FIELD TEST OF A TWO TON CAPACITY MAIZE SOLAR DRYER

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ABSTRACT

The design and field testing of a two ton capacity maize solar dryer are described. Successful drying was achieved but natural convection reduced the energy efficiency. It is concluded that the seasonal short-term utilisation of the dryer does not justify the financial investment.

INTRODUCTION

Many papers deal with theoretical studies, modelling and laboratory work on solar drying (Kranzier 1975, Harris 1976, Midwest Plan Service 1980, Muthweerappan 1978). During the last 6 years our laboratory has designed and tested a number of experimental scale solar dryers. These include 5 kg capacity solar dryers (for wood) and 250 kg capacity dryers for maize, cassava, sea fish, and okra. Three solar dryers of 2.5 m^3 capacity have now been built for cooperative farmers. Their design and construction details, and the results of a field test are described below.

DESIGN AND CONSTRUCTION

The solar dryer was designed for crops of about 20% water content to be reduced to 13% according to regional climatic data and governmental regulation.

It is of a mixed type of design with a heat storage system. Solar energy is collected on a glazed area of 81 m^2; 27 m^2 on the roof (D_1, D_2) and 54 m^2 for the indirect heat collection process (C_1, C_2) (Figure 1). The area for indirect collection is twice as big as that for collecting solar energy directly so that the temperature in the drying cabinet is kept higher than the ambient temperature even at night.

Because the latitude of the location is low (6° - 7°N), a symmetrical profile is adopted to reduce heat losses by the side walls and to allow easy loading and unloading of the crops. The walls are insulated by a 10cm thick layer of cotton. Two drying trays, 1.20 m by 12 m, are separated by a corridor of 1 m in width. Below each tray, a rock pile storage system of 0.4 m thickness helps to keep the relative humidity lower than 60% even with an ambient value of 100%. The thickness of the rock pile is calculated according to the time of heat propagation from the bottom to the top of the bed. The diameter of the rocks is about 5 cm in order to allow easy circulation of the hot air.

The lower air collectors have a 0.1m thick layer of rocks as asborber, heat exchanger and inlet air filter. The resultant higher heat exchanging area compensates for the thermal inertia of the rocks. These rocks are commonly used and available in rural villages. The rock layer is painted black and supported by a fine wire mesh. The inlet air has to cross it before flowing into the drying cabinet through the storage bed.

In the symmetric profile, a row of collectors faces south and a second north (Figure 2).

RESULTS OF FIELDS TRIALS

Field trials were conducted with two tons of maize in a layer of 6 to 8cm thickness. Figure 3 shows the temperatures and relative humidity within the dryer during 5 days operation. Mean daily insolation was 4 kwh/m²/day. The temperature inside the dryer ranged from 30°C to 58°C as the ambient temperature increased from 21°C to 35°C during a day. The air temperature in the drying cabinet is about 16°C higher than the ambient temperature and is sufficient for grain drying. The relative humidity varied from 18% to 60% against 60% to 100% for the ambient air.

The air flow was very weak but the moisture content dropped from 20% to 14% in the first day (Table 1) with an overall energy efficiency of 15%. The second day reduces the moisture to 13% followed by the usual fluctuation around 12% of the next two days in good agreement with the general equilibrium curve of maize and relative humidity of the ambient air (Figure 4).

CONCLUSION

Maize grain can be successfully dried in the solar dryer in two days instead of four days in the traditional air drying process. A drop in moisture content from 20% to 14% is achieved in one day. This performance can be further improved by increasing the air flow to $3m^3$/min for one m^3 of maize. As in an earlier prototype, PVC ducts can be installed through the storage bed to be opened on the first day and closed later on.

Local material and manpower were used but the cost ($10,000) remains high comparatively to the 4 to 6 weeks of utilisation during the year.

ACKNOWLEDGEMENT

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FIGURE 1: Cross-sectional diagram of a two ton capacity maize solar crop dryer

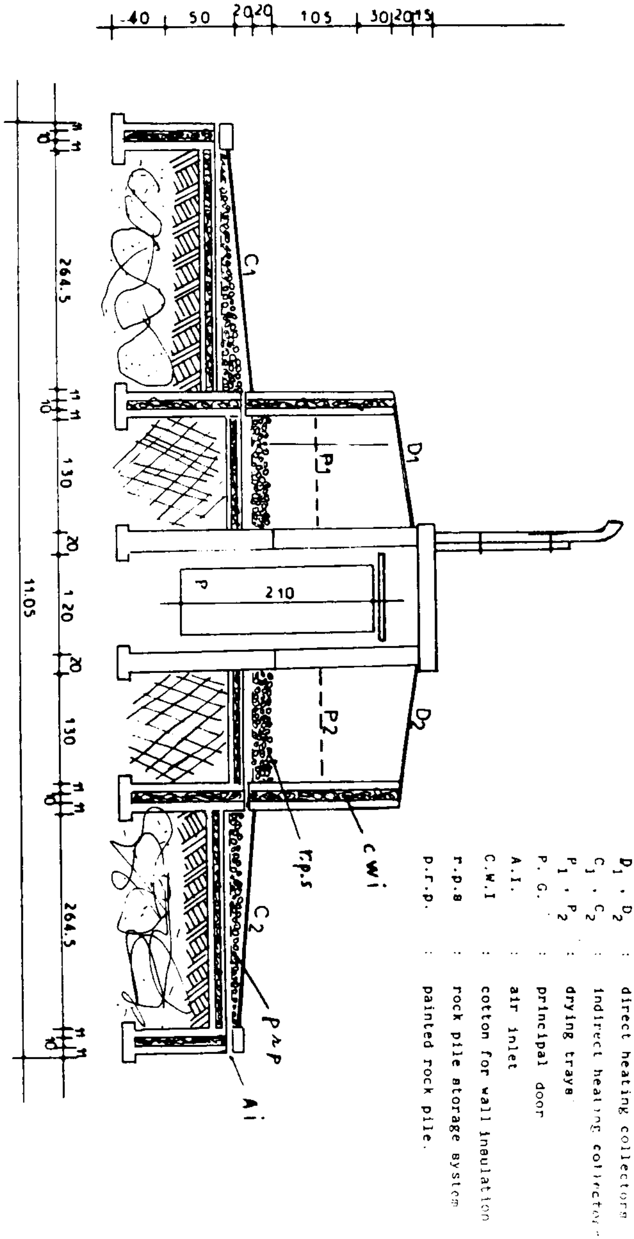

FIGURE 2: Symmetric plan of two ton capacity solar drop dryer for maize

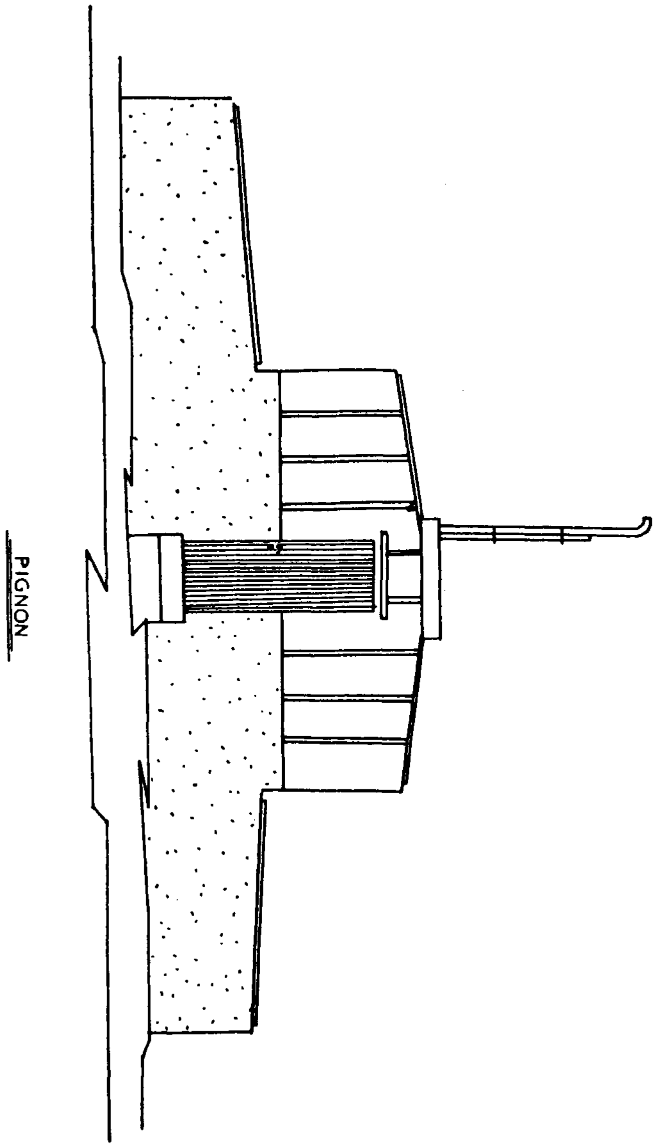

FIGURE 3: Temperatures and relative humidity within solar crop dryer during 5 days operation and the insolation, ambient air temperature and relativity humidity

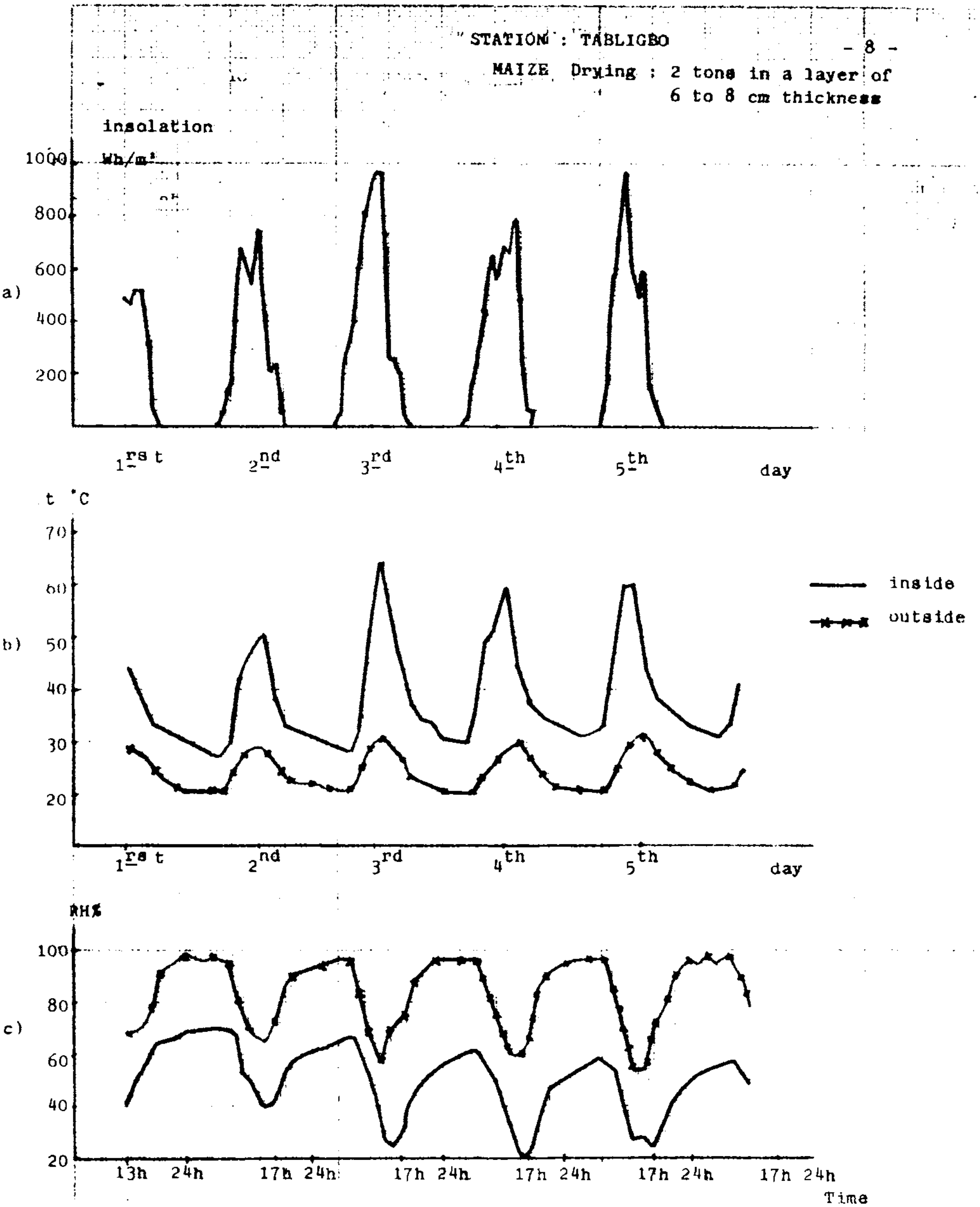

TABLE 1: Moisture content of maize durin uring drying time

	Initial moisture	Drying Time (days) 1	2	3	4	5	6
$\frac{Me}{Mo}$	20%	14%	13.2%	12%	11.6%	12.1%	12.6%

Me : water weight; Mo : maize initial weight

FIGURE 4: Maize dehydration curve