SOLAR FISH DRYING PROJECT IN MOPTI (MALI)

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INTRODUCTION

In Mali, fishing is a traditional occupation for more than a hundred thousand people living on the banks of the rivers Niger and Senegal. Fishing production attains 100,000 tons per year. Because of the lack of means of refrigeration to store fresh fish or transport it, most of the fish is dried or smoked. The traditional drying process consists of laying fish on sand or straw on the banks of the river and letting it dry under direct sunshine. This process is lengthy (5 days or more) and leaves fish vulnerable to insect attack and dust. Fish losses during this process can be as high as 50-60%!

In order to improve hygienic conditions of this drying process and reduce fish losses, the Solar Energy Laboratory of Bamako (LESO) and a fishing development organisation called "Operation Peche Mopti" (OPM) set up a project to introduce improved solar drying. This project has received support from the "International Development Research Centre" (IDRC) from Canada. A survey was initially conducted in fishing villages to determine needs. This survey resulted in the definition of three types of dryers requested to meet the needs expressed: a natural convection stationary dryer for permanent fishing villages, a natural convection mobile dryer for temporary fishing villages, and a forced convection dryer for the OPM office. After this survey a research programme was set up and resulted in the development of a tent dryer, a TAOS dryer and a 150 kg forced convection dryer. These prototypes, after full testing at laboratory level, have been installed at the OPM office and two fishing villages. Field monitoring was performed, and as a result, the tent dryer was abandoned, improvements were done on the TAOS dryer to prevent dust settling on the fish, and the forced convection dryer proved to be usable for other purposes, such as reprocessing of wet smoked fish. Results of laboratory testing and field monitoring are given in the paper.

CHOICE OF SYSTEMS

The choice of systems is based on our own experience and on that of the neighbouring countries' research centres (primarily Senegal), as well as on technical and economic criteria.

For permanent fishing villages, we have chosen as dryer, the dryer-tent inspired by models tested by the Institute of Food Technology at Dakar (Figure 1). This was motivated by the simplicity of the system, the possibility of using local materials (for example, bamboo) and the low cost.

For temporary fishing villages, our choice was the solar dryer TAOS, made by GATE (GTL) and which has mainly been tested in Latin America. This dryer is simple and small, which eases transport from one place to another by pirogue (fishing boat) for example: that is what justifies the choice. In addition, it can be easily copied by pirogue builders using wooden planks (Figure 2).

For OPM's head office, we have chosen a solar dryer equipped with an electric ventilator. This is placed in the roof to avoid any problems of shadows. The ventilator has a flow shutter which can effect the temperature of the interior of the drying cabin (Figure 3). The dryer has a capacity of 150 kg and can easily be doubled up to meet the estimated OPM needs of up to 300 kg. The possibility of regulating the interior cabin temperature through flow rate adjustments means that the dryer could be used for treatment of dried or rehumidified smoked fish. At the moment, OPM uses archaic ovens, which burn a great deal of wood.

LABORATORY TESTING

The laboratory tests are mainly concerned with forced convection drying, as we found plenty of experimental data on the other two systems: the dryer-tent and the TAOS dryer.

Description of the forced convection dryer (SCF)

The initial diagram of the SCF is given in Figure 3. The roof panel is made of 9 collectors (3 series of 3). Each collector has a working area of $1.55m^2$, which means the entire panel has a working area of $13.95m^2$. Figure 4 gives the collector diagram. Air circulates above and below the absorber before entering the isolated drying cabin. Two ventilators with shutters upstream of the cabin vary the rate of flow from $638.27m^3/h$ to $1,485.71m^3/h$.

Test procedure

Tests are carried out in outdoor conditions on several consecutive days. The thermocouplings were placed in different sections of the dryer (Figure 3) and the temperatures were read from 8.30h to 17.30h, at one hour intervals, by an Omega Data Logger.

The solar radiation on the collector surface was measured and integrated by a Haenni pyranometer and integrator.

The tests were run under no- and full-load conditions.

Results and discussions

Test under no-load conditions

Figure 5 gives the curves of temperature variation at different points in the dryer on a typical day. The average temperature in the cabin, $T_{4, m}$, is obtained by adding the different values measured of T_4 and dividing them by the number of times measured. The average temperature increase in the collector $(T_3 - T_2)m$, is obtained by adding the differences $(T_3 - T_2)$, and dividing them by the number of times measured. From the global radiation on the collector surface, given in Wh/m^2, the average strength of the global radiation was obtained in Wh/m^2 by dividing this amount by the length of time of the solar intensity.

Thus, from the experimental data, we were able to show (Figures 6 and 7), the variation of $T_{4, m}$ and of $(T_3 - T_2)m$ with respect to the average intensity of the solar radiation (Figure 6) and with respect to the rate of flow (Figure 7).

It can be seen that the average temperature in the dryer and the average temperature increase in the collector rise with the average intensity of the solar radiation and lower when the rate of flow increases.

Test under full-load conditions

For the full load testing, 50 kg of scaled headed and eviscerated fish were placed in the dryer. The tests took place from 8h to 18h and periodically the temperatures were taken and fish weighed. The amount of incident of solar radiation was measured by a Haenni pyranometer coupled to an integrator. The fish stayed in the dryer overnight with the ventilators closed.

The test lasted 4 days. The final weight of the fish was 15.89 kg, that is 32% of the initial weight, which is within the limit of 25-35% recognised by the OPM. Figure 8 gives the drying curve.

During the test, we noticed the development of maggots on the fish from the second to the third day. However, on the fourth day, due to intense solar radiation producing temperatures of more than 50°C, the maggots were removed. The drying had taken place without any previous chemical treatment of the fish.

This proved that the forced convection dryer was suitable for fish drying.

TESTS ON SITE

For the tests on site, a dryer-tent and two TAOS dryers were installed in the fishing village of Sense near Mopti, and a forced convection dryer was placed in the fishing port of Mopti at the OPM head office. The following results were obtained:

Dryer-tent

The dryer-tent could not be used by the fishermen because of tears in the transparent polyethylene cover caused during installation by very strong wind. The dryer was finally destroyed by tornadoes.

Following this unfortunate experience, it was decided to abandon that system.

TAOS dryer

After installation, the TAOS dryers were used daily by the fishermen: about 60 kg of fish were dried per week per dryer, in spite of the shortage of fish in the area. The Sense Fish Inspector regularly conducted performance tests on the dryers. Figure 9 gives a typical drying curve produced by the Inspector, which indicates the following benefits from TAOS dryers:

- shorter drying time;
- better quality of dried fish;
- no insect attack;
- increased quantity of dried fish in comparison to drying in open air (less loss during drying).

The Inspector did, however, underline the negative effectof dust-bearing wind which blows into the dryer and settles on the fish.

The fishermen were satisfied with the dryers: in fact the fish dried there was of greater quantity and, above all, is a product which sells quickly because of its good quality. However, they did not approve of the small capacity of the dryer.

The Inspector then tested the transportation of the dryer by pirogue. The test showed that the dryer could easily be put on the roof of the pirogue; however, the fishermen had wanted a dryer which could be completely dismantled.

Forced convection dryer

Installed at the OPM head office, this dryer was mainly for use in re-drying dried or smoked fish which arrived at the port of Mopti. During stocking and transport, the dried or smoked fish reabsorbed humidity and re-drying was necessary before selling. Equally this destroys the maggots on the fish.

OPM has hitherto used ovens which burn a great deal of wood for re-drying, something of increasing scarcity in the area of Mopti. A test run with gas-oil oven failed because of cost and poor performance (fish breaking and smelling of gas-oil).

Figure 10 gives the curve obtained during re-drying of an experimental load consisting of 31.32 kg of dried humid fish and 10.57 kg of smoked humid fish. The re-drying lasted 3 days. The weight loss was 17% for the dried fish and 25% for the smoked fish. The fish was completely clear of maggots, and was considered to be of very good quality by the OPM agents.

CONCLUSIONS

The main conclusions which can be drawn from the work carried out as described earlier, are as follows:

a) the transparent polyethylene available in Mali is not sufficiently strong for the climatic conditions there, which limits the possibility of using dryer-tents, in spite of their low cost;

b) the TAOS dryers are well adapted to the needs of the fishing villages; they produce very good quality dried fish in a shorter period of time without loss of weight due to insects; in addition they can be transported by pirogue which makes them suitable for travelling fishermen; the problem of dust can be solved by turning down the air inlet and outlet to protect them from the wind: this is in the process of being tested;

c) the forced convection dryer is as good for drying as for re-drying of fish; by using it, the OPM could save the wood used up to now for re-drying; the use of photovoltaic baskets to provide electric energy for ventilators makes this system completely independent of the normal sources of energy, so it can be used in areas without electricity.

ACKNOWLEDGEMENTS

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FIGURE 1: Closed dryer

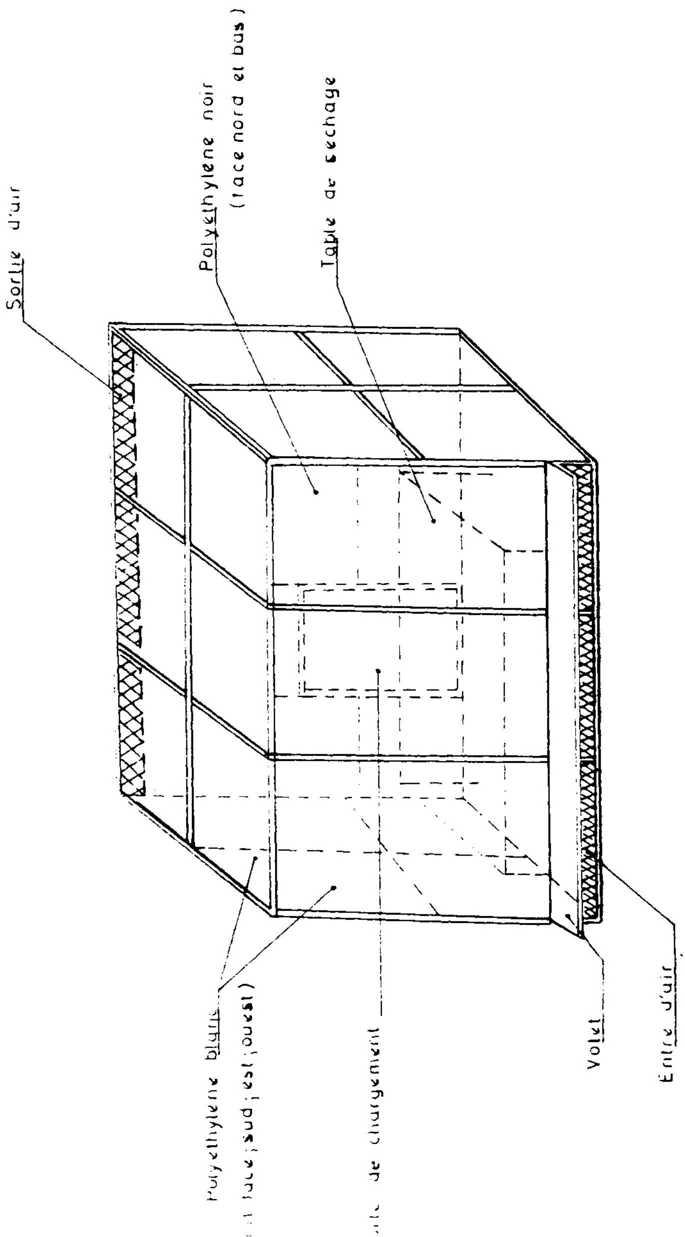


FIGURE 2: TAOS dryer

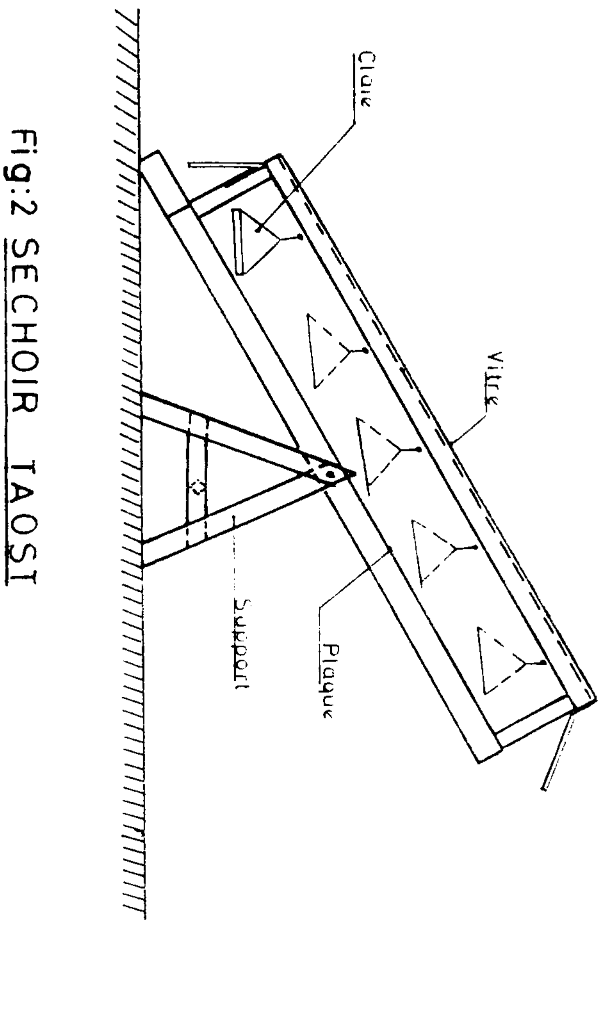
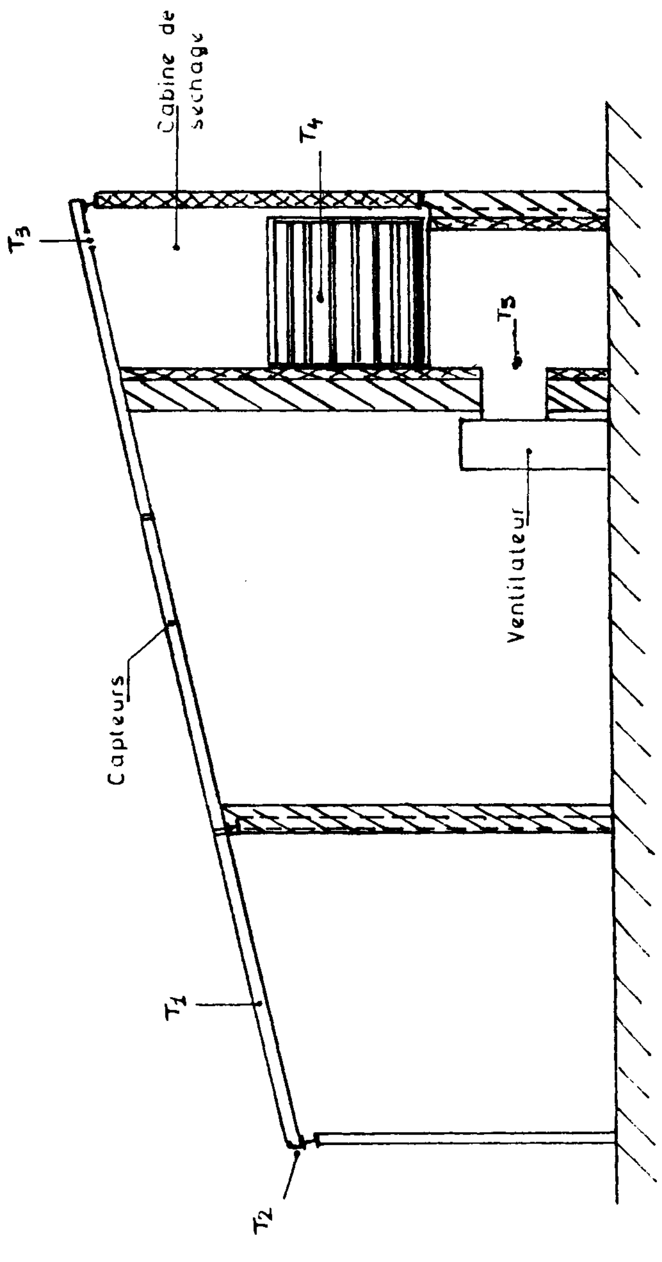


FIGURE 3: Section of forced convection dryer



T1 PLAQUE
T2 ENTREE AIR FRAIS
T3 " " CHAUD
T4 INTERIEUR CABINE
T5 SORTIE AIR CHAUD

Figure : 3 COUPE DU SECHOIR A CONVECTION FORCEE

FIGURE 4: Sections through a hot air receptor

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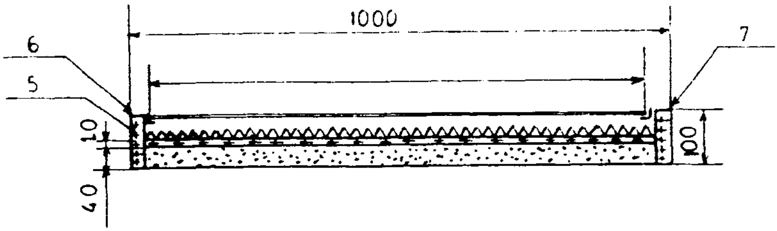
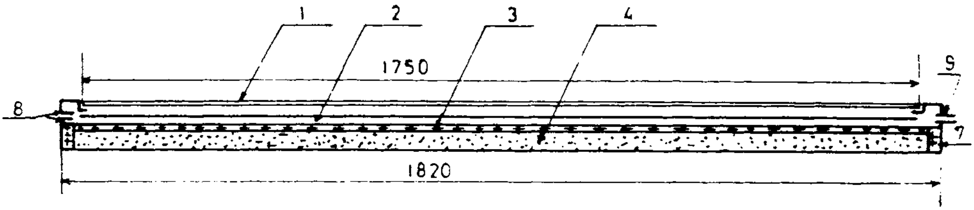


Transversal section



Longitudinal section

1. Vitrage
2. Plaque
3. Isolation (laine de verre)
4. Plaque polystyrene
5. Laine de verre
6. Forme laterale
7. Forme frontale
8. Embout femelle
9. Embout male

Surface utile: 1,60m²

FIGURE 5: Typical temperature variations in dryer over operating day

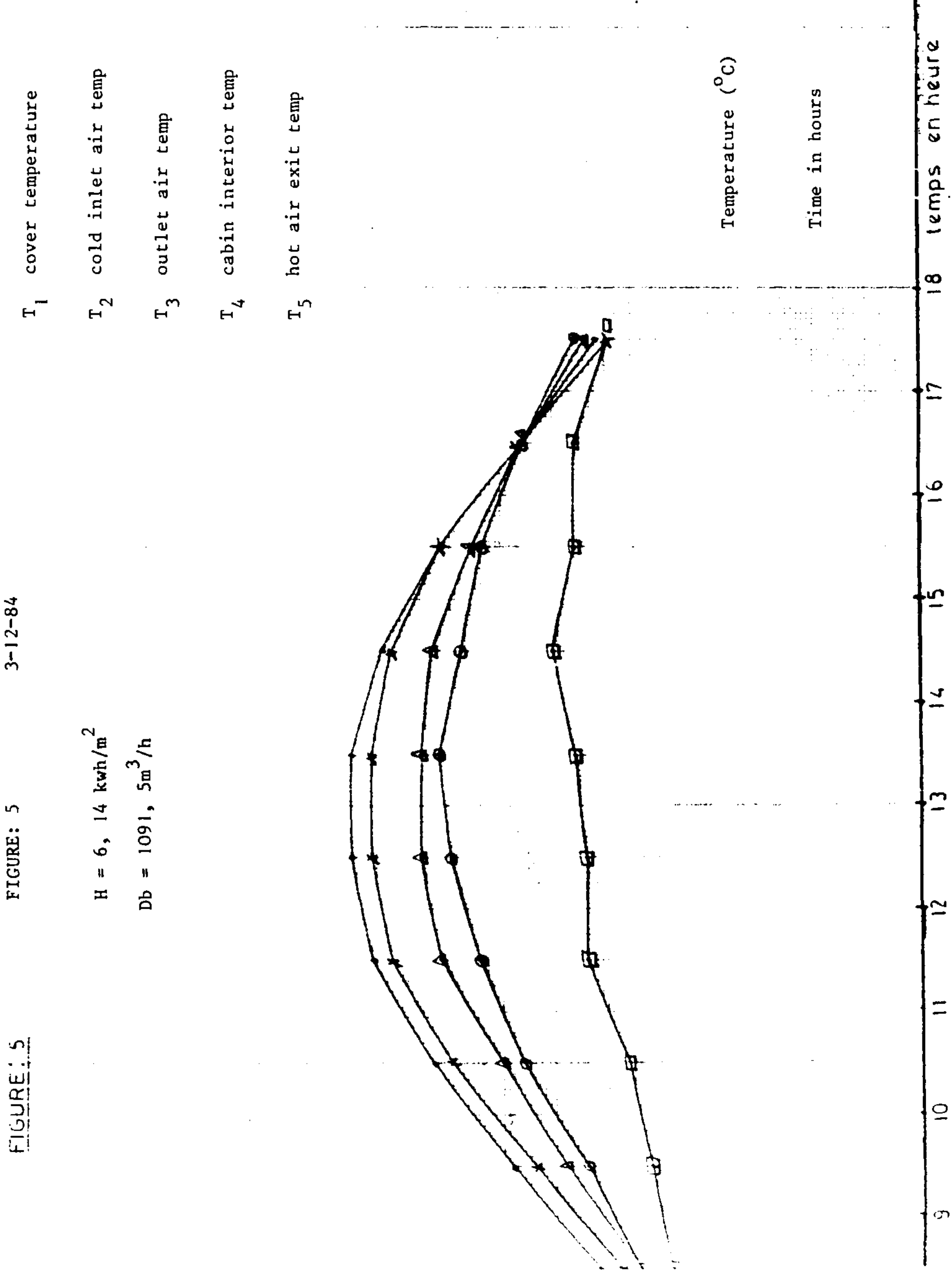


FIGURE 6: Variation in the average temperature in the dryer and average temperature increase in the receptor due to solar intensity

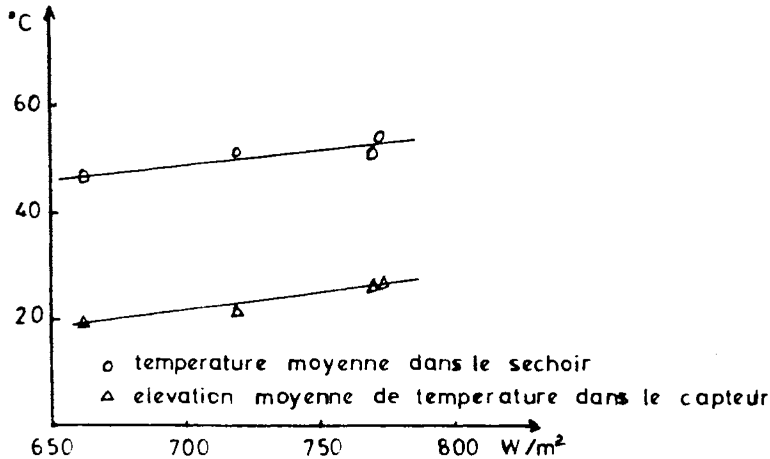


FIGURE 7: Variation in the average temperature in th edryer and average temperature increase in the receptor due to the rate of flow

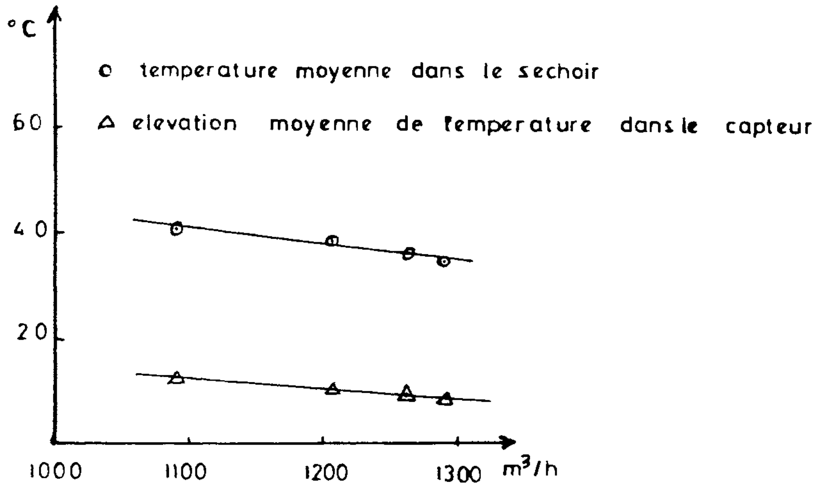


FIGURE 8: Drying curve of fresh fish in the forced convection dryer

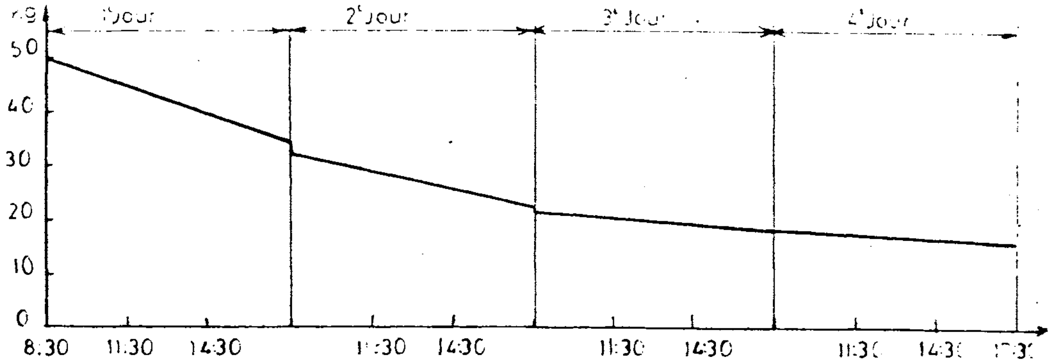


FIGURE 9: Drying curve of fresh fish in the TAOS dryer

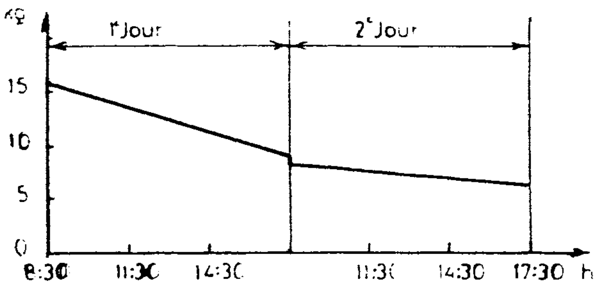


FIGURE 10: Re-drying curve of dried fish (full treatment) or smoked fish