SOLAR DRYERS FOR HIGH VALUE AGRO PRODCUTS AT SPRERI

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Topic addressed: *Solar food processing and back-up systems*

1. Abstract

Drying processes play an important role in the preservation of agricultural foods. Application of solar energy for drying of various high value agro products is getting more and more attention in view of the raising cost of fossil fuels as well as the pollution caused by these fuels. Studies at the institute have established that solar dryers are suitable technically and economically feasible in comparison to dryers running on conventional fuels. The Institute has developed an indirect type forced circulation solar drying technology for different industrial and commercial applications. A number of solar drying systems have been designed and commissioned with financial assistance from the various agencies. The systems designed for drying various high value agro products like Amla, Ayurvedic medicinal powder, tomato, mushroom & other fruits-vegetables, non-agro products like handmade paper, wooden planks and silica gel, are operating successfully. This paper covers the technical details about the few representative solar drying systems for high value agro products installed in the state of the Gujarat and their economic against diesel based system.

2. Introduction

Drying, the removal of undesired moisture from a product is an age-old practice followed at various levels. Many agricultural, horticultural and industrial products including chemical and pharmaceuticals are dried for various purposes like safe storage, easy handling, value addition, further processing and quality improvement. Many of the agricultural products are dried at the farm level to prevent decay and improve storage properties.

2.1 Traditional Sun Drying

Drying using the sun under the open sky for preserving low value foods and agricultural crops may be the most inexpensive and extensively used option since early times. Major disadvantage of this method is contamination of the products by dust, birds, animals and insects, spoiled products due to rain, wind and moisture, and the method totally depends on good weather conditions. Further, the process is labour intensive, unhygienic, unreliable, time consuming, non-uniform drying, and requires a large area for spreading the produce out to dry.

2.2 Mechanized drying

In the organized sector, for drying of large quantities of low and high value products, many mechanical dryers have been developed that use fuels like firewood, groundnut shells, saw dust, petroleum fuels like LDO & diesel, LPG and electricity to dry products. This method is energy intensive and expensive, and ultimately increases the product cost. The incessant rise in cost and shortages being experienced in regard to conventional fuels and pollutants being added to the atmosphere have resulted in a search for safer alternatives to open sun drying and mechanized drying like solar dryers.

2.3 Solar dryer

A solar dryer is an enclosed unit, to keep the food safe from damage, birds, insects and unexpected rainfall. The food is dried using solar thermal energy in a cleaner and healthier way. Studies undertaken so far have clearly indicated that while the initial cost of solar dryers are high, the life time cost of drying is only a third of dryers based on conventional fuels. At the present cost of conventional energy, solar dryers are more economical if used to dry upto two ton of high value products per day. Out of many types of solar dryers, forced circulation solar dryers are used more extensively [A]. In the forced circulation systems, blowers or fans operated by SPV or electrical power are used to produce air flow which air then used to dry the products kept in drying chambers. Forced circulation dryers usually lead to faster drying rate, higher airflow rates and better control of hot air temperature. Dryer can be designed to meet different capacities depending on the user needs and availability of the open space. Indirect forced circulation solar drying (FCSD) systems are highly suitable for industrial and commercial applications due to the good controls available and scope of integrating with existing systems. Indirect type FCSD systems with thermal back-up are found to be the most adaptable and suitable for obtaining large quantities of high quality high value agro products. Roof space available in small-scale industries would normally permit installation of systems of one to two tones per day capacity. This is also a more efficient method of drying that produces better quality products.

3. Indirect Type Forced Circulation Solar Dryer (FCSD)

Indirect type FCSD system mainly consists of solar air heating units, insulated ducting, blower, drying cabinet, monitoring & control devices and thermal back up (optional). Solar air heaters are flat plate collectors or packed bed collectors or unglazed collectors that can be installed on the ground, roof etc. In order to obtain maximum heat from solar energy, the solar air heaters need to be installed facing true south at a suitable tilt with respect to horizontal. It is essential that no shadow from any building or trees fall on the solar collectors throughout the year. All the three types of collectors may be of different sizes and of different configurations. Depending on the temperature of hot air, air flow rate and type of product to be dried, collectors are installed in series and parallel modes.

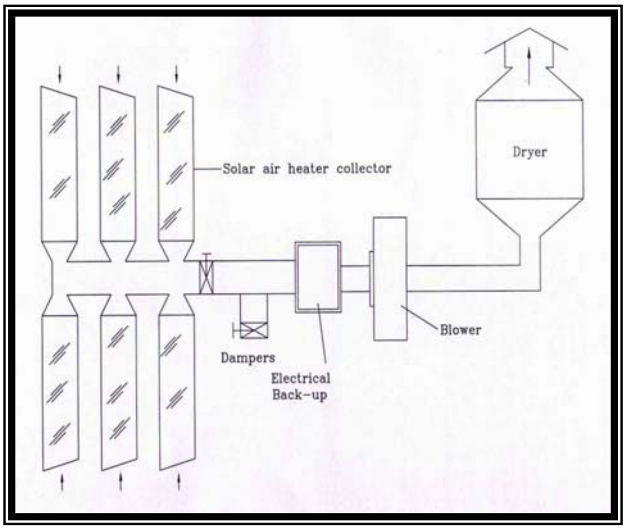

Figure 1: Line diagram of indirect type FCSD system

An electrical blower of adequate capacity is used to flow air through solar air heater. The blower can be installed before the collector or after the collector. In this system, the blower is usually connected between the collectors and the drying chamber so that the collector works under slight negative pressure to minimize the effect of minor leaks if any developed with time. Positive pressure is maintained inside the dryer to avoid entry of dust and cold air into the dryer.

Different types of dryers can be connected to solar air heaters. Tray dryer, continuous dryer, tunnel dryer, etc. are some of the types to which solar air heaters can be integrated. It might be possible to connect a solar air heater to an existing dryer and also use the available heating source as the back up. Air duct designed to match the different components of the solar drying system and maintain desired flow rate is another critical component. The required air flow, to be maintained inside the dryer, would depend mainly on the properties of the product to be dried. Through flow or cross flow is maintained inside the dryer so as to obtain near equal temperature inside the dryer and uniformly drying of products. Line diagram of a typical indirect type FCSD system is shown in Figure 1.

4. SPRERI designed indirect type FCSD systems in the field

SPRERI, Vallabh Vidyanagar has designed, installed and commissioned four different models of indirect type FCSD systems in the state of Gujarat with financial assistance from different agencies like All India Coordinated Research Project on Renewable Sources of Energy for Agricultural and Agro-based Industries of Indian Council of Agricultural Research, New Delhi (AICRP-ICAR on RES) and Ministry of New and Renewable Energy (MNRE). With these, total fourteen different solar drying systems have been installed in the field. The systems designed for drying various products like Amla, Ayurvedic Churnas, Tomatoes and Oyster mushroom are operating successfully and these systems are found to be technically and economically feasible to the users.

4.1 Solar tomato dryer

An indirect type FCSD system with LPG back up for drying tomatoes has been installed at M/s Shivam solar dryer, Thol near Ahmedabad. The system consisted of 60 m² of packed bed type solar air heaters, tray dryer and LPG back-up unit. In the packed bed solar air heaters, some packing material was placed between the glazing surface and absorber plate to increase the contact area of air to be heated. This system can dry 125 kg of fresh tomatoes, cut into four or six pieces, from an initial moisture content of 90% to final of 10% in a day. Figures 2 and 3 are photographs of the system [C].

Figure 2: Packed bed solar air heaters installed at Ahmedabad

Figure 3: Drying chamber for tomato dryer

This system has been provided with controls and instrumentation to make the operation user friendly, safe and ensure high product quality. In order to achieve uniform drying, alternate air flow rate arrangement with the help of motorized dampers and timers is provided from the top and bottom of the drying chamber. Another timer based control was provided to operate the system for specified drying durations. The required air temperature for drying tomato was about 80°C, which was difficult to achieve through solar energy only. To control/maintain the required temperature inside the drying chamber, solar air heating with automatic LPG ignition system was provided. Solar energy is used as a supplementary fuel to the LPG. The temperature inside the drying chamber was regulated by a controlling unit. The hot air temperature is programmable through a controller that operates the burner and gas supply to ensure uniform heating of air. This system is working satisfactorily. A temperature gain of 25°C to 30°C, through solar energy only, could be easily achieved and the payback period for this type of system is around 3½ to 4½ years.

4.2 Solar dryer for mushroom

Roof integrated unglazed solar air heater based solar dryers has been installed at the industry in village: Itola in Vadodara district. This firm, M/s Mashika Agritech Pvt. Ltd. grows Oyster Mushrooms on a commercial basis. The system consists of 80 m² roof integrated unglazed solar air heater, electrical back up, drying chamber, ducting and other controls and safety devices. A solar dryer to dry 75 kg per day has been designed, commissioned and are working satisfactorily (Figure 4).

Figure 4 Unglazed solar air heaters installed at Village: Itola

This type of dryer is suitable for low temperature drying products like mushroom and leafy vegetables. Though the efficiency is lower but the cost of fabrication and installation is also lower and pay back period is also less than 2 years. Total temperature gain of 10 to 15°C could be achieved.

4.3 Solar ayurvedic medicinal powder dryer

Figure 5: Glazed and unglazed solar air heaters at GSFDC

Figure 6: Drying chamber

SPRERI designed a solar dryer, for a government entrepreneur who was engaged in processing and manufacturing of the ayurvedic medicinal powder and herbs, consisting of $18m^2$ of glazed flat plate and 40 m² unglazed solar air heaters, a two horsepower blower and a tray dryer capable of loading 100 kg of ayurvedic product per batch. A batch could be dried in about six to eight hour in a day. Figure 5 and 6 show the solar dryer for ayurvedic product to which an electrical based thermal backup was integrated. Its efficiency and pricing comes in the middle of above two models of the systems. The payback period for the system is around three years.

4.4 Amla dryer at SPRERI

A solar hot air dryer to dry 60 kg of fresh sliced amla in about seven hour duration was designed and installed at the campus [B]. The system consisted of 32 m² of glazed air heaters, a 2 hp electric blower, tray dryer with 24 trays, electrical heater as backup and ducts and controls. Blower capacity identification depends on the product to be dried, air heating collector connection, temperature required to dry the product, type of air heating unit and pressure drop. In this case, a higher capacity blower was installed so as to meet the requirement of future up-gradation of the drying system by increasing the no. of air heating unit. Figure 7 is the photograph of the system.

The outlet air temperature of the solar air heater varied from 55 to 70°C and the dryer inside temperature varied from 50 to 65°C depending on the solar radiation and state of drying. The system could dry a batch of 60 kg fresh sliced amla in a day. The electrical backup was used only when the product was not fully dried by the evening. This system was used to dry many other products also.

Figure 7: Solar air heating unit installed at SPRERI

5. Summary and conclusions

Potential for solar drying systems is present in many agro-industrial segments due to better quality of finished high value agro product, better hygiene and also lower payback period. Operating costs of the systems are normally high due to the need to use blowers to circulate air through dryers. However, the energy contribution of solar air heating unit is far greater than the surplus energy consumed by the blower. The running consumption of electricity in electrical dryers (only) is 40% to 60% higher than the solar/hybrid operated dryers. However, the actual running cost depend on the type of the product to be dried, air flow rate, capacity/size of the dryer, and it varies with the seasonal changes.

The current cost of indirect type FCSD system is in the range of Rs.8,000 to Rs.12,000 per square meter. Further, due to a rapid rise in the price of hydrocarbons, the economics of solar energy use is becoming competitive and the payback period varies from 2 to 4½ years. All the solar dryers installed by the SPRERI at different locations are working satisfactory. The institute has installed many more solar dryers in the field for commercial applications. Nevertheless, continuous R & D efforts are going on to develop the solar dryers with higher loading capacity and lower operating cost, to bring down the initial cost of solar dryers to a level when the more and more potential user would gladly accept the system.

6. Acknowledgement

Financial support provided by All India Coordinated Research Project on Renewable Sources of Energy for Agricultural and Agro-based Industries of Indian Council of Agricultural Research, New Delhi (AICRP-ICAR on RES) and Ministry of New and Renewable Energy, New Delhi (MNRE) for this work is gratefully acknowledged.

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