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COLLECTION OF SCIENTIFIC PAPERS

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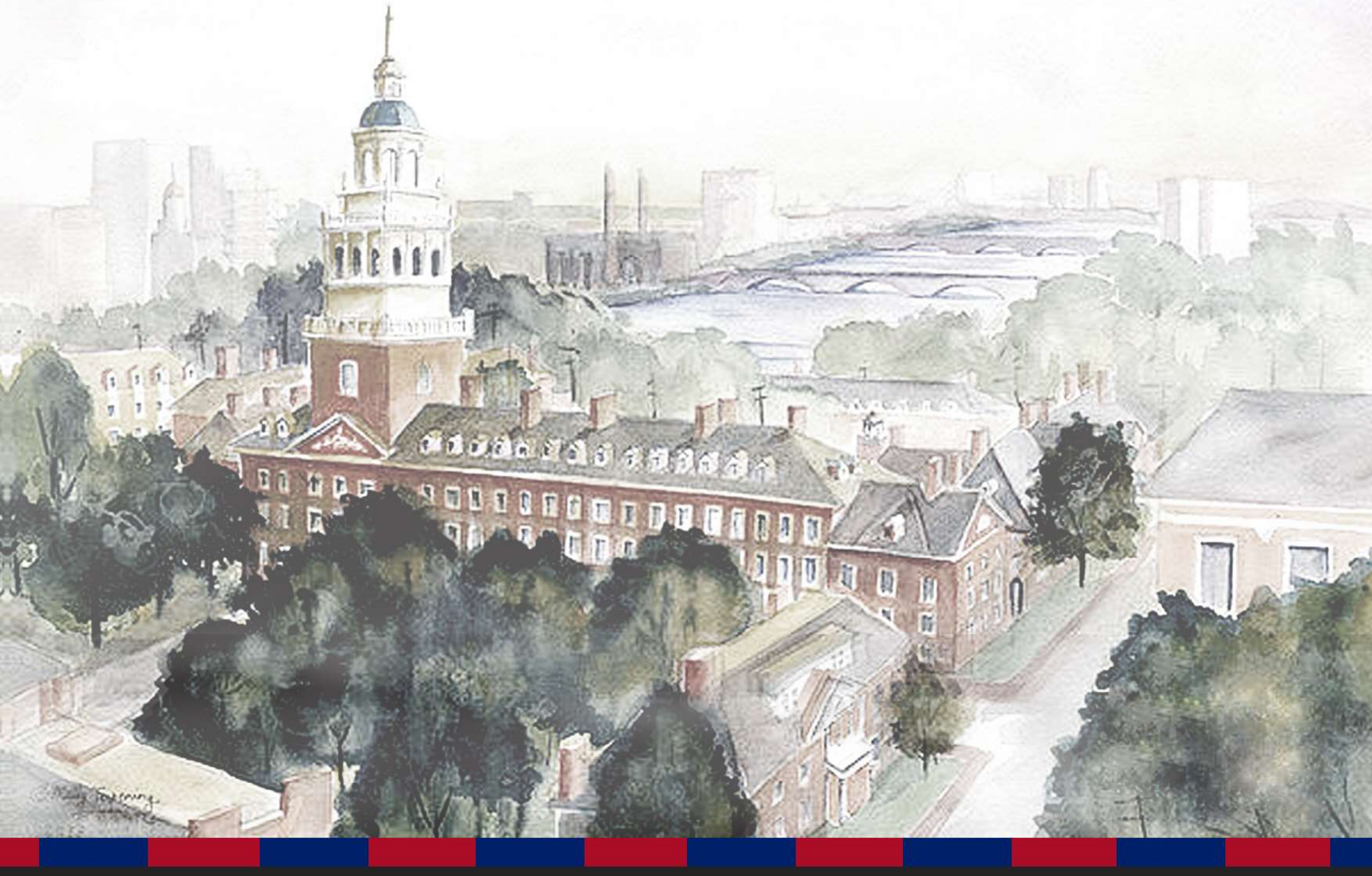
EDUCATION AND SCIENCE OF TODAY: INTERSECTORAL ISSUES AND DEVELOPMENT OF SCIENCES

OCTOBER 29, 2021 • CAMBRIDGE, GBR

VOLUME 1



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SECTION XIII.
ENERGY AND POWER ENGINEERING

SECTION XIV.
ECOLOGY AND ENVIRONMENTAL PROTECTION TECHNOLOGIES

SECTION XV.
COMPUTER AND SOFTWARE ENGINEERING

SECTION XVI.
SYSTEM ANALYSIS, MODELING AND OPTIMIZATION

SECTION XVII.
INFORMATION TECHNOLOGIES AND SYSTEMS

SECTION XVIII.
PHYSICS AND MATHEMATICS

SECTION XVI. SYSTEM ANALYSIS, MODELING AND OPTIMIZATION

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BUILDING A MODEL AND RESEARCHING THE PROCESS OF MOISTENING GRAIN

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The quality of products manufactured at any type of flour mills and factories largely depends on the quality of the original grain. In this direction, the European countries and the CIS countries have a different approach to solving this issue, hence the results obtained.

The grain supplied for processing usually has a low moisture content, while the structural and mechanical properties of the endosperm and shells are negligible. To change the technological properties of grain, various methods of hydrothermal treatment (HTT) or conditioning are used.

The purpose of the research is to study the distribution of moisture in grain material, depending on the method of HTT and determination of the coefficient of internal friction of grain before and after moistening.

The main task of the research is to determine the influence of the moisture content of the feedstock, it is included in the first drained system, on the flour yield and the main indicators of its quality, as well as the determination of the coefficient of internal friction of grain in a hopper with a spiral auger.

The work is devoted to the construction and study of a mathematical model that takes into account the dynamics of temperature, grain moisture, hydrothermal parameters of the intergrain space and the geometry of the container, in which the grain does not damp. With the help of this model, it is possible to most adequately substantiate the modes of hydrothermal treatment of grain before grinding, taking into account the heterogeneity and changes in time of operating parameters (temperature, humidity) and modeling the dynamics of indicators of the state of the grain mass, subject to control, in order to substantiate a rational system for controlling the process.

Neglecting the distribution of temperature and moisture inside the grains due to their small size and a change in air temperature with a change in pressure, heat transfer in air and a dense layer of grain, we describe the system of differential equations of heat and moisture transfer during electromagnetic drying (Lykov's equations) [2]:

$$\varepsilon\rho_a c_a = \varepsilon\lambda_a\nabla^2 T_a - \bar{v}\nabla T_a + Q + \alpha a_0(1-\varepsilon)(T_s - T_a); \quad (1)$$

$$(1-\varepsilon)\rho_s c_s\frac{\partial T_s}{\partial t} = (1-\varepsilon)\lambda_s\nabla^2 T_s - h_v m + \alpha a_0(1-\varepsilon)(T_a - T_s); \quad (2)$$

where:

ε – grain mass porosity; ρ – specific density, kg· m $^{-3}$; c – specific heat, J· kg $^{-1}$ ·K^{-1}; T – temperature, °C; λ – thermal conductivity, W·m^{-1}·K^{-1}; $\vec{v}$ – air velocity in intergranular space, averaged over sections, m s^{-1}; Q – volumetric heat dissipation, W · m^{-3}; α – heat transfer coefficient from grain to air, W · m^{-2}; a_0 – relative area of one grain, m^{-1}; m – the rate of evaporation of moisture from grain, kg · m^{-3} · s^{-1}; t – time, s; h_v – specific heat of vaporization of water; indices: s – grain, a – air of intergrain space, v – vaporous moisture in intergrain space, 0 – value at the start time.

The expression describes the heat exchange of grain with air according to Newton's laws, $\bar{v}\nabla T_a$ – heat transfer associated with air movement, $a_0(1-\varepsilon)$ – specific surface area of grains, $c_v m(T_s - T_a)$ – the heat given off for heating evaporated from the water grain with the air temperature.

In the calculations, it is assumed that at the border of the temperature of both grain and air, the initial conditions for (1) and (2) can change - the temperature at any point inside is equal to the temperature of the boundaries T_0.

In [4] the formula for calculating the drag coefficient of the layer of air movement is given.

$$R_p = K\mu_a\frac{a^2}{s^3}; \quad (3)$$

where:

K – Kozeny-Karman constant, theoretical value K = 4,5.

Assuming R_p is independent of coordinates:

$$0 = \nabla^2 P - \nabla(\bar{g}\rho_b(T_a - T_b)). \quad (4)$$

Since *P* is determined from (4) up to a constant, then for a closed capacity at any one point, and for an open one - over the entire surface of contact with the atmosphere, it is necessary to set: *P*=0.

Moisturizing processes take place in wet grain, that is, when there is free moisture in the grain that moves easily. Consequently, there is no need to take into account various types of connection moisture with grain [3] and the process of establishing equilibrium moisture content can be described by a simplified relationship:

$$f_w = \frac{w_{s,e} - w_s}{\tau_w}. \quad (5)$$

Time constant selected τ_w= 2 h.

Grain properties were described by dependencies:

$$\begin{aligned} \varepsilon &= 0{,}28 + 0{,}0045 w_{s.o} \\ \rho_s &= 1388 - 3{,}2 w_{s.o} \\ \lambda_s &= 0{,}1 + 0{,}0005(\rho_s - 690) \\ c_s &= 1520 + 21{,}8 w_{s.o} \end{aligned} \quad (6)$$

Conclusions. Since the overpressure *P* under natural convection and conventional ventilation modes is many orders of magnitude less than atmospheric, then all the characteristics of the air in the intergrain space were calculated for a pressure of 1 atm.

$$D_v = 2{,}5007 \cdot 10^{-5} \cdot \left(\frac{T_a + 273}{273}\right)^{1{,}94}$$

$$D_0 = 1{,}78 \cdot 10^{-5} \cdot \left(1 + \frac{T_a}{273}\right)^{1{,}5}$$

$$c_v = 1954 \text{ Дж} \cdot \text{кг}^{-1} \cdot \text{К}^{-1}$$

$$c_a = 1018 \text{ Дж} \cdot \text{кг}^{-1} \cdot \text{К}^{-1}$$

$$\rho_a = 1{,}2 - \frac{273}{273 + T_a} \text{ кг} \cdot \text{м}^{-3}$$

$$\lambda_a = 0{,}02368117 + 0{,}69833 \cdot 10^{-4} \cdot T_a.$$

The optimum moisture content of the grain is 17%, since at this moisture the optimal indicators of the quantity and quality of the finished product will be obtained.

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