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CONSTRUCTION AND EVALUATION OF A SOLAR THERMAL-WIND HYBRID DRYER FOR FOOD PROCESSING IN CHIAPAS, MX

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Purpose

Solar dryers are a solution for solar food processing and some of these devices are designed to dry just with the heat of the sun during the day reducing the period of drying. To increase the quality of solar food, it is required to maintain the most important operation parameter - the temperature. As a solution of the sun intermittency and to maintain a constant temperature, an auxiliary system is required to backup the main system. We propose a solar thermal system as the main resource in the drying process and electrical heat back up powered by a wind system. The first subsystem is solar thermal heating; it is composed of 2 solar vacuum tube collectors consisting of 30 heat pipes, a thermal storage tank, a heat exchanger, 2 fans and a water circulation pump. The second consisting of a wind turbine, a voltage regulator, a battery bank and an inverter and 2 heat resistances, thus keeping 24-hour stable working conditions; which work as follows: The evaluation of solar dryer was conducted in no load condition without backup and with backup while controlling the temperature at (40, 50, 60 and 70) °C, the results are showed above.

Experimental processes

Solar Dryer

1. Design conditions and assumptions
2. Energy demand
3. Energy available
4. Selection of materials and equipment
5. Implementation
6. Evaluation

Apple Drying

1. Product treatment
2. Heat treatment (Solar and Conventional)
3. Measurement humidity in product
4. Drying kinetic determination of apple

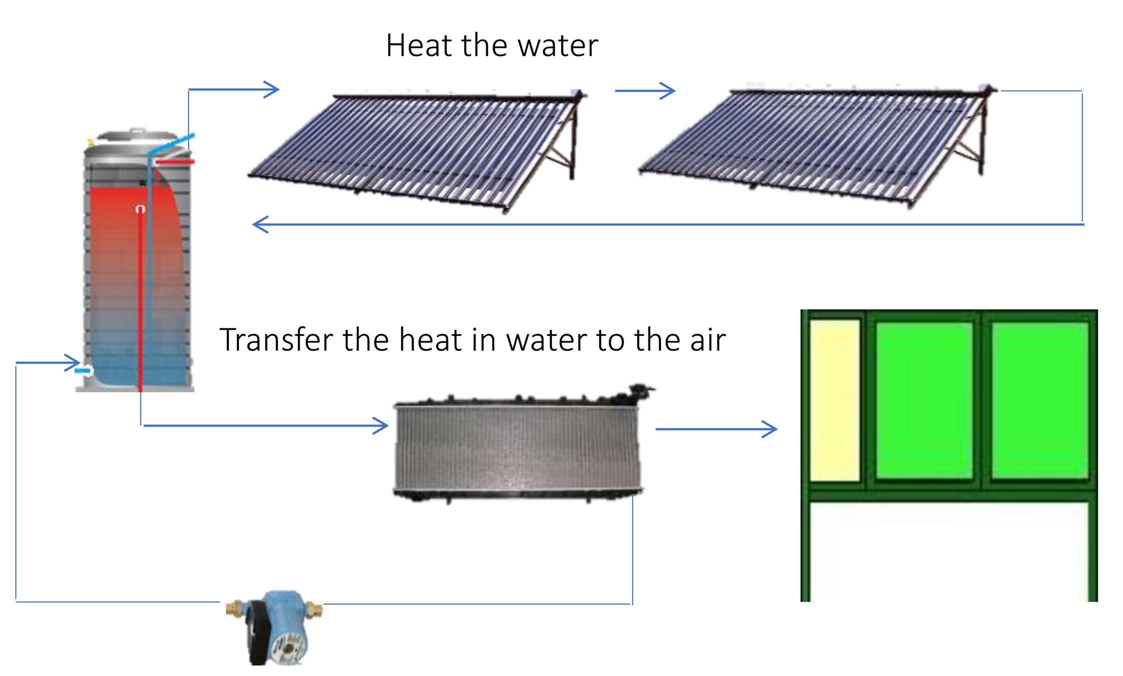

Figure 1. Components of solar wind hybrid dryer.


Figure.2. Hybrid dryer in solar platform - CIDTER, UNICACH, Chiapas, MX.

Results.

The results show that without backup the chamber temperature depends of the solar radiation and they go from 50 to 70 °C during the day and in the night the temperature keep constant. When backup system is used low temperatures can be maintained during 24 hours and electrical resistance are used early in the morning and in evening time, and for low temperatures backup is not needed in high radiation days. For high temperatures, electrical resistances always are used early in the morning and in evening time and the backup system is fundamental to maintain the temperature constant and the use of it is longer compared whit low temperature. For charged chamber with apple samples, the temperature was controlled at 50,60 and 70°C during 24 hours

Description of the solar thermal-wind hybrid dryer

Heat pipe evacuated tube collectors capture solar radiation for heating a fluid which is stored in a thermal storage tank. This heat in the fluid is transferred to the drying chamber through the heat exchanger, while the energy generated by the wind turbine is used for the operation of the fans and pump for the circulation system of air and water. A control system also provides a portion of the thermal energy to the drying chamber with the dissipation of heat with electric resistances.

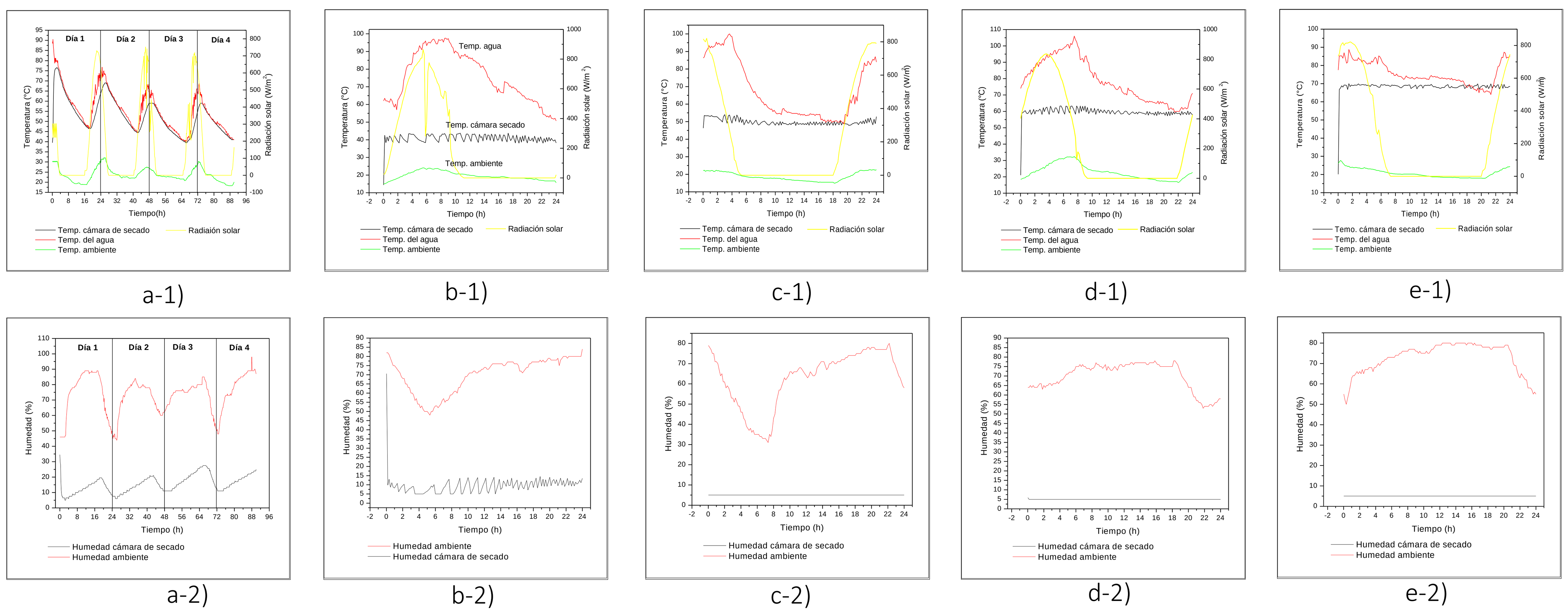

Figure 3. The Graphic from a-1 to e-1 show the temperature in tank water, temperature in drying chamber, and environment temperature vs time vs radiation. The graphic from a-2 to e-2 show the moisture or humidity inside the chamber and environment moisture vs time. 'a' graphics correspond to a test without back up energy and control. 'b' graphics correspond to a test at 40°C, 'c' graphics correspond to a test at 50°C, 'd' graphics at 60°C and 'e' graphics test was run at 70°C. All this graphics correspond to the evaluation of solar dyer whit no load condition.

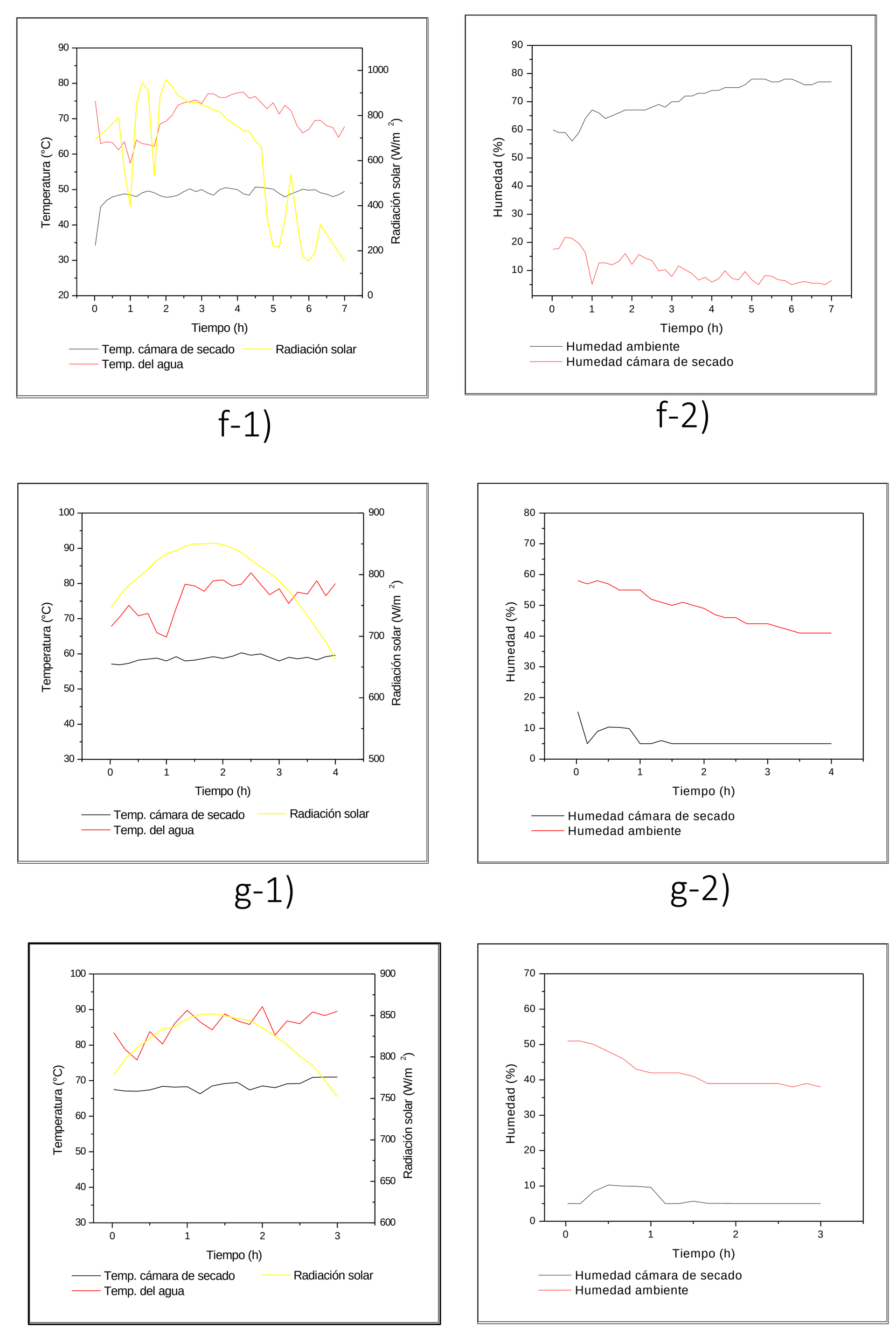

Figure 4. The graphics from f-1 to h-1 shows temperature in chamber, temperature in tank water vs time, radiation, and moisture. This test corresponds to the evaluation of solar dryer whit load of apples at 50, 60 and 70 °C.

Conclusion

a) The implementation of the wind turbine as an auxiliary power source was satisfactory since it allowed the operation of the fan, pump, extractor, at all times.

b) It was possible to establish and control different temperatures in the drying chamber, managing to maintain stable temperatures of 40, 50.60 and 70 ° C for 24 hours even in days of low solar radiation.

c) The thermal efficiency was determined depending on the temperature controlled per hour in the drying chamber obtaining a maximum efficiency of 34.46, 33.43, 34.55 and 30.15% for 40, 50, 60 and 70 ° C respectively.

d) Apple was dehydrated at controlled temperatures of 50, 60, and 70 ° C, thanks to this the dehydration time was short of 7 hours for 50° C, 4 and 3 hours for 60 and 70 ° C. In this period of time, the initial humidity reached 89% to a final humidity of 16.03%, 15.34% and 14.28% for dehydrated samples at 50, 60 and 70 ° C respectively.

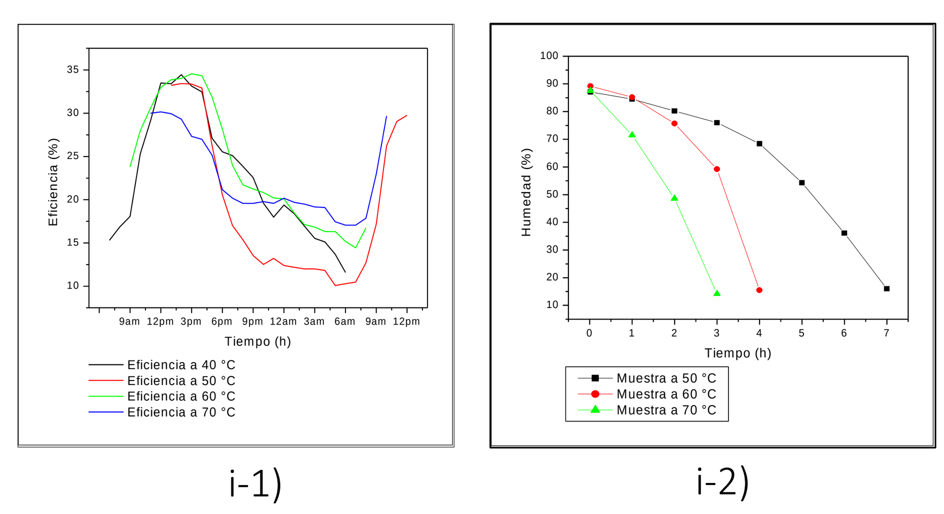

Figure 5. i-1 shows the efficiency evaluation and i-2 shows the kinetic drying curve of apple samples at 50, 60 and 70°C.

Reference

[1] Gama Pérez J. David," Análisis teórico-experimental de un deshidratador solar combinado (Térmico-fotovoltaico), para el tratamiento de arroz", México, 2007.

[2] Durán G., Condorí M., Echazú R.,Díaz G.," Secador solar híbrido para la producción continua a escala industrial de pimiento para pimentón", INENCO, Instituto de Investigación en Energía No Convencional. Universidad Nacional de Salta, U.N.Sa. Argentina, 2010.

[3] Deolarte Martínez C. Gerardo, "Secador solar híbrido para deshidratar productos agropecuarios", Universidad Nacional Autónoma de México, México, 2008.

[4] Hermosillo J., Gudiño A., Mendoza R.; Notas Sobre el Curso de Energía Solar; Departamento de Procesos Tecnológicos e Industriales, División Ingeniería. ITESO; Jalisco, México 1995.