

Effect of Air Flow Velocity on the Drying Parameters of Food Products in Sub Saharan Africa

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Abstract: *In the Sub-Saharan Africa, drying remains one of the modes of food preservation used and the most important issue which is ensuring food self-sufficiency is not always guaranteed. In the process of drying the main variables to be measured are the masses, temperatures, air velocities, and the heating power and the quantities of water to be removed from the product. These values require good control for achieving a good dryer [1, 2]. This work helps in providing answers to the following specific questions: what dryer (type, size, and power) is to be used? What are the optimal conditions (wind speed, temperature, humidity, water body to remove ...) of its operations? The use of sensors (manipulation, reading)? What is the drying time? The answer to all these questions is the basis of a possible development of research on the case study «drying of Local products" [3]. Our contribution is to optimize the drying conditions of the product by varying the speed of the air which should have a good ability to absorb water vapor released by the product of a function of variation of heating power. This variation in air speed achieved in our experiment stand is based on the variation of the supply voltage of the fan. This device guides the choice of blowing speed and optimum power to be used for drying a product knowledge temperature drying of a product.*

Keywords: resistance – drying – power- temperature – humidity – velocity - voltage

I. INTRODUCTION

The results for the drying that will be presented in this work are the synthesis experiments mainly done using an electric dryer that we have achieved. It consists of a horizontal wooden sheath, a fan and three electrical resistors. Calculations are done using the principles and laws governing the laws of thermodynamics [4, 5]. The heat transfer equations of mass and [6,7] and the treatment of the humid air [8,9] are used. Matlab simulations allowed us to plot the curves to make a wise choice for the

realization of such a dryer (electric or solar) adapted to our needs.

II. Description

The electric dryer realized is composed of a fan and three identical electrical resistors inside spaced apart. The inlet of the dryer has a square opening of 20 cm while the outlet is a rectangle of length 30.5 cm and breadth 25.5cm ; but to increase the air speed at the outlet we have used a Plexiglas with a

circular aperture of diameter $D = 8\text{mm}$. The conduit of the electric dryer is timber thereby limiting heat loss and can convey temperature ranges used in drying food products, it has a dimension of 1.27 m in length, 25.5 cm of width and 30.5cm high. The losses are neglected in this study because of the small dimensions.

The fan power is provided by an AC source with a variable resistor in which AC voltage varies from 0 to 260V. In our case the variation in the voltage causes the variation in air velocity and the electric resistances are connected in parallel to a fixed supply voltage of 230V. We have used a double pole circuit breaker (single phase) : 32A , 230V to protect our electrical circuit against overvoltage and short circuits. There is also the presence of a digital voltmeter used to read the fixed voltage. The thermocouples are connected in different parts of the device to measure the dry and wet air temperatures. A voltmeter is connected to measure the supply voltage and an anemometer to measure the air velocity.

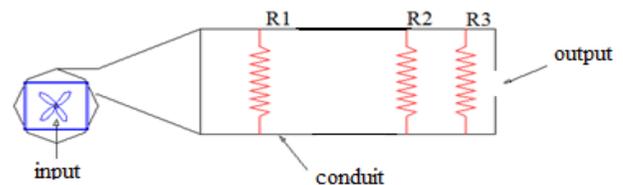


Figure 1: Electric Dryer



Figure 2: A picture of the Electric Dryer

II THEORY

This part studies the parameters of the air treated from the air heating duct. We elaborate in this part, the theoretical expressions of the various parameters in question.

II-1 Relative and absolute humidity

The relative humidity is the ratio of the mass of water vapor contained in moist air (mv) to the maximum mass of water vapor that air can contain this (ms), it is given by:

$$HR = \frac{P_v}{P_s(\theta)} \times 100 \quad 1$$

P_v is the partial pressure of water vapor at the temperature θ .
 $P_s(\theta)$ is the saturation pressure of pure water at the temperature θ given by the equation:

$$\log P_{sat} = \frac{7,625 \cdot \theta}{241,0 + \theta} + 2,7877$$

2

The absolute humidity is the ratio of the mass of water vapor in humid air and the mass mv of dry air (without steam) contained in the same moist air.

$$x = \frac{m_v}{m_a} \quad 3$$

x is expressed in kg of water vapor per kg dry air (kg / g or kgAS / kgAS) and air is called the water content of air or specific humidity or absolute humidity .

II.2 Enthalpy

It is defined by the sum of the enthalpies kg of dry air and that of the water vapor contained in this kg dry air. It is given by:

$$h(\theta, x) = c_{pa} \theta + x(L_v + c_{pv} \theta)$$

4

Where : c_{pa} : specific heat capacity of dry air: $c_{pa} = 1006 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$

c_{pv} : specific heat of water vapor $c_{pv} = 1840 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$

L_v latent heat of vaporization of water at 0°C $L_v = 2501 \text{ kJ kg}^{-1}$

II.3 Temperatures

- The dry and wet temperatures will be measured by a hygrometer at two temperatures with dry and wet bulbs.
- The dew point temperature is determined from the diagram of moist air

III Experimental results

An experimental study of the device was conducted in the laboratory of refrigeration and air conditioning of LARC "G15 ". It involves applying a variable supply voltage (50V to 230V) with an AC source, which allows us to determine for each voltage power corresponding heater. Then the anemometer is also used to measure the velocity of the air which is used to calculate the air mass flow and a psychrometer to determine

experimentally the wet and dry air temperatures. The use of three resistors provides a good range of variation of heating power used in drying food products [10].

The following table shows the results of measuring the air speed obtained by varying the supply voltage.

U(V olt)	5	7	90	11	12	13	15	17	19	21	23
V(m/ s)	9. 8	1 0	11 .2	11 .6	11 .7	11 .9	12 .1	12 .3	12 .5	12 .8	

The other parameters of air are determined by the diagram of the humid air. The results obtained are shown in the curves plotted using MATLAB

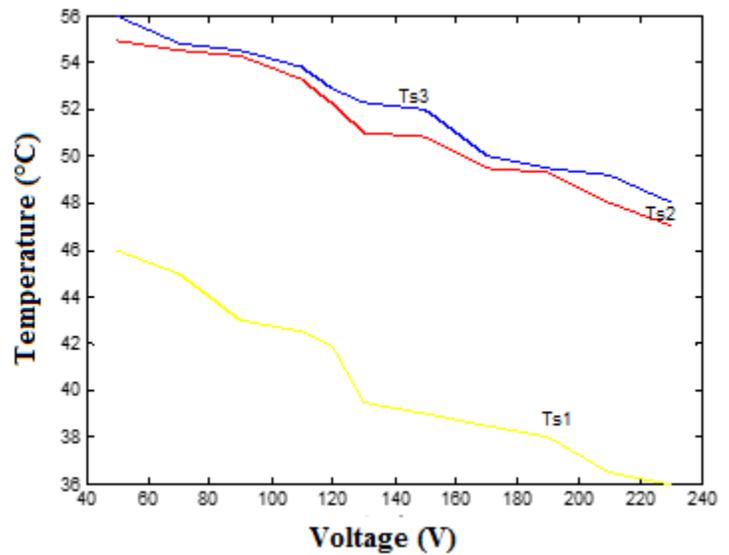


Figure 3: the variation of voltage as a function of the dry bulb temperature

Ts1 is the graph when only one resistor is used and Ts2 represents the graph when two resistors are used and the Ts3 for three resistors.

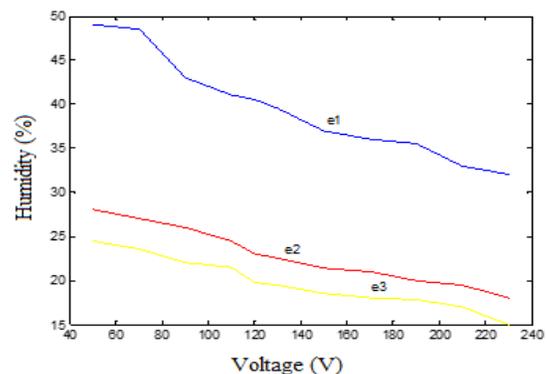


Figure 4: Relative humidity as a function of the voltage

Curves: one resistor (e1) two resistors (e2) , and three resistors (e3)

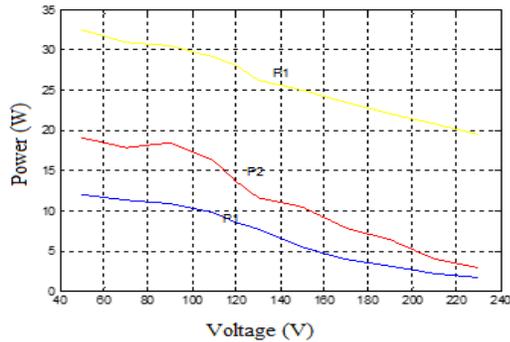


Figure 5: The heater power as a function of the voltage

Curves: one resistor (P1), two resistors (P2), and three resistors (P3)

IV. Analysis of experimental results

For a given starting drying temperature of the product under consideration these results allow us to use Figure 3 and determine the voltage to be applied to the system and the number of resistors by taking the point of intersection of the horizontal line with the corresponding resistance curve and resolve it vertically on the axis of the voltage. The table provides us with the experimental velocity air to blow on the product. Figure 4 provides information on the relative humidity of hot air then results in Figure 5 indicates the heating power of the dryer. Thus the knowledge of the heating power and the speed of the air will allow us to determine the type of dryer be it Electrical or Solar and its fan for a good convection.

V. Conclusion

This study has enabled us to better know the influence of the variation of the velocity of the air on the parameters of a heating dryer. This is achieved by varying the supply voltage and has facilitated the design of drying units, that is to the determination of the heating power and other characteristics of the air drying .

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