Design of Solar Dryer with Turboventilator and fireplace

Prof. Ajay Chandak & Dr. Sunil K. Somani, Prof. Deepak Dubey PRINCE, Suman Foundation, Shamgiri, Agra Road, Deopur, DHULE: 424005, INDIA

1. Abstract

Author has been using solar dryers for food processing, especially making Amla candy, since last five years. First drier is an innovative design with combined draught, natural and induced with fan. This dryer works well when fan induces draught. However when there is no power, the dryer works with natural draught but system under performs as the airflow is drastically reduced. In rural areas in Maharashtra Power cuts were increased to almost 14 hrs a day and practically no power is available to run fan during daytime when Sun is available. To counter this problem author has come up with a new design of solar dryer, which uses turboventilator for creating draught. Turboventilator runs on external wind and creates necessary draught and maintains good airflow through the solar dryer giving excellent performance. As the turboventilator works on outside wind only, no power is required and unit is truly a renewable energy gadget. The unit is also provided with a fireplace and bypass chimney. This facility permits the use of the dryer in night hours, cloudy days and also to accelerate the drying process when the Sun is available, by using some fuel like waste biomass. Turboventilator was preferred over Solar PV operated fan for the reasons of cost and possibility of operation at night or in cloudy period. Results of new solar dryers are very encouraging.

2. Introduction

2.1 Drying: Drying is an excellent way to preserve food and solar food dryers are an appropriate food preservation technology for a sustainable world. Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Water content of properly dried food varies from 5 to 25 percent depending on the food. Successful drying depends on:

- Enough heat to draw out moisture, without cooking the food;
- Dry air to absorb the released moisture; and
- Adequate air circulation to carry off the moisture.

Agricultural and other products have been dried by the sun and wind in the open air for thousands of years. The purpose is either to preserve them for later use, as is the case with food; or as an integral part of the production process, as with timber, tobacco and laundering. When drying foods, the key is to remove moisture as quickly as possible at a temperature that does not seriously affect the flavor, texture and color of the food. If the temperature is too low in the beginning, microorganisms may grow before the food is adequately dried. If the temperature is too high and the humidity too low, the food may harden on the surface. This makes it more difficult for moisture to escape and the food does not dry properly.

In industrialized regions and sectors, open air-drying has now been largely replaced by **mechanized dryers**, with boilers to heat incoming air, and fans to force it through at a high rate. Mechanized drying is faster than open-air drying, uses much less land and usually gives a better quality product. But the equipment is expensive and requires substantial quantities of fuel or electricity to operate.

2.2 Solar drying in this context of solar drying, refers to methods of using the sun's energy for drying, but *excludes* open air 'sun drying'. The justification for solar dryers is that they may be more effective than sun drying, but have lower operating costs than mechanized dryers. A number of designs are proven technically and while none are yet in widespread use, there is still optimism about their potential.

3. Background

Even though solar dryers have been known to people since long, its widespread use is restricted, especially because of high capital investments. It is observed that even though solar dryers does not attract any running cost on account of energy, but it involves longer operating hours and lack automation and hence overheads and labour costs are higher making the technology financially unattractive.

Author designed and used a solar dryer for over five years now. This design combined natural and induced draught in the same dryer. The dryer was designed in such a say that the cabinet was placed on the first floor roofing and the arrey of solar collectros hanging on the south side. Such design reduced structural cost and also provided natural draught when there is no power to run the fan.

Experiments with this design of dryer have shown that cost of energy saved by solar dryer over mechanised dryers is set off because of higher capital cost (interest burden) and higher labor and overheads. Hence replacing existing mechanised dryers with solar dryer only on account of energy saving cost was not practicable. However author noticed that there is huge value addition to the solar dried products on account of improvement in taste, aroma and color. Author experienced that this high value addition to the product can fetch higher cost for the produce and improve viability of the project. Author shared his experiences in a conference in Granada.

4. Project

Because of large overheads cost, one can conclude that solar drying is not commercially viable on smaller scale. Minimum size recommended by authors is 50 sqm of collection panels to justify the labour and other overheads.

4.1 Challenges in designing Solar dryers:

Solar dryer designs need to overcome many challanges to become competitive and become financially viable and practicable to use. Authors have tried to address those challanges and ways to overcome those challanges while improving the solar dryer design.

- Reduction in capital investment: Following measures were taken for reducing the capital investment in any solar drying project.
    - Dryer cabinets were installed on the first floor of the building and drying panels hanging out on the south side at designed angle to get optimum radiation. Such a design reduced structural cost and also worked as a roofing. This makes large covered space available under the dryer panels that can be utilised for storage, food processing activities etc. Saving on capital investment on buildings. Capital cost of solar dryer can be set off partially by savings on the building cost by using solar collectors as roofing.
    - Two arreys of solar collector panels were combined in one solar cabinet.
    - Cabinet partitions were also made in glass to capture more radiation. Glass being cheaper partition meterial, it also saved on the cost.
    - Precoated sheets were used for constructing the dryer panels, which resulted in good savings on fabrication and painting.
- Improving utilisation: It is observed that farm produce is available for a short duration and need to be processed in that short time. Author manufactures ’Amla Candy’ using solar dryers since last four years. Amla is harvested only for a period of one month or so and all the produce need to be processed or sold in that short duration of time. Other

crops will also face the same problems. Authors added a fireplace and heat exchanger in the design so that biogas or biomass from the farm can be burnt in this place. Burning biomass in day time will accelerate drying process and at night when Sun is not available the dryers can run only on biomass improving net output from the dryer.

- Maintaining adequate draught: First system was designed to work on combined natural or induced draught. Induced draught was created with the help of a fan consuming auxilliary power. Whenever there is a power cut the system will work under natural draught. Dryers underperform when they are run only on natural draught. In rural areas power cuts are large and hence practically there is no power available in day time. Runnign induced draught fan on solar PV arrey was one of the options, but authors decided against it because of high cost and limitations for night operations on alternative fuels. Authors added an innovation of making use of turboventilators for generating the induced draught. Turboventilators work on ouside wind and exhausts air from drying cabinet inducing draught.

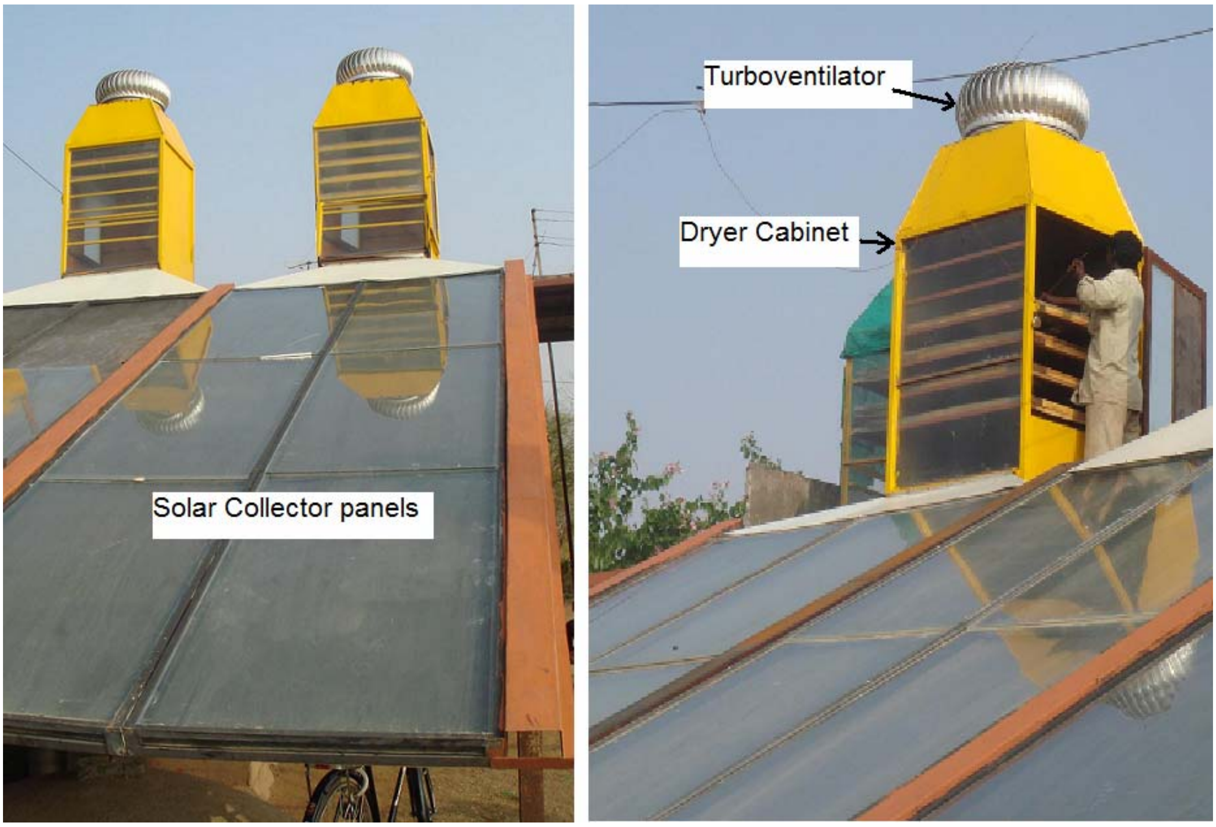

Fig. 4.1 Photographs of a new design of solar dryer with turboventilator.

Fig. 4.2 Photographs of a fireplace with chimney outlet on side.

Fireplace was designed and placed at the bottom of the cabinet in such a say as not to obstruct air flow from the solar collectors. Finned surface was provided for the interface to increase heat transfer from the fireplace to the cabinet side. Indirect heating is adopted as flue can not be permitted to pass through the food stuff. Separate opening was provided on the sides for chimney to allow flue directly to escape to atmosphere as shown in Fig. 4.2.

4.2 System operation:

Three solar collectors of two sqm each are connected in series to give effectively six sqm collector area in one row. Two such rows are connected to one cabinet. Air heated by Sun flows upward in the solar collectors either by natural draught or by draught created by the turboventilator and passes through the food stuff arranged in wooden trays with stainless steel mesh, taking out the moisture. Fuel can be burned in fireplace and flue escapes through the chimney on sides. Heat is exchanged through a finned partition to the cabinet side in the drying zone when Sun is not available.

4.3 Results & discussion:

Drying rate of the product depends on following parameters.

- Solar radiation intensity.
- Air flow rate.
- Outside humidity.
- Size distribution of the product to be dried.
- Initial moisture level of the food produce.
- Final moisture level to be maintained in the food product.
- No. of drying trays and design of solar dryer.

As most of these parameters are climate dependent there is large variation noticed about the drying rates. From the experience of manufacturing Amla Candy, for all practical purposes drying rates can be taken at around 3 kg of moisture removal per sqm per day when used only in solar mode.

Quality of produce from solar dryer, in terms of colour, aroma and taste, is much better than that of electrical dryer. Hence it is unfair to compare payback period of

solar dryers against fuel/power saving of mechanised dryers. Considering capital investment in Solar dryer which works out around at Rs. 3000/- to Rs. 5000/- (US $ 60 to 100) per sqm, including cost of cabinet, turboventilators and trays, payback period of 3 years is possible when compared to electrical dryer with minimum 200 days of operation of solar dryer. If value addition because of better quality produce is taken in to account, solar dryers may payback in less than two years. Author could fetch around 20% extra price for solar dried Amla Candy as compared to the one processed on mechanised/open sun drying. If biomass is used as backup fuel for cloudy days and night operations then the payback will further reduce.
In Solar dryer of this new design panels are used as roofing for the room created below the solar dryer. If the cost of roofing is discounted from the capital investment of solar dryer, then effectively the cost of dryer will reduce by 25%

5. Conclusion:

New design of solar dryer incorporating turboventilator and fireplace has following advantages.

- Unit does not require external power because of use of turboventilators. It is possible to use the unit at night hours as well, which is not possible with solar PV drive to fan.
- Typical design which uses solar collector panels as roofing and provides large covered utilisable area for store and processing unit. This feature saves huge cost on the structure of the solar dryer as well as roofing cost of the building under the solar collectors.
- Fireplace adds value to the product as night operations are possible. This permits high product output over small duration during which vegetables-fruits are harvested and processed. Large amount of biomass is available for free in the farms and can be effectively utilised in this unit.
- Interest burden of the capital investment is distributed over large production, improving financial viability to a great extent. With large volume of production, subsidies may not be required.
- It is unfair to compare amortisation issues with only fuel savings. Quality of goods processed on solar dryer is much superior in terms of colour, aroma and taste and hence fetches higher selling cost and hence higher margins. Paybacks with this value addition will be less than two years if dryers can be used for 200 days a year.

Compared to conventional solar dryer new design delivers almost three times more output if used round the clock. Lot of waste biomass is available in the farm which can be burned in the fireplace. As the unit uses energy from Sun, Wind and biomass, this new design has come out as a genuine renewable energy gadget.