SIMULATION OF THE DRYING PROCESS WITH THE OPTIMIZATION OF ENERGY

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Abstract: As the food moisture has different forms of communication, requiring 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.

Keywords: energy supply, drying process, optimization

Most foods contain a significant amount of water that enters the plant and animal tissues and is a necessary part of them. However, an excess of water reduces the nutritional value of food, increasing transportation costs and can cause damage to livelihoods as a result of various microorganisms. In this regard, people must significantly draw attention to the dried vegetables and fruits.

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

The basis of mathematical modeling method was based on Brandon method, which allows us to obtain the nonlinear functional dependence of the output parameters and factors of the process.

The work from a mole of water separation, for an isothermal reversible process is expressed as:

$$A = RT \ln \frac{p_p}{P_{nas}} = RT \ln \varphi \tag{1}$$

φ – (relative vapor pressure, is equal to the ratio of the vapor pressure of the material at this moisture content U, to the vapor pressure of the water P_{nas} (the saturated vapor pressure at the temperature T))

Differentiating (1) with respect to T, we are finding the total amount of heat, indispensable for dehydration of the product.

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

$Q_1(u)$ - heat of evaporation of water from the material at this moisture content;
Q_0 - free water evaporation heat;

On the assumption of the equation (2)

$$Q_1(u) = RT^2 \frac{\partial \ln P_{par}}{\partial T} \tag{3}$$

where R - gas constant of water vapor that is equal to 461.58 (J/kg K)
T - temperature, K

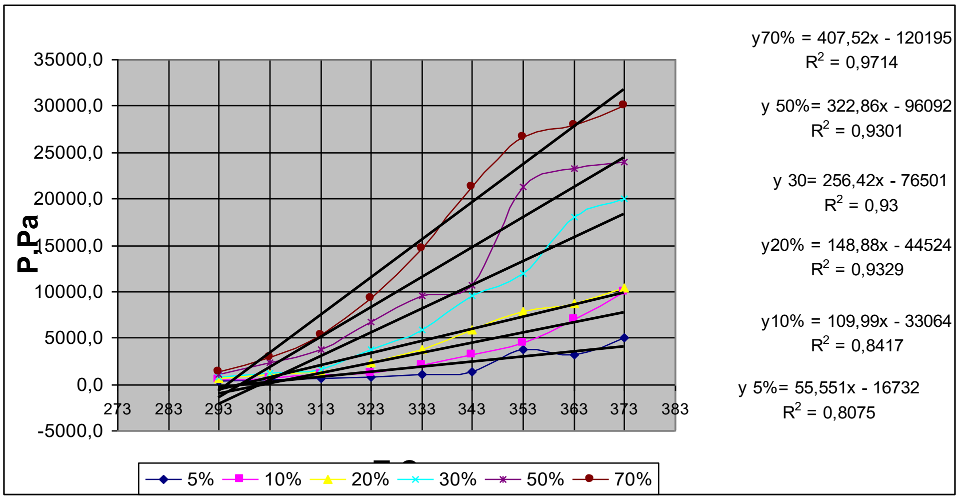

Figure 1 represents the dependence of partial pressure on temperature for different humidity.

If substituting functional dependencies P =f(T) in the equation (3), we obtain the calculated value Q1(u) - heat of water evaporation from the material at different moisture content of the product:

$$Q_1(5\%) = RT^2 \frac{\partial(55.551 \cdot T - 16732)}{\partial T} \tag{4}$$

$$Q_1(10\%) = RT^2 \frac{\partial(109.99 \cdot T - 33064)}{\partial T} \tag{5}$$

$$Q_1(20\%) = RT^2 \frac{\partial(148.88 \cdot T - 44524)}{\partial T} \tag{6}$$

$$Q_1(30\%) = RT^2 \frac{\partial(256.42 \cdot T - 76501)}{\partial T} \tag{7}$$

$$Q_1(50\%) = RT^2 \frac{\partial(322.86 \cdot T - 96092)}{\partial T} \tag{8}$$

$$Q_1(70\%) = RT^2 \frac{\partial(407.52 \cdot T - 120195)}{\partial T} \tag{9}$$

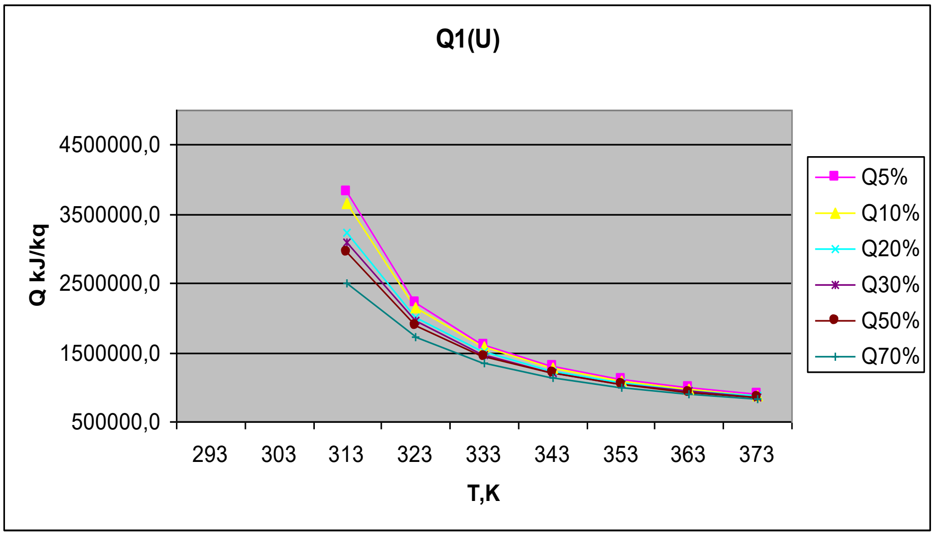

Figure 2. Q_1(u) - heat of evaporation of water from the material at this moisture content

The second constituent of the equation (3) represents the heat of evaporation of free water:

$$Q_0 = RT^2 \frac{\partial \ln P_{nas}}{\partial T} \tag{10}$$

Herewith, this schedule of values of saturated vapor can be rather well approximated with the formula:

$$P_{nas} = 4.96 \cdot 10^{-2} (T - 273)^{3.1546}, \text{ Pa} \tag{11}$$

$$Q_0 = RT^2 \frac{\partial \ln(4.96 \cdot 10^{-2} (T - 273)^{3.1546})}{\partial T} \tag{12}$$

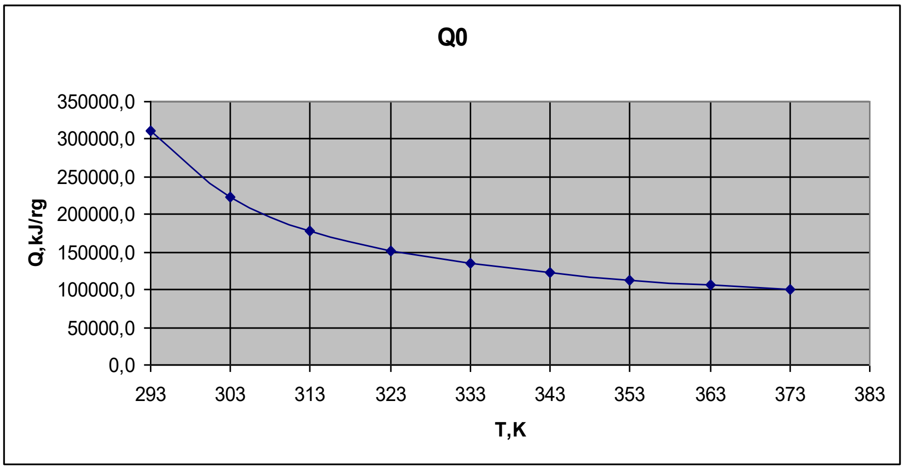

Figure 3. Q_0 - free water evaporation heat

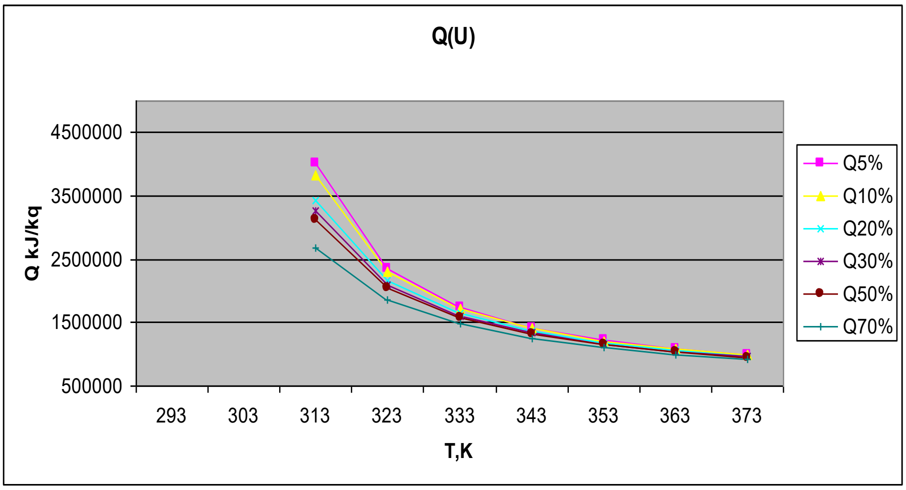

Figure 4.

Figure 4 shows the maximal balanced quantity of heat, necessary for evaporation of moisture from the material and evaporation of free water. Binding energy decreases dramatically with diminution of moisture content of the product. The difference of energy consumption for the moisture of 5 and 70 percent, at 313 K consists 1372 KJ/kg, with temperature increasing this difference considerably reduces and at 373K is approximately 70 KJ/kg.

A received balanced functional relationship will form a base of the mathematical model for optimization a power conduit with internal source of heat of tension of the electromagnetic field, of the moisture, of electro physical operation factors - the dielectric loss tangent and inductive capacity, and also the time of heating.

$$Q_v = f_1(E) f_2(W) f_3(T) f_4(tg\delta) f_5(\varepsilon) f_6(\tau) \tag{13}$$

Mathematical relationship (8) is based on non-linear forms of links of outside factors xi, the solution of such models is possible using the method of Brandon [2]. For a more accurate construction of functional dependence of the function fi(Xi) in expression (13), should be placed in descending order the influence of Xi on , that is, to use ranking factors.

The check on the adequacy of the mathematical model is studying using statistical Fisher criterion [3].

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