SOLAR HEATING IN FOOD PROCESSING

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ABSTRACT

In conventional method of food processing, hot air (thermal energy) is being used to dry the food products such as grapes, fish, banana etc. by using fuels like kerosene, fire- wood, diesel, electricity. High moisture content is one of the reasons for food spoilage during storage and preservation. The conventional methods of heating though are popular but have some problems. Solar air heating system makes maximum use of air heating potential of sunlight. Special solar heat absorber is used for food processing applications by absorbing the heat and using for hot air generation. Solar collector like parabolic dish, solar shuffler system can be used. The trials carried out with parabolic systems show not only fuel saving but also great value addition because of better quality of product in terms of color, aroma and taste.

KEYWORDS: *Food processing, solar heating system, solar collector*

I. INTRODUCTION

In conventional method hot air (thermal energy) is being used to dry the food products such as grapes, fish, banana etc. by using fuels like kerosene, fire- wood, diesel, electricity. Present energy scenario indicates these sources are costly and depleting day by day. They also pollute the environment and responsible for hazards like global warming. The renewable energy bridges the gap between mounting energy demand and diminishing supply of conventional sources of energy. Need of cleaner environment and the increase in demand of more healthy and hygienic food-products encourages the use of renewable energy in agro-industrial production process.

Solar energy, the mother of renewable energy sources, is an inexhaustible, clean, cheap source of energy. Lying between 8^0 to 36^0 norths, India has 2500 to 3200hours of sunshine per year providing 5.4 to 5.8Kw of power per m^2 per day @1kJ/sec/m^2. Utilizing small portion of this immense resource would save our fossil fuels and forest without sacrificing our energy consumption. Solar hot air generation systems are more reliable, durable and cost effective energy production methods for agricultural and industry process. It is more efficient, easily adaptable from existing fuel-driven systems, environmentally friendly and hygienic. [1]

II. BACKGROUND

Food preservation or processing is done by drying or heating process. High moisture content is one of the reasons for food spoilage during storage and preservation. The conventional approach is with direct heating and indirect heating methods. These methods though are popular but have some problems such as:

- Higher cost of fuels and Requirement of bulk quantity of fuels
- Depletion of conventional fuels
- Environmental impacts with emission of CO2
- Cost of electricity and load shedding

Considering these difficulties some new methods are to be adopted. As far as food processing and preservation is concerned solar energy known as green energy is the best option available. Solar air heating system makes maximum use of air heating potential of sunlight. Special solar heat absorber is

used for absorbing the heat and using for hot air generation. Solar collector like parabolic dish, solar scheffler system can be used. [2]

2.1 Conventional Drying Process

Traditionally, in India people have been using solar energy for centuries mainly for agricultural purpose such as drying of grains and species, drying of fish, preservation of food products. The drying process removes moisture and helps in the preservation of the product. Open drying (or direct solar heating) of food products is done under sun by spreading it on open ground or a base plate is a common practice a various places[3]. This method is cheap but has several disadvantages:

- Possibility of contamination of the food product dirt, insects, rodents, birds which makes it unhygienic.
- Exposure of food product to the elements such as rain and wind which causes spoilage and losses.
- Loss of nutrition values and natural appearance like color, texture etc.
- The process is slow and long time period is required.
- Uneven heating or drying can be done.

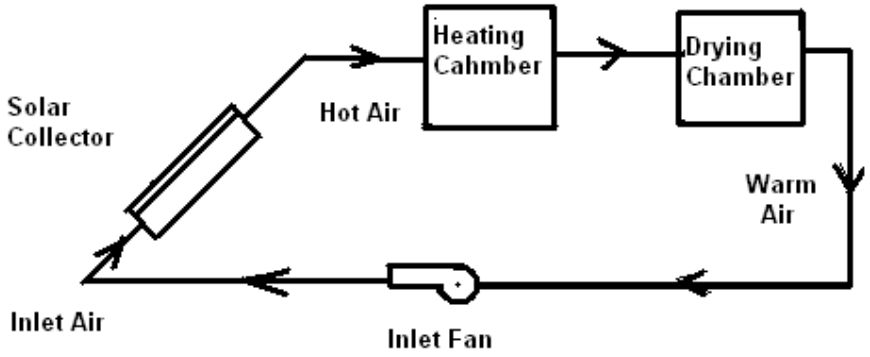

Figure 1 Solar Indirect Heating

In indirect heating (drying) is done by using a solar heater of a type which furnishes hot air to a separate drying unit. This can be advantageously used for big industries which require hot air. The system consists of air heater, drying chamber and thermal storage device. Solar collector collects radiation which heats the air which is blown to drying chamber for drying process. Air, thermal liquids or water can be used as heating medium. Thermal liquid is limited in quantity whereas water has uncertainty and low thermal efficiency. Air is ideal medium as it is free, easily available in bulk quantity and no extra auxiliary equipment is required. Parabolic dish collectors, flat plate collectors and shuffler system can be used for collecting solar radiations. Figure 1 shows the block diagram of Indirect heating. It consists of some basic components which are a) Solar collectors b) Solar heating chamber c) Drying chamber d) Inlet Fan [4]

III. CASE STUDY 1: SOLAR DRYER FOR BANANA SLICES USING PARABOLIC SOLAR COLLECTOR DISH

3.1 Working principle

The basic principle of solar dryer is to make use of solar energy to heat the air which is used to dry the products. When air is heated, its relative humidity decreases and it is able to hold more moisture. Warm, dry air flowing through the dryer carries away the moisture that evaporates from the surface of the food. Banana contains 80% of water, when heated up-to 70^0C moisture content reduces to 10% [5].

3.2 Solar dryer system

System consists of solar collector, heat absorber, drying chamber and control unit.

1) Solar collector :-Solar parabolic dish collector (Aperture diameter- 1.4m ; Focal length - 0.28m)
2) Heating cabinet:-It consists of no. of tubes made up of copper wound in a coil, placed in a black box that absorbs maximum heat energy. (Tube diameter- 1cm. ; Length- 33cm ; Width- 4cm ; No. of turns – 18)
3) Drying chamber :- Length – 33cm ; Width – 4cm; No. of plates -5
4) Control unit:- Three control circuits are required.
    a) Orifice plate - For air control at inlet valve
    b) RTD(PT-100) – To regulate the temperature of drying chamber
    c) Load cells – to register end point of the process (reduction in weight of banana) in terms of mill volt. This output voltage is amplified using amplifier and gives signal to relay to operate alarm.

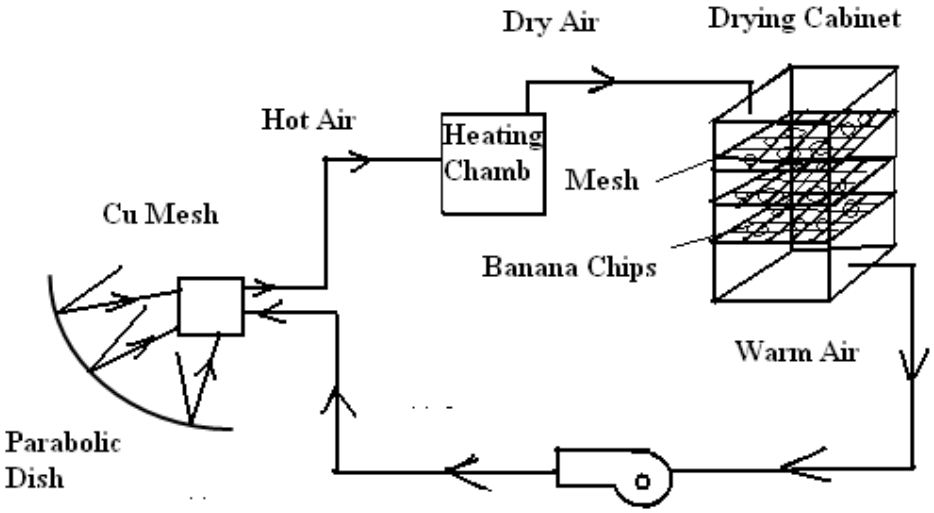

Figure 2 Solar Dryer

3.3 Observations

Table1

Before Drying	
Initial weight of banana	1kg (1000gms)
Initial temp. of banana	28^0C
After Drying	
Final weight of banana	Approximately 778gms
Expected reduction in moisture content	20%
Drying time	3 hrs 53 min. (theoretical)
Actual drying time	4 to 5 hrs

3.4 Conclusion

- The average drying rate is found to be 0.17kg/hr
- Drying rate can be increased by controlling inlet air temperature and air velocity at drying chamber.
- Drying time can be reduced by combined mode of free and forced convection.
- Outlet air can be recycled in heating unit to increase the efficiency, drying rate as well as to reduce drying time.

3.5 Applications

- This system can be used for processing of grain and other food products like spices, tea leaves, fish, dehydrating fruits& vegetables.
- This system can also be used in industry for producing paper& board, supplying hot air to boilers, space heating at hill stations, processing leather& hides, etc.
- Same system can be used for heating the thermal liquid which can be used as heat source.

3.6 Advantages

Compared to conventional methods are

- Makes product more uniform, healthy, and hygienic
- Preserves color, texture and natural appearance and Retains nutrients like beta carotene
- Gives long life to products
- Maintains moisture level at optimum level
- Can be easily adopted into fossil fuel systems
- The system Functions consistently and efficiently for 15-20years.

3.7 Improvement

- To generate more quantity of hot air shuffler solar dish can be used which also increases drying rate with reduction in drying time.
- For small quantity of food stuff solar cooker can also be used.

IV. CASE STUDY 2: SOLAR DRYER (OVEN) FOR CASHEW NUT ROASTING

Arrangement is proposed to install the cabinet for loading the material on rooftop, while collector panels were laid on south side towards ground. This saved cost of fabricated support structure. As the cabinet is placed at higher elevation than the collector panels, with uniform slope, natural draught assists the induced draught created by fan. Because of combined draught overall auxiliary power consumption for fan is reduced.

Solar collectors were constructed in powder coated M.S. sheets instead of aluminum sheets. This reduced the cost of solar collector panels by around 50%. Outer shell of panel is constructed in single sheet without any joints, which takes care of possibility of hot air leakages. Cabinet for loading material was constructed with plastic sheets on three sides & plywood door on rear side. Cost of the cabinet contributes a lot in conventional solar or other mechanized dryer as it is to be constructed in stainless steel and need to be properly insulated. Replacing this envelop by plastic sheets saves 85% of the cabinet cost. No insulation is required in this case [6].

Design of cabinet permits even distribution of hot air throughout cross section, which permits uniform drying, rates. Control on maintaining moisture at desired level is easily possible. Even unskilled worker can operate the unit. Negligible running cost. Mechanized unit require 8 kWh of auxiliary power and 50 kg of coal per day for a 100-kg/day capacity while solar dryer requires less than 2 kWh of auxiliary power for fan, for same capacity [7].

4.1 Trials and results

- In Cashew processing the shelled kernel is covered with the testa and to facilitate removal, i.e. to peel in order to produce the blanched kernel, the shelled kernel is dried. The moisture content is approximately 6% before drying and 3% after. Same unit was used for drying shelled kernel successfully.
- In Cashew nut processing, roasting of the nut in box ovens give excellent quality nuts. Breakage of nuts was reduced by 50% and roasting was uniform. Nuts roasted in box ovens followed by drying kernel in solar dryers, not only save energy cost but also fetch handsome Rs. 50/- per kg more than the nuts produced by electrical boilers and dryers.
- Roasting application with solar concentrator requires great skill and there were incidences of food burning, especially with cashew nuts, soybean and groundnut. It is observed that solar ovens are better suited for baking and roasting applications than concentrators. Uniform

baking and roasting is observed in solar ovens. Even an unskilled worker can work well with ovens, but not with the concentrators.

- Moisture removal rate was observed at around 3 kg per sq. mtr. area of panel in dry climate.
- Apart from fossil fuel savings, quality improvement of the food product and better process control are main advantages.

V. GOVERNMENT SUPPORT

The Ministry of Food Processing Industries is the nodal agency of the Government of India for processed foods and is responsible for developing a strong and vibrant food processing sector. In the era of economic liberalization where the private, public and co-operative sectors are to play their rightful role in development of food processing sector, the Ministry acts as a catalyst for bringing in greater investment into this sector, guiding and helping the industry in a proper direction, encouraging exports and creating a conducive environment for the healthy growth of the food processing industry. Ministry of Food Processing Industries or nominated nodal agencies are responsible for implementing programs relating to this sector in the concerned State Governments. The Ministry also interacts with various promotional organizations like

- Agricultural Products Export Development Authority (APEDA),
- Marine Products Export Development Authority (MPEDA),
- Coffee Board and Cashew Board
- National Research Development corporation (NRDC),
- National Cooperative Development Corporation
- National Horticulture Board(NHB)

This growth of the Food Processing Industry will bring immense benefits to the economy, raising agricultural yields, meeting productivity, creating employment and raising the standard of very large number of people throughout the country, specially, in the rural areas. Economic liberalization and rising consumer prosperity is opening up new opportunities for diversification in Food Processing Sector. [8]

5.1 MOFPI Schemes

- Scheme for infrastructure Development - Setting up of Mega Food Park, Cold Chain infrastructure Modernization of Abattoirs
- Scheme for Technology Up Gradation, Establishment And Modernization Of Food Processing Industries
- Scheme for Quality Assurance, Codex Standards, Research & Development And Other Promotional Activities

Table 2 Projects Assisted by MOFPI

State-wise Financial Assistance Extended under Plan Scheme for Technology Up-gradation/Establishment/ Modernization of Food Processing Industries in India (2002-2003 to 2006-2007)					
(₹in Lakh)					
States/UTs	**2002-03**	**2003-04**	**2004-2005**	**2005-2006**	**2006-07**
Andhra Pradesh	124.74	465.57	797.67	689.80	504.21
Maharashtra	239.95	529.03	778.67	1251.94	721.80
Karnataka	41.85	151.49	425.32	419.73	199.65
West Bengal	163.54	132.96	325.74	400.14	271.08

5.2 NHB Schemes

National Horticultural Board (NHB) is providing schemes related to technology development and transfer, Introduction of New Technologies, Domestic visit of farmers, Technology Awareness. It is also releasing up to 100% financial assistance as under

a) Up to ₹25.00 lakh

b) As per actual
c) Up to ₹50,000/seminar

NHB also provides market information service for horticulture crops

a) General information on wholesale prices, arrivals and trends in various markets for horticulture produce and
b) Dissemination of information through Media & Publications
c) To assist farmers, exporters, dealers research organizations etc.

5.3 Government Schemes and Policies related to Solar Energy

Ministry of new and renewable energy (MNRE) is supporting to promote use of renewable energy in different areas of application. Various schemes and programs are lunched by MNRE to spread the importance of renewable energy applications and products. It is also providing subsidies for installing renewable applications in different areas. For solar energy MNRE has launched a program called Jawaharlal Nehru Solar energy Mission. Under this various Solar Air Heating schemes are introduces by MNRE. [9] Salient features of the scheme are:

- To promote Solar Air Heating/Steam Generating Systems, financial support in form of 50% of the cost of system
- Subject to a maximum of 5000 per sq. m of dish area for solar concentrating systems, and ₹2500 per sq. m. of collector area for FPC based solar air heating systems/ dryers will be provided to non-profit making institutions/organizations.
- 35% of the cost of system, subject to a maximum of ₹3500/-per sq. m of dish area for solar concentrating systems, and ₹1750 per sq. m. of collector area for FPC based solar air heating systems/ dryers will be provided to commercial/industrial organizations (profit making and claiming depreciation).
- Proposals could be directly generated by the beneficiaries in association with suppliers & State Nodal Agencies (SNAs) and submitted to the Ministry through implementing agencies, which will be provided service charges @ 3% of MNRE support.

VI. CONCLUSION

Conventional methods used for heating for in food processing are costly and energy consuming. Need of cleaner environment and the increase in demand of more healthy and hygienic food-products encourages the use of renewable energy in agro-industrial production process. For promoting solar energy application on a large scale in food processing industry, it is very important to integrate knowledge of food processing with capabilities of different solar gadgets. Great quality improvement in solar processed food was observed in terms of retention of color, aroma and taste.

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