PILOT FRUIT DRIER FOR THE LOS AZUFRES GEOTHERMAL FIELD, MEXICO

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ABSTRACT

The region around the Los Azufres geothermal field is a large fruit producer, thus the local growers may be interested in constructing dehydration facilities at Los Azufres and to buy surplus heat from CFE. CFE is installing a small fruit drier to demonstrate the feasibility of drying fruit with geothermal water, and thus encourage private development on a larger scale. The pilot drier will be enclosed in a small building with room for two trucks (hand carts) each holding 30 one-meter square trays with a total capacity of approximately one tonne of wet fruit. The forced air heat exchanger and fan unit were designed for the high elevation (3000 m). Operation will begin in the summer of 1995.

Key words: dehyration, fruit drying, direct use, agriculture, truck drier.

1.0 INTRODUCTION

Comision Federal de Electricidad (CFE) has a division in charge of the exploration of geothermal reservoir located in Los Azufres, State of Michoacan (about 250 km west of Mexico City). At present, CFE is only using the steam from the wells and rejecting the hot water that comes off associated with the steam.

CFE is promoting the use of the geothermal hot water in industries with high consumption of heat. Several local industries are interested in constructing facilities at Los Azufres and to buy heat from CFE. So far, CFE has installed a chamber for drying lumber with very good results. They have also constructed a pilot greenhouse to grow cut flowers in winter and to produce gladiolus bulbs.

Since the region of Los Azufres is mainly a fruit producer (pears, peaches, guava, etc.), they propose to construct a small fruit dehydrator for demonstration purposes. They are confident that if they succeed in showing the feasibility of drying fruit with geothermal heat, they will have a demand for larger drying installations.

As a result of this interest, the Geo-Heat Center in cooperation with CFE, designed a pilot geothermal fruit drier that is presently under construction. The details of the design are presented in this paper.

2.0 LOS AZUFRES GEOTHERMAL FIELD

The Los Azufres geothermal field, started in 1981, is located approximately 80 km east of Morelia (Fig. 1). The elevation of the field varies from 2000 to 3000 m. The mean annual air temperature is 12" C with the temperatures ranging from 31° *C* to -4" C. The annual precipitation is 1,171 mm, the average relative humidity is 63% and the atmospheric pressure 0.73 bars (based on average conditions from 1983 to 1990).

The field has 63 geothermal wells at an average depth of 2,100 m. The total steam production is 1,550 t/h with a noncondensible gas content of 3% by weight, which is composed of 97% CO_2 and 3% H_2S. The field's brine production is 1,600 t/h at a separation

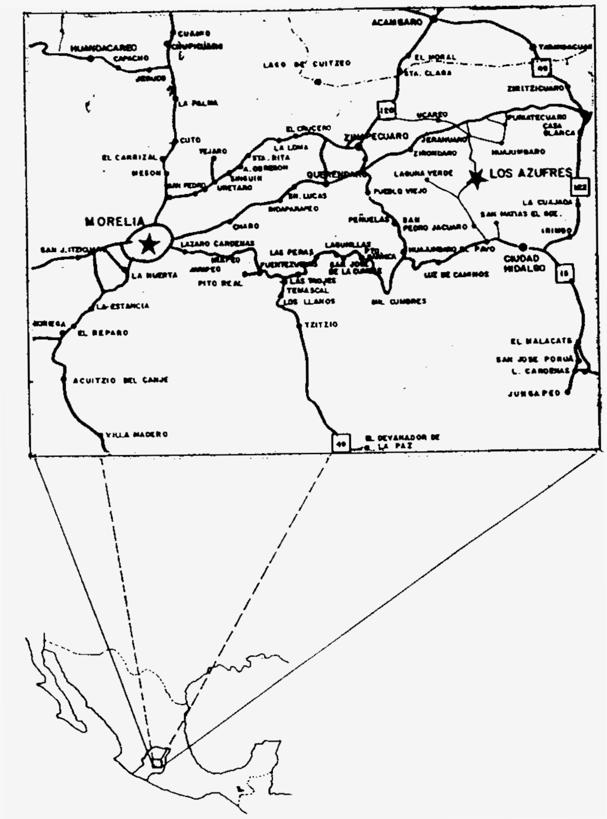


Figure 1. Location of the Los Azufres geothermal field, Mexico.

temperature of 170" C. The average production from a well is 50 t/h, with the brine at a pH of 7.2 and a chemical composition of (in mg/L):

Cl	4,399
Na	2,321
SiO_2	1,050
K	628
B	365
HCO,	83
Li	32
As	28
SO_4	23
Ca	16
Rb	5
c s	4
Mg	trace

The well to be used for the fruit drier is AZ-22 located on the main administration building compound at Los Azufres, at an elevation of 2864 m. The well produces 110 t/h at **170"** C. The production from this well will be shared with the timber drier and used for future space heating of the administration buildings. Cold water is available from a nearby stream

3.0 FRUIT PRODUCTION AND DRYING

At present, the annual fruit production of the surrounding area is as follows (in tonnes/year):

Pears	15,000
Prunes	5,000
Peaches	1,350
Guavas	900
Apples	140

Based on recent studies, it is estimated that there is a demand for drying 40% of the annual fruit production. This would allow the growers to sell the fruit over a longer time period and to ship to more distant markets without worrying about spoilage.

Since two thirds of the fruit grown in the area is pears, the drier was designed to handle this fruit; however, other types can also be dehydrated in the same drier.

The preparation and processing of the fruit is based on a 1946 report prepared by the California Agricultural Experiment Station (Perry, et al., 1946). No new publications are available; however, the information is still valid according to Dr. James Thompson of the Agricultural Engineering Station at the University of California at Davis (Thompson, 1992). These details will not be discussed in this paper.

The actual design will handle about one tonne of fruit (wet) per drying cycle. Cutting, storing and packaging of the fruit will be done on site in a separate building. A cold storage facility may be designed to keep fresh fruit when harvest exceeds the capacity of the drier.

4.0 FRUIT DRIER DESIGN

Since the drier is a demonstration project, the size will be minimal to expedite construction and minimize cost. The design is based on preliminary work reported by Herman Guillen (1987).

4.1 Building Design

The drier building will be about 4.00 m long, 1.35 m wide and 3.2 m high (Fig. 2). The actual dimensions will depend upon the sue of local building materials.

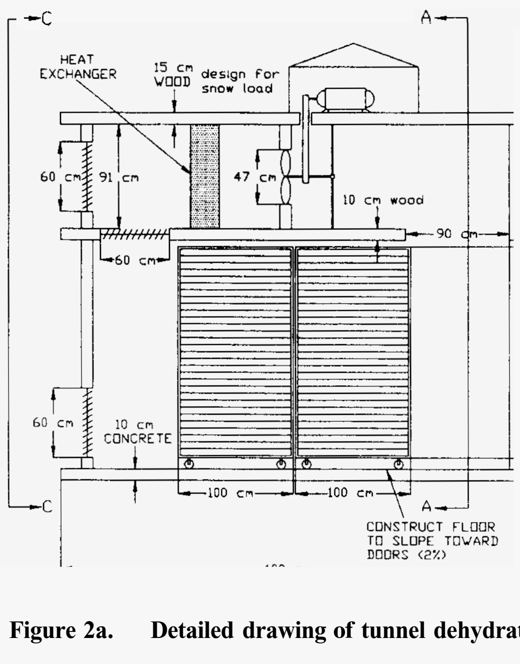


Figure 2a. Detailed drawing of tunnel dehydrator.

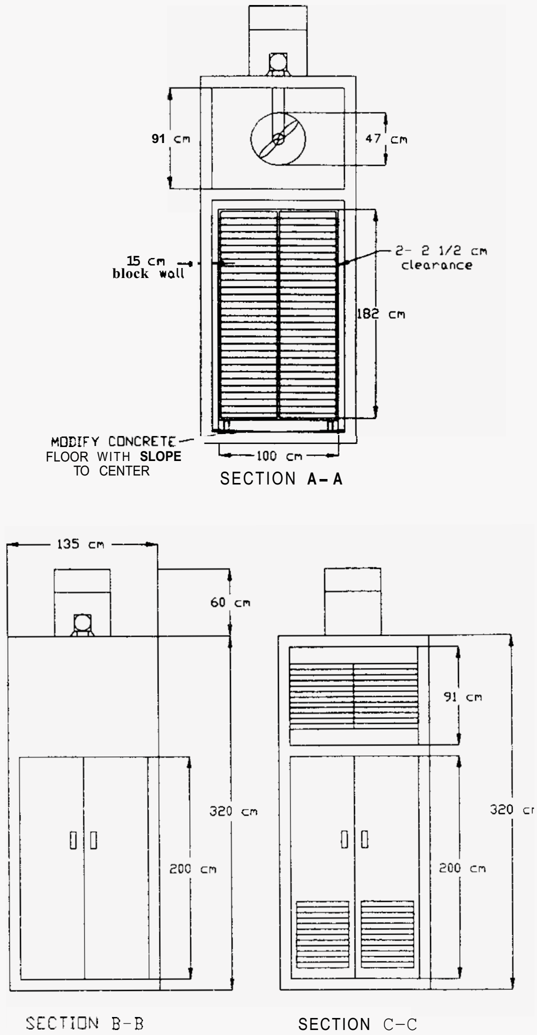


Figure 2b. Cross sections of dehydrator.

The walls will be constructed of concrete block, the ceiling and roof of timber and the floor of placed concrete. The floor will have a slight depression down the middle and slope toward the front doors to drain any juices from the drying fruit and for ease of cleaning. The heat exchangers and fan motor will be housed on the roof so that the latter is away from the hot air stream.

The trucks and walls are designed so that there is no more than about 2 to 2.5 cm of clearance on either side and at the top. This will maximize the air velocity and efficiency of the system.

Louvered doors will be provided for entering, recirculating and leaving air. The louvers will be manually set, but could be set automatically as controlled by temperature and humidity sensors.

4.2 Truck and Drying Tray Design

Two trucks will be used; each with a base of 1.00 m by 1.00 m and 1.82 m high when loaded with trays (Fig. 3). The truck base will have four casters (pivot wheels) and a detachable handle that can be attached at either end. This will allow the trucks to be reversed when halfway through the drying process time. The base will be constructed of plywood approximately 2 cm thick. Each truck will carry 30 trays. Each tray will carry approximately 15 kg of fruit (wet) for a total of 450 kg per truck and almost one tonne per drying cycle for the two trucks. During the drying operation the moisture content of the fruit will change from about 80% to 20% by wet weight. Drying time is approximately 24 hours (Thompson, 1994).

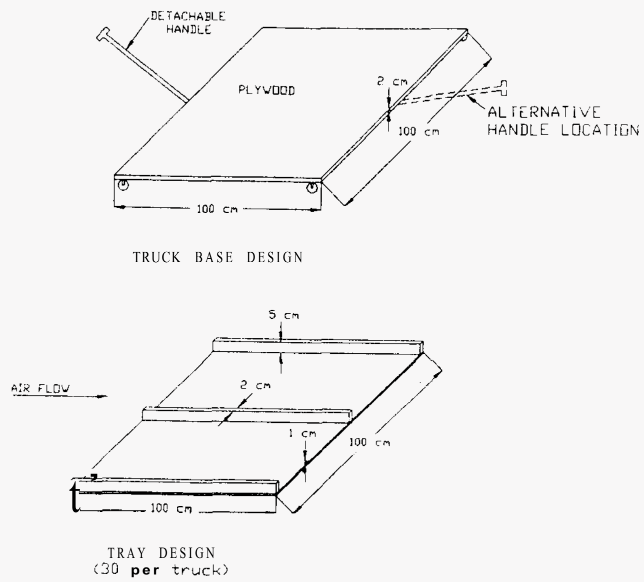


Figure 3. Truck and tray design.

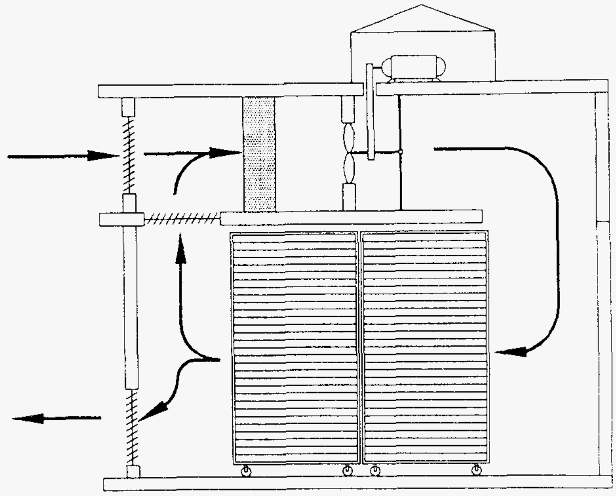


Figure 4. Tunnel dehydrator air flow pattern.

The trays will be constructed of 1-cm thick plywood and have 5-cm high by 2-cm wide wood strip attached to either edge, along with one down the center (parallel to the air flow) for strength and stacking. The plywood trays will have 1-cm diameter holes drilled in them for drainage of fruit juice produced during drying.

4.3 Heat Exchanger Design

The required air speed for fruit drying is high; ideally about 240 to 300 m/min. with a minimum of 150 m/min (Thompson, 1992). Estimating that the trays and fruit block 50% of the tunnel, then the cross section for air flow will be 1.00 m x 2.00 m x 0.50 = 1.00 m^2. Thus, a minimum capacity of 150 m^3/min will be needed (240 to 300 m^3/min. ideal). Converting this requirement to 2864 m elevation (air density ratio equals approximately 0.70), a minimum capacity of 215 m^3/min. will be necessary at Los Azufres to produce the same drying capacity. Fortunately, the evaporation rate will also be increased at this elevation due to the reduction in outside pressure relative to the vapor pressure in the fruit, thus allowing the use of the minimum design air flow.

A minimum of 0 C outside entering air temperature and a maximum of 70" C drying temperature was assumed. (The ideal temperature for pear drying is 60" C and the maximum is 74" C.) The geothermal resource was assumed to enter at 120" C and exit at 100" C. Based on these assumptions, the required heat exchanger will need two rows of 8 finned tubes at 91 cm by 91 cm cross section (Rayner, 1992).

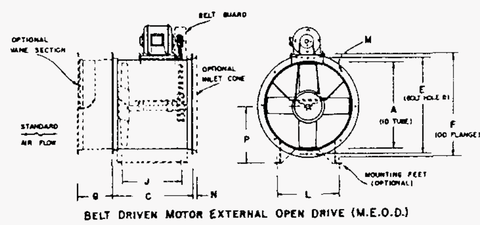
This is the design for the most severe conditions. The geothermal flow rate can be adjusted by a valve to compensate for changing outside air temperature. A three-way valve with a temperature sensor in the air stream could be used for automatic control. The air flow will enter through a 60 cm x 100 cm louver, through a 91 cm x 91 cm duct in the top of the building, and then flow down through the trucks (Fig. 4). The air can then be exhausted or it can be recycled if the outside air temperature is very low. In many dehydrators, at least 90% of the air is recycled to conserve input energy.

The actual temperature and air flow rates will have to be adjusted by trial-and-error to achieve the proper final product in terms of moisture. texture and color.

A second heat exchanger of the water-to-water type may be necessary to reduce the possible effects of corrosion or scaling from the geothermal water. This would consist of a small plate heat exchanger with a secondary loop supplying passive water to the water-air heat exchanger in the drier building. The plate heat exchanger would be sized to handle the future heating load from the administration buildings.

4.4 Fan Unit Design

The tube axial fan was designed for 215 m^3/min and 2 cm of water pressure head loss (air flow friction loss) at 0.722 g/L air (1.20 g/L at sea level). This will require 1.05 BHP or a 1.5 hp motor (1.12 kW). The fan will be 61 cm in diameter and have 5 blades with a 10.5" blade tip pitch. Due to the high temperature of the air flow, the fan motor will have to be located on top of the building outside of the hot air stream. Details of the fan and housing are shown in Figure 5 (Rayner, 1992).



SIZE	A	B	C	D	E	F	G	H	J	K	L	M	N	P	SHAFT
15	15-3/8	15	25-1/2	32	16-9/16	17-9/16	8	11	21-1/2	28	12-1/2	8 - 3/8" Ø	3	11-3/4	1-7/16
18	18-3/8	16	26	32	19-9/16	20-9/16	8-1/2	12	22	28	14-1/2	8 - 3/8" Ø	3	13-1/4	1-7/16
21	21-3/8	19	27-1/2	32	23-1/16	24-9/16	9	14	22-1/2	27	16-3/4	8 - 1/2" Ø	3	14-3/4	1-7/16
24	24-3/8	19	28	32	26-1/8	27-5/8	9-1/2	14	23	27	19	8 - 1/2" Ø	3	16-5/16	1-7/16

Figure 5. Details of fan unit.

4.5 Estimated Costs

The estimated costs are as follows:

Building	$2000
Truck and trays	500
Heat exchanger	800
Fan unit	1700
Controls/piping	1000
TOTAL	$6000

The use of local materials and labor may reduce the above costs.

5.0 CONCLUSIONS

The building is presently under construction and will be completed in early 1995. Operation will begin for the summer/fall 1995 harvest season. Through this project and others, CFE anticipates increased interest and use of the waste geothermal brine. Cascading will increase the efficiency and reduce the cost of producing and utilizing the geothermal resource.

6.0 REFERENCES

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