of 0.3 centimeter and 200*100 centimeters dimension which has a porosity of 25 per 5 centimeter square, which is painted in black matt color and installed on the front part of the drier.

Main section of the drier-the drier has a dimension of 200*100*200 centimeter and behind the collector there is a sheet of steel with dimension of 200*75 centimeters. In the gap a fan for suction of warm air is used.

The drier has three trays with dimension of 25*100*10 centimeters, which are made of steel and meshed at the bottom, to help passing the warm air through the product.

Technique of building drier with sinusoidal transpired collector (type two drier)

collector-the collector is made of steel sheet with the thickness of 0.3 centimeter and its dimension is 200*140 centimeter, which has a porosity value of 25 per 5 centimeter square and it is painted in black matt color. Of course it has been made sinusoidal to fit the 100 centimeter width of drier, which has a larger area to the solar radiation.

The main part of drier-this drier has 200*100*200 centimeter dimension and behind the collector a sheet of steel with dimension of 200*75 and like the first type, there is a fan situated in gap to convey the warm air into the drier.

The drier has three drying tray with dimension of 150* 100*10.

Conditions of the experiments

The overall conditions of the experiments are tabulated in Table 1. The drying experiments were performed in the last month of the summer, using fresh parsley as the agricultural sample to be dried.

Table 1-condition of the experiments in both dryers

Initial weight of the samples	10 kg
Initial water content of parsley	85%
Air Humidity	32%
Average solar radiation	1501kj
Average ambient temp.	33.09c°
Average air pressure	74cmHg
Average thickness of parsley in the trays	3.0cm
Average speed of the warm air flow	~0.06m/s
Temp. just behind the flat collectors	40.12c
Temp. on top of the tray for dryer with flat collector	42.18c°
Temp. just behind the sinusoidal collectors	42.93c°
Temp. on top of the tray for dryer with sinusoidal collector	45.95c°
Direction of the collector dryer	south

7Efficiency calculation of the

a) flat transpired collector

$A=\pi r2$=3.14×0.003752 m2

$Vf=A$×50×100×0.06=0.0132 $m3/s$

$mf=\rho\times Vf$=0.0156

$Qf=mfcp\Delta T$=0.0156×1007×6.22

$\mu f=Qf\rho earth$×0.5×Is=0.1882

Efficiency of flat tor=18.82%

b) sinusoidal transpired collector

$Vs=A$×60×100×0.06=0.0159 $m3$/s

$ms=\rho\times Vf$=0.0188

$Qs=mscp\Delta T$=0.0188×1007×8.82

$\mu s=Qs\rho earth$×0.5×Is=0.2635

Efficiency of sinusoidal collector=26.35%

CONCLUSION

In three days three experiments are conducted and it is deduced type 2 collector has approximately 7.53% more efficiency, so if type 2 collectors are used the time of drying is reduced and if the collectors are built in the wind direction the efficiency could be even more.

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