PREDICTION OF THE AMOUNT OF ENERGY NECESSARY DURING THE *PROCESS* OF *DRYING*

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Annotation: As the food moisture has different forms of communication, requiring the large amounts of energy for their destruction, we attempted to simulate the optimization of energy supply and to present it as a function of the energy needed for evaporation depending on the energy needed to break ties between the moisture and the product using internal heat source

Key words: energy supply, drying process, optimization

In the production of many food products, drying as well is an obligatory operation that represents a sufficiently power–consuming phase of production. The quality of the product depends on drying regime and hardware–technological processing.

We had a difficult task – to calculating an optimum amount of energy during the process of combined drying: convection + high–frequency current, in which would be maintained equilibrium between the speed of evaporating of combined moisture from the material and the speed of the evaporation of water from free surface.

In view of the above, we have calculated by formula (1) the total heat, necessary for a product dehydration, taking into account a *functional dependence* of *temperature* and *pressure (partial and saturated)* for different humidity [1].

$$Q = RT^2\left(\frac{\partial \ln P_p}{\partial T} - \frac{\partial \ln P_{nas}}{\partial T}\right) = Q_1(u) - Q_0 \qquad (1)$$

Where,
$Q_1(u)$ – heat of evaporation of water from the material at a given moisture content;
Q_0 – heat of evaporation of free water.

Mathematical relation between Q and temperature for different humidity was calculated and presented by us as follows:

$$Q(5\%) = -34007{,}39 \cdot T^3 + 736424{,}5 \cdot T^2 - 5358504{,}13 \cdot T + \\ +14323009{,}27 \quad (2)$$

$$Q(10\%) = -30958{,}8 \cdot T^3 + 672586{,}56 \cdot T^2 - 49920115{,}32 \cdot \\ \cdot T + 13322776{,}38 \quad (3)$$

$$Q(20\%) = -24546{,}63 \cdot T^3 + 537773{,}3 \cdot T^2 - 3988576{,}62 \cdot \\ \cdot T + 11174295{,}41 \quad (4)$$

$$Q(30\%) = -22180{,}52 \cdot T^3 + 487799{,}78 \cdot T^2 - 3640862{,}74 \cdot \\ \cdot T + 10362464{,}08 \quad (5)$$

$$Q(50\%) = -20116{,}02 \cdot T^3 + 44075{,}67 \cdot T^2 - 3335314{,}69 \cdot \\ \cdot T + 9643622{,}79 \quad (6)$$

$$Q(70\%) = -14308{,}42 \cdot T^3 + 320308{,}83 \cdot T^2 - 2461992{,}56 \cdot \\ \cdot T + 7552941{,}32 \quad (7)$$

As a result of our calculations, we can draw a conclusion that energy decreases sharply with decreasing moisture content in the product.

The difference of energy expenditure at a humidity of 5% and 70% at a temperature of 313K is 1372 J / kg,

With increasing temperature, this difference is significantly reduced and at 373 K is 70 KJ/kg.

At different temperatures the dependence of the balanced amount of heat against humidity was approximated by us as a regression relationship:

So, then for 60°C $$Q = -3735 \cdot W + 1743647 \quad (8)$$

for 70°C $$Q = -2388 \cdot W + 1422033 \quad (9)$$

for 80°C $$Q = -1690 \cdot W + 1224470 \quad (10)$$

for 90ºC $$Q = -1278 \cdot W + 1091447 \quad (11)$$

for 100ºC $$Q = -1012 \cdot W + 996321 \quad (12)$$

Derived functional dependencies allowed us to elaborate the model (13) – optimal energy supply of the internal source of heat as a function of intensity of electromagnetic field, of humidity, of electrical parameters – tangent of the angle of dielectric loss and permittivity, as well as a heating time. This mate model takes into account a nonlinear functional dependence of main ranged factors from the basic parameter.

$$Q = 1265981 \cdot (-0.013T + 2.0216) \cdot (0.98E^{0.00829}) \cdot$$
$$\cdot (0.0009 \cdot W + +0.92227) \cdot (0.0015t + 0.9633) \cdot \quad (13)$$
$$\cdot (-0.009tg + 1.006) \cdot (-0.0009\varepsilon + 1.0009)$$

where,

Q	-	represents the energy required to carry out the process, KJ/k
W	-	humidity, %
T	-	temperature, °C
F	-	electromagnetic field frequency
ε	-	relative dielectric permittivity
tgδ	-	tangent of dielectric loss angle
E	-	electromagnetic field strength, W/m
t	-	time, s

The checking of the adequacy of the mathematical model was investigated using *Fisher's* exact *test* [2]. Precision of the model is illustrated in the Figure 1.

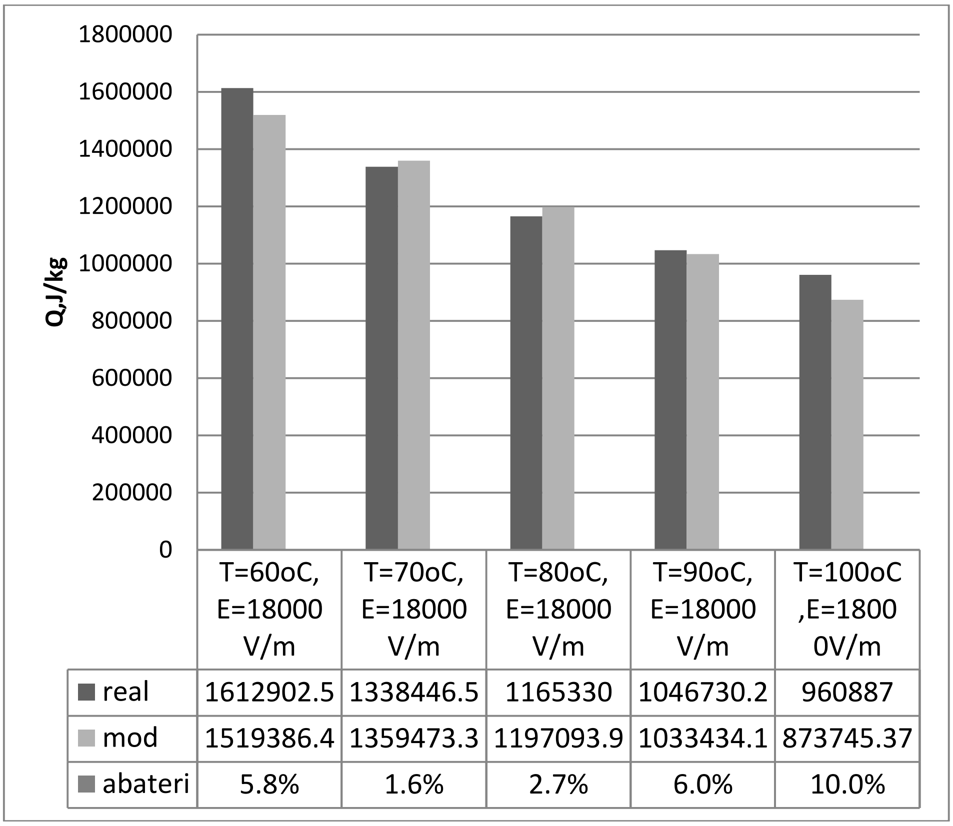

Fig. 1. Experimental data of heat and data calculated using the model necessary for drying at 60°C and electromagnetic field intensity 1080 V/m.

The resulting mathematical model will allow a high probability and accuracy optimization of energy consumption in the process of food drying.

Literature:

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