A Moisture Transfer Model for Kenaf fiber Drying

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Abstract

This paper deals with an experimental and theoretical investigation of microwave drying of moist kenaf fiber. A drying model [1-3] is used to determine drying process parameters (e.g. drying coefficient , lag factor) and moisture transfer parameters (e.g. moisture diffusivity and moisture transfer coefficient), and to calculate moisture content distributions. Experimental part includes the measurement of moisture content distribution of kenaf slabs with 5mm thickness during microwave drying at the temperature 40 C^0 , 100 C^0 and 200C^0. The results shows a appreciably high agreement between the measured and predicted moisture content values for the correlation.

Keyboard : kenaf, drying, microwave

Introduction

Moisture diffusivity is an important transport property needed for accurate modeling in drying applications. In this work some of the most significant drying process parameters, lag factor, drying coefficient, Biot number, moisture diffusivity and Moisture transfer coefficient have been studied for Kenaf drying. In this regard, the objective of this study is to develop a model to estimate the moisture transfer parameters and hence moisture content variations [1-5].

Analysis

The dimensionless moisture content values with time can be expressed in exponential for as follows [1],

$$f = \mathbf{G\,exp(-St)} \qquad (1)$$

Where G is the lag factor and S is drying coefficient (1/s) . The dimensionless moisture (Φ) content can be represented in terms of moisture content at any point (M) of the object , subscript i means initial and subscript e means equilibrium case,

$$f = \frac{\mathbf{M - M_e}}{\mathbf{M_i - M_e}} \qquad (2)$$

The Biot number (Bi) for moisture transfer can be defined as a function of moisture transfer coefficient, moisture diffusivity (D) and characteristic dimension (Y) as;

$$\mathbf{Bi} = \frac{\mathbf{KY}}{\mathbf{D}} \qquad (3)$$

The moisture diffusivity (D) relation for slab ids given as ,

$$\mathbf{D} = \frac{\mathbf{SY^2}}{m_1^2} \qquad (4)$$

Where m_1 is characteristic root.

The moisture transfer coefficient for slab is obtained from Biot number definition as,

$$\mathbf{K} = \frac{\mathbf{D * Bi}}{\mathbf{Y}} \qquad (5)$$

The characteristic root (m_1) which appear in the moisture diffusivity relation eq. (4) are determined as follows:[4].

For slab,

$$m_1 = -419.24G^4 + 2013.8G^3 - 3615.8G^2 + 2880.3G - 858.94 \qquad (6)$$

The dimensionless moisture distribution are given in simplified form,[1]

$$f = A_1 B_1 \qquad (7)$$

$$A_1 = G = \exp\left(\frac{0.2533Bi}{1.3 + Bi}\right) \qquad (8)$$

$$B_1 = \exp(-m_1^2 F_0) \qquad (9)$$

$$F_0 = \frac{Dt}{Y^2} \qquad (10)$$

Results

The following procedure is employed to determine the moisture transfer parameters and dimensionless moisture distribution:

a) Lag factor is determine by regressing the experimental dimensionless moisture content values against the drying time in the form of Eq.(1) using the least square curve fitting method for three cases (temperature 40 ^{0}C, 100 ^{0}C, 200 ^{0}C).
b) Using Eq. (8) the Biot numbers are determined.
c) The characteristic roots(m_1) are evaluated using the relation of Eq.(6).
d) The moisture diffusivities are then calculated using Eq.(4).
e) The moisture transfer coefficients are determined using Eq.(5).
f) The dimensionless moisture distribution are determined using Eq.(7-10).

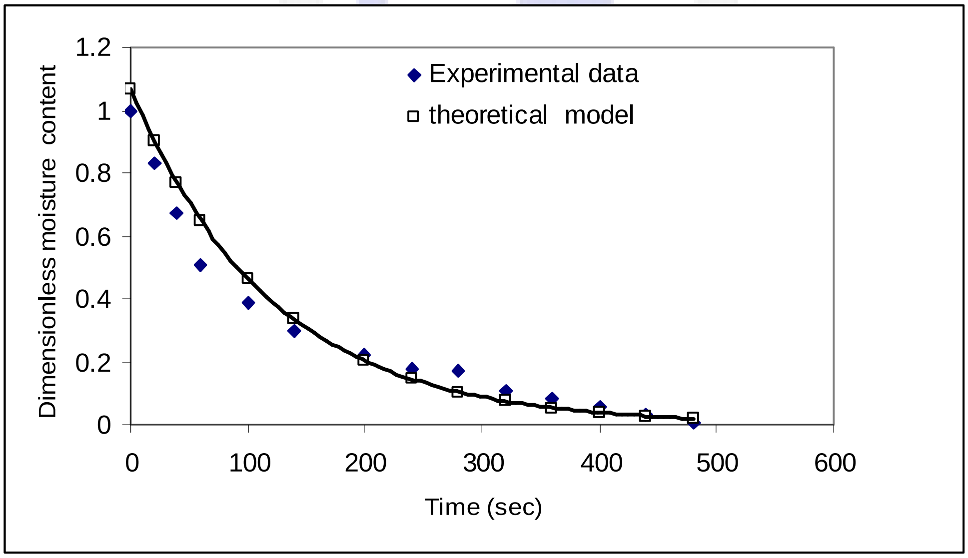
The values of drying coefficient (S), lag factor (G), Biot number (Bi), root of characteristic equation (m_1), moisture diffusivity (D) and moisture transfer coefficient (K) were obtained using the above listed methodology and these are tabulated for three temperatures (40 ^{0}C, 100 ^{0}C,200 ^{0}C) in table 1.

Table1 obtained drying process and moisture transfer parameters of Kenaf drying

parameters	40 ^{0}C	100 ^{0}C	200 ^{0}C
S	0.0083	0.0153	0.0385
G	1.0673	1.0983	1.253
Bi	0.45	0.7642	10.56
m_1	0.69	0.82	1.431
D(m^2/s)	1.0896e-7	1.4221e-7	1.1751e-7
K(m/s)	1.96125e-5	4.3472e-5	4.9635e-4

The dimensionless center moisture distribution for temperature (40 ^{0}C) are obtained and compared with experimental values in Fig.1.

Fig 1 Dimensionless moisture content against time



Conclusions

In this paper, we have studied a simple moisture transfer model for determining drying process parameters (e.g. drying coefficients, lag factor) and moisture transfer parameters (e.g. moisture diffusivity and moisture transfer coefficient).
The moisture diffusivity values increase with an increase during microwave drying temperature. Also, increasing drying microwave temperature decreases the drying time. Moreover, dimensionless center moisture distribution were obtained, which found to be in good agreement with experimental data.

References

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