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Effect of Relative Humidity on Oven Temperature of Locally Design Solar Carbinet Dryer

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Abstract - Among other atmospheric factors, relative humidity of the air plays an important role in the drying by solar radiation. The effect of relative humidity over oven temperature was investigated in this work. This study reveals that is a relationship between relative humidity and temperature. From the work done it has been found out that the higher the temperature the lower the relative humidity and hence the faster the drying rate of the material. It was also observed that the time, at which the maximum temperature was obtained, the relative humidity was minimum. Throughout the period of the research the oven temperature was higher than the ambient temperature while the ambient relative humidity is higher than the oven relative humidity.

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I. INTRODUCTION

Drying is used to remove water from foods for two reasons: to prevent (to inhibit) micro – organisms and hence preserve the food and to reduce the weight and bulk of food to cheaper transport and storage. When carried out correctly, the nutritional quality, colour, flavor and texture of dehydrated foods are slightly less than fresh food but, for most people, this has only minor nutritional significance as dried foods from one component in the diet. However if drying is carried out incorrectly there is a greater loss of nutritional and eating quantities and more seriously, a risk of microbial spoilage and possibly even food poisoning (Practical Action).

Tropical countries are characterized by relative high ambient temperature, relative humidity and rainfall. In these countries agricultural products are harvested all year round and must be dried immediately to reduce mass losses and prevent spoilage. These losses might occur as a result of microbial activities, especially mould (Ndukwu, 2009).

For effective drying, air should be hot, dry and moving. These factors are inter – related and it is important that each factor is correct: for example cold moving air or hot, wet moving air is unsatisfactory. The dryness of air is termed humidity – the lower the

humidity, the drier the air. There two ways of expressing humidity (or Relative Humidity, RH) the most useful is a ratio of the water vapour in air to air which is fully saturated with water vapour. The temperature of the air affects the humidity (higher temperatures reduce the humidity and allow the air to carry more water), (Practical Action). Rapid dehydration is desirable: The higher the temperature and the lower the humidity, the more rapid the rate of dehydration will be. Humid air slows down evaporation. If drying takes place too fast, however, 'case hardening' will occur. This means that the cells on the outside of the pieces of food give up moisture faster than the cells on the inside. The surface becomes hard, preventing the escape of moisture from the inside (Drying Food).

The review of literature revealed some limited work on this area; however post – harvest machine designed with their data cannot function effectively because of the peculiar agro climatic conditions of a particular area (Ndirika and Oyeleke, 2006). Various studies on the drying of biomaterials indicate that drying constant and drying rate are important factors in predicting the drying time of biomaterials (Brooker et al. 1992). The importance of drying constant in relation to handling processing and design of post harvest machine is justified.

In this work the effect of relative humidity on oven temperature of a locally designed solar cabinet dryer was studied with the main chamber that supplying heat energy required by the drying chamber of the dryer.

II. MATERIALS AND METHODS

The solar dryer used in this work was designed by Ajadi and Adelabu (2003). The distance between the glass cover and the absorber plate was fixed for 4 cm (Ajadi, 2007). This region is known as absorption region which allows maximum absorption and emission of the sun radiation, and thus the absorber plate acts as a perfect blackbody. The solar dryer was positioned in an open space and protected against all obstruction of shades to allow maximum sun radiation to fall on the surface of the glass through out the day between 8.00 am and 6.00 pm local time. The dryer was cleaned from dust effect (Ajadi et al, 2007) before each day readings are recorded.

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The experiment was performed during the hammattan season for a period of 21 days in the month of January 2009. Electronic digital multi-meter which is of 5 in 1 Auto Ranging Digital Multi-meter with number MS 8209, was used to determine the humidity for ambient (H_a) and oven (H_o). The same instrument was used to determine the temperature of the ambient (T_a) and oven (T_o) respectively. The readings were taken at an interval of 30 minutes for each day. The results are tabulated below.

III. RESULTS AND DISCUSSION

Table 1 : Oven Relative Humidity and Oven Temperature

Time	$H_o(\%)$	$T_o(^{\circ}\text{C})$
8.0	70.2	26.4
8.5	66.5	27.1
9.0	62.8	27.5
9.5	60.2	28.1
10.0	57.1	28.7
10.5	55.2	29.1
11.0	52.7	29.7
11.5	49.8	30.2
12.0	48.1	31.6
12.5	45.2	32.1
13.0	40.6	32.6
13.5	39.8	32.9
14.0	39.0	33.5
14.5	37.1	34.2
15.0	37.6	35.0
15.5	38.9	34.6
16.0	40.4	34.0
16.5	43.1	33.6
17.0	44.5	32.2
17.5	45.1	30.8
18.0	44.9	29.5

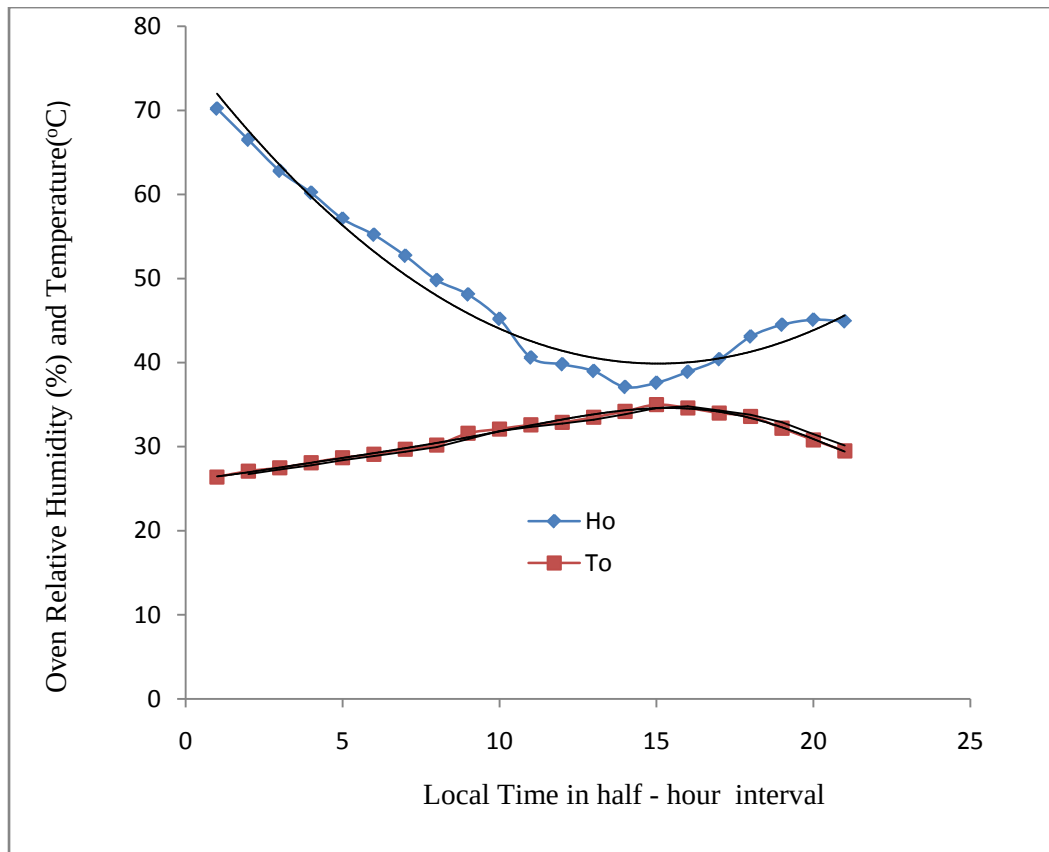
13.5	32.2	32.9
14.0	32.8	33.5
14.5	33.7	34.2
15.0	34.2	35.0
15.5	33.7	34.6
16.0	32.4	34.0
16.5	31.8	33.6
17.0	30.0	32.2
17.5	29.7	30.8
18.0	27.4	29.5

Table 3 : Ambient Relative Humidity and Oven Relative Humidity

Time	$H_a(\%)$	$H_o(\%)$
8.0	70.8	70.2
8.5	68.1	66.5
9.0	64.6	62.8
9.5	62.3	60.2
10.0	59.4	57.1
10.5	57.0	55.2
11.0	54.6	52.7
11.5	51.3	49.8
12.0	50.6	48.1
12.5	47.8	45.2
13.0	44.3	40.6
13.5	40.7	39.8
14.0	39.5	39.0
14.5	38.8	37.1
15.0	38.9	37.6
15.5	40.7	38.9
16.0	42.8	40.4
16.5	43.9	43.1
17.0	45.2	44.5
17.5	45.8	45.1
18.0	46.1	44.9

Table 2 : Ambient Temperature and Oven Temperature

Time	$T_a(^{\circ}\text{C})$	$T_o(^{\circ}\text{C})$
8.0	26.0	26.4
8.5	26.7	27.1
9.0	27.0	27.5
9.5	27.6	28.1
10.0	28.2	28.7
10.5	28.4	29.1
11.0	29.9	29.7
11.5	29.8	30.2
12.0	30.8	31.6
12.5	31.5	32.1
13.0	31.9	32.6



(7)

Figure 1 : Oven Humidity and Oven Temperature against Time

Figure 1 display the graph showing the average daily variation of the relative humidity and temperature with time as obtained from Table 1 above. Both graphs follow the normal polynomial curve of degree five with $R^2 = 0.99$. The curves show that at about 14 hour local time, the humidity shows minimum point while the temperature shows maximum point. From this graph it could be observed that the higher the temperature recorded the lower the relative humidity before the minimum/maximum point and vice versa after the point. This can be explained from the expression for relative humidity given as:

$$\text{RelativeHumidity} = \frac{\text{Actual Vapoure Pressure}}{\text{Saturated Vapoure Pressure}} \quad (1)$$

This is because increase in temperature raises saturated vapour pressure, which leads to reduction in the relative humidity as seen in Equation 1 above. Hence the higher the temperature observed the lower the relative humidity.

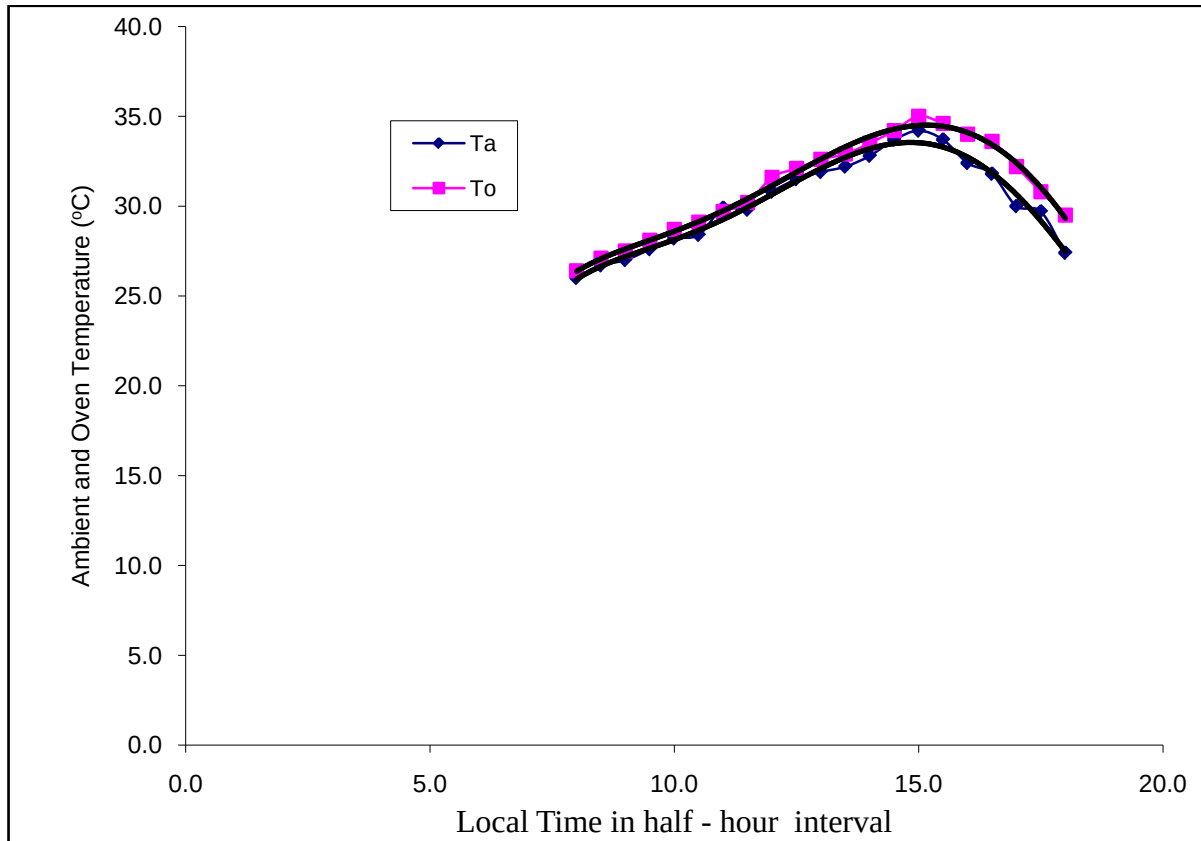


Figure 2 : Ambient temperature and Oven Temperature against Time

Figure 2 display the graph showing the average daily variation of the ambient and oven temperature with time as obtained from Table 2 above. Both curves follow the normal polynomial curve of degree five with $R^2 = 0.99$. The curves also show that at about 14 hour local

time, both curves are at maximum point. It is observed that the temperature of the oven is always higher than the temperature of the ambient (environment), this shows that drying in the oven will be faster than that in the open air drying.

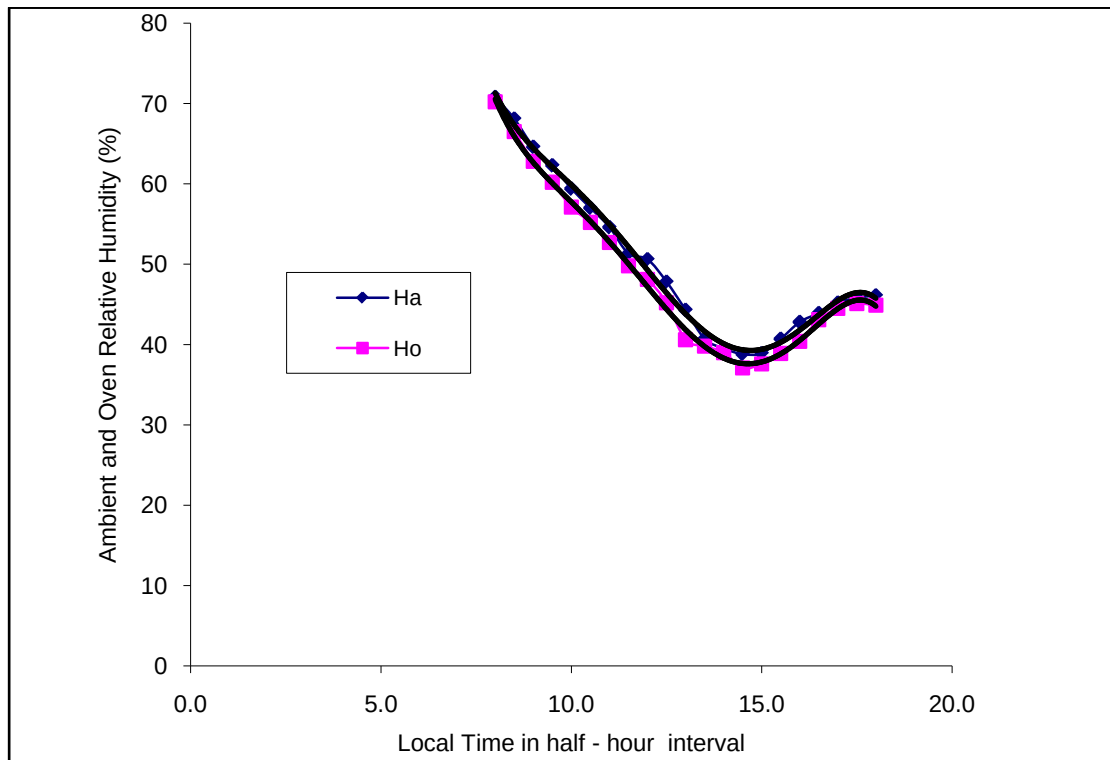


Figure 3 : Ambient Humidity and Oven Humidity against Time

Figure 3 display the graph showing the average daily variation of the ambient and oven relative humidity with time as obtained from Table 3 above. Here it is observed that the relative humidity of the oven is always lower than the relative humidity of the ambient (environment) which in turn favours the drying rate or reduce the drying time of the dryer for better dried products. The two curves follow the normal polynomial curve of degree five with $R^2 = 0.99$. The curves also show that at about 14 hour local time, both curves are at minimum point.

IV. CONCLUSION

The relative humidity plays an important role in solar drying to achieve good quality dried products. In view of this, the effect of relative humidity on oven temperature of a locally designed solar cabinet dryer was experimentally studies. Based on the results obtained, it has been found that out the higher the temperature the lower the relative humidity and hence the faster the drying rate of the material. Also it was observed that the time, at which the maximum temperature was obtained, the relative humidity was minimum. Throughout the period of the research the oven temperature was higher than the ambient temperature while the ambient relative humidity was higher than the oven relative humidity.

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