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Design and development of Hybrid seed dryer with airflow inversion and recirculation

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***Abstract**:*

Sun drying is still the most common method used to preserve agricultural products in most tropical and subtropical countries. Some of the problems associated with open-air sun drying can be solved through the use of a solar dryer who comprises of collector, a drying chamber and sometimes a chimney.

Dryers have been developed and used to dry agricultural products in order to improve shelf life. Most of these either use an expensive source of energy such as electricity or a combination of solar energy and some other form of energy. There is spoilage of fruits and other fresh foods that could be preserved using drying techniques in India and other developing countries.

Keywords Hotair, Moisture content, Seed germination, Regeneration.

1. Introduction

Drying of seeds and vegetables is one of the oldest forms of food protection methods known to man and is the most important process for preserving food since it has a great effect on the quality of the dried products. The major goal in drying agricultural products is the reduction of the moisture content to a level which allows safe storage over an extended period. Drying of agricultural products is an energy intensive operation. Solar energy is one of the most promising renewable sources of energy which is freely available in most of the developing countries including India and is considered as an immaculate source of energy. Solar air heaters have been extensively used for meeting low temperature energy requirement such as drying of agricultural produce, space heating and air conditioning and for meeting industrial process heat requirement. Solar dryers are now being increasingly used since they are a better and more energy efficient option available today. Seed with lower moisture content and higher germination rate fetch higher market price. To achieve low moisture content, normally seed are dried at 55–60 °C air temperature; but at these temperatures seed germination level falls. A number of studies have report that the drying air temperature should not be above 40 °C for good seed germination.

To avoid dehumidified air loss to the environment during forced circulation air drying, closed circulation dryers have also been reported developing a dryer for thin-layer drying of long-grain rice and medium-grain rice from initial moisture content of 19.6 % and 17.5 % respectively.

The most important advantage of the solar dryers is that they work on renewable energy and are pollution free. Also, solar dryers can be easily constructed from local materials. It is successfully proved how solar dryer technology is key element to climatic and environmental protection as well as sustainable development.

2. Solar and Electrical Drying

The principle that lies between the design of solar and electrical dryer is that in drying relative and absolute humidity are of great importance. Air can take up moisture, but only up to a limit. This limit is absolute (maximum) humidity, and it is temperature dependent. When air passes over a moist food it will take up moisture until it is virtually fully saturated, that is until absolute humidity has been reached. But, the capacity of the air for taking up the moisture is dependent on its temperature. Higher the temperature, higher will be the absolute humidity and hence larger uptake of moisture. If air is warmed, the amount of moisture in it remains the same, but the relative humidity falls and the air is therefore enabled to take up more moisture from its surrounding. To produce a high-quality product economically, it must be dried fast, but without using excessive heat, which could cause product degradation. Drying time can be shortened by two main procedures. One is to raise the product temperature so that the moisture can be readily vaporized, while at the same time the humid air is constantly being removed. The second is to treat the product to be dried so that the moisture barriers, such as dense hydrophobic skin layers or long water migration paths, will be minimized.

3. Principle Operation Of Solar Dryer

In the indirect dryers air enters to the blower opening at the bottom of the air controlling unit. The sunlight falling on the solar panel plate heats up the plate, which in turns heats up the air heating coil which then rises temperature and further increases air temperature. Drying is the process of moisture removal from the product, or grain in this case. Since grain is a hydroscopic material which can either absorb or desorbs moisture from the air or its surroundings depending on the difference in vapor pressure, moisture transferred from a higher vapor pressure, to the lower one. In the sun drying process, grain is heated by solar radiation thus creating a higher vapor pressure in grain than the surrounding air. In the same manner, the heated air drying process starts when the grain is heated (by conduction) when it comes in contact with the air. Higher velocity air flow in heated air drying has the advantage of reducing the boundary layer of the grain, thereby increasing the heat transfer coefficient of the grain, as well as increasing the rate of moisture movement from grain to the surrounding air. Therefore, the drying rate of a specific kind of grain is dependent on both air temperature and air flow rate.[5]

4. Principle Operation of Electrical Dryer

In the indirect dryers air enters to the blower opening at the bottom of the air controlling unit. Where in electrical drying air enters to blower from atmosphere, further it's passed to air controlling unit and air is gets heated up by the air heating coil, heater is connected to the alternative source (AC) supply. The heated air is passed to the drying cabinet the grains absorbs the heat then removal of the moisture content of the seeds takes place, and moist air escapes through outlet ball valve by opening.

5. Design Procedure

A seed dryer has been designed and fabricated. It has two chambers viz., air conditioning control unit and seed drying chamber, so as to have airflow inversion. The air conditioning control unit supplies drying air at low temperature and low relative humidity to seed drying chamber and the drying chamber holds seed to be dried. The seed drying chamber and air conditioning control unit are connected using an arrangement of G.I. pipes of 50 mm diameter. A single-phase 1 hp electric air blower was used to circulate air through the seed dryer. To control the direction of air flow in two chambers, eight gate valves were fitted in GI pipes arrangement.[1]

The details of the air conditioning control unit and seed drying chamber are given below:

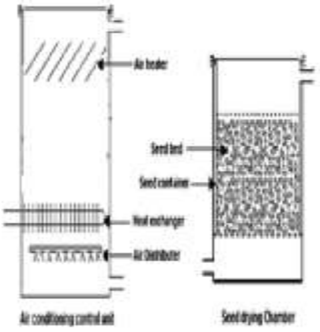

Figure1. Schematic of air conditioning control unit and seed drying chamber

As shown in Fig. 1 the air conditioning control unit consists of, heat exchanger, air distributor and electric air heater. This unit is made of galvanized iron (G.I.) sheet having length 350 mm, width 400 mm and height 500 mm. Dryer is designed to dry 2 kg of seed in 6 hour. The air distributor has three pipes of 1.25 cm diameter and 28 cm long, and each pipe has 13 holes of 3 mm diameter on the lower side for proper distribution of air. For air heating, a 150 W electric air heater consisting of 8 heating strips inclined at 45° with horizontal is used.

5.1 Electric Air Heater

Figure 2. Electric air heater

For air heating,300mm long and 180mm width a 150 W electric air heater consisting of 8 heating strips inclined at 45° with horizontal is used.

5.2 Heat Exchanger

Figure 3. Heat Exchanger

The heat exchanger is of 'tube-and-fin' type. The design detail of heat exchanger has 24 copper tubes of 16 mm diameter each, arranged in 8 columns and 3 rows. Distance between two consecutive columns of pipes is 40 mm and between consecutive rows is 20 mm. These pipes are connected in such a manner that there is a single entry and a single exit of water. These pipes have 16 identical parallel copper fins of 295 mm×160 mm in size and consecutive fins spacing is 15 mm. For good thermal contact, pipes and fins are brazed together.

5.3 Seed Drying Chamber

Figure 4. Seed drying chamber

The rectangular seed drying chamber is made of 26 gauge thick G.I. sheet having length 180mm, width 300 mm and height 500 mm. It has a seed container made of 26 gauge GI sheets of length 180 mm, width 300 mm and height 5 mm with wire mesh base having holes in drying area. A removable wire mesh is provided on the top of seed bed to avoid the flow of seed with drying air. This is because as the drying proceeds the seed gets lighter and tend to flow with drying air. The seed container is insulated with 25 mm thick thermocouple.

6. Testing

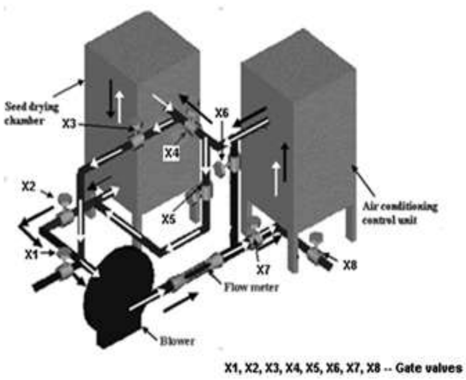

Figure 5. Air flow path of seed drying

The flow rate of drying air through seed bed was 0.106 m^{3}/s. During the experimental run, the air flow was reversed every half an hour. For air flow from bottom-to-top, the valves X1, *X*2, X4, X6 and X8 were closed while the valves X3, X5 and X7 remained open as shown in Fig.5 To reverse the air flow (top-to-bottom), the valves X3, X5 were closed and *X*2, X4 were opened while keeping other valves in same position. Water at 25 °C was circulated through the heat exchanger. The temperature at the inlet of seed drying chamber was maintained close to 38 °C.[1]

Table 1. Specifications of Seed Drying

Sl.No.	Parts	Quantity
1	Electrical heating coil (150W)	1
2	Temperature controller	1
3	Thermocouple	1
4	GI Pipe	7m
5	T Section	8
6	Gate valve	8
7	Reducer	1
8	Pin and tube type heat exchanger	1

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9	Seed drying chamber	1
10	Air conditioning chamber	1
11	Connecting wires	6m
12	Blower (0.75 hp)	1

7.Test and Results

7.1 Solar drying variation in moisture content

7.1.1 Solar drying of Pease.

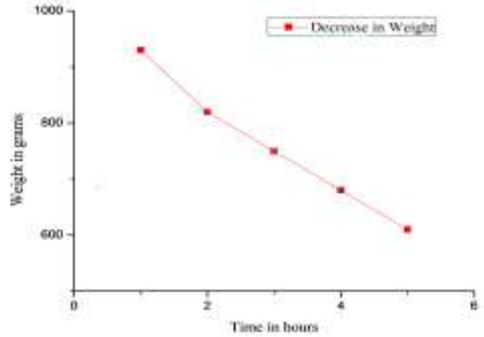

Figure 6. Solar drying of Pease.

7.1.2 Solar drying of green Pease.

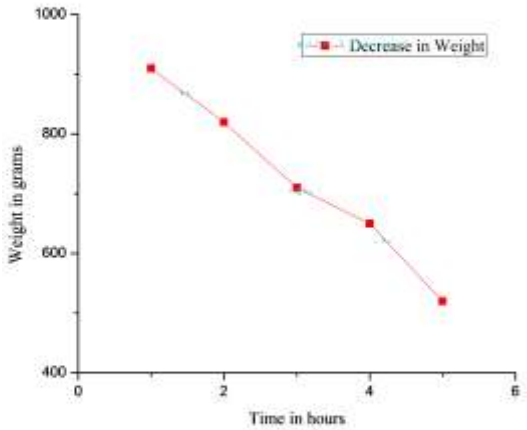

Figure 7. Solar drying of green Pease.

7.2Electrical drying variation in moisture content

7.2.1 Electrical drying of Pease

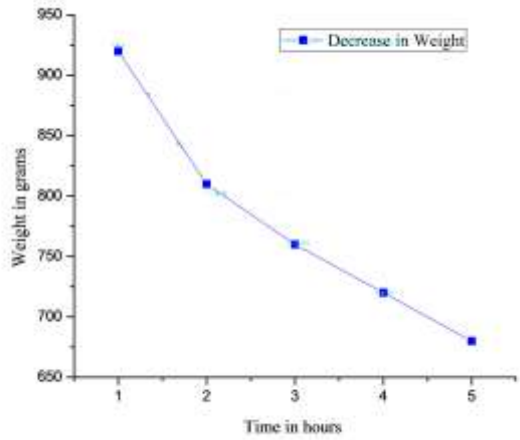

Figure 8. Electrical drying of Pease.

7.2.2 Electrical drying of green Pease

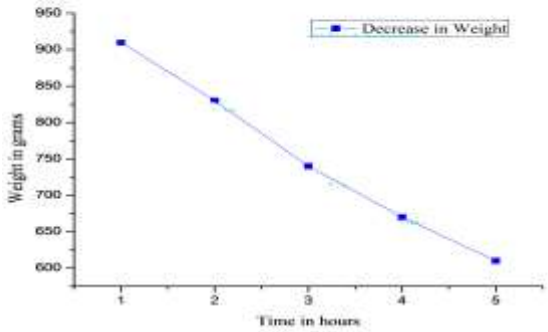

Figure 9. Electrical drying of green Pease.

7.3 comparison between solar and electrical drying.

7.3.1 Comparison between solar and electrical drying of Pease.

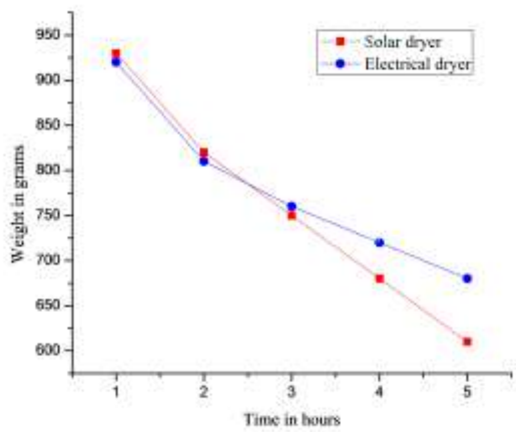

Figure 10. Comparison between solar and electrical drying of Pease.

7.3.2Comparison between solar and electrical drying of Green Pease

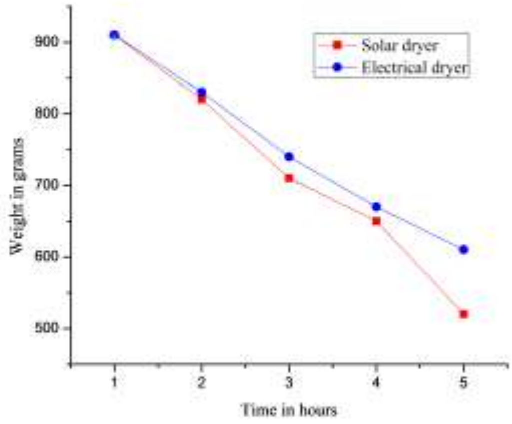

Figure.11. Comparison between solar and electrical drying of Green Pease.

8. Conclusion

Low temperature seed dryers are not able to dry seed in deep bed as in deep bed seed drying, the seed in lower layers of the bed gets over dried thereby impairing its germination. To overcome this, an improved desiccant seed dryer has been developed. It has a provision of air flow inversion through seed bed for uniform deep bed drying. This dryer will be able to dry seeds of higher moisture content level at 45-55 °C temperature. The seed germination will be not impaired after drying as the drying was carried at low temperature using dehumidified air. Using electrical dryers as an alternative method for drying has given good results. Hence dryer can be used in all the seasons. Installing induced type fan is proven to be more efficient compared to natural convection drying.

9. References

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