THE INTENSIFICATION OF PROCESSES AND PHYSICAL MODEL OF DRYING AND GRINDING OF MEATBONE FLOUR

ZHAILAUBAYEV D.T., GINZBURG A.S., FYEDOSOV B.S.

Semipalatinsk Technological Institute of Meat and Milk Industry, 490011 Semipalatinsk, Glinka Street 49, The Republic of Kazakhstan

SUMMARY: The change of boundary conditions as a result of the material division in drying-and-grinding apparatus leads to the sharp intensification of mass-transfer process.

INTRODUCTION: Using the apparatus with active hydrodynamic regimes to intensificate heat- and mass-change processes in 2- and 3-phase polydispersive systems is one of the tendencies to develop meat and other industries.

MATERIALS AND METHODS: Drying process is intensified during grinding due to surface increase of phase contact between gas and disperse material. Let us consider a drying model, e.g. a non-boundary plate with R thick. The field of moisture content and temperature in the plate is uniform at the initial time moment $\tau=0$ Let us assume that moisture content on the plate surface during the whole drying process is constant and is equal to equilibrium moisture u_p If the plate division takes place at time moment τ_1 the moisture content distribution in its components will be specified by the curves.(1) It is evident that drying conditions for the plate divided into two parts will differ from drying conditions in the undivided plate.

Let us introduce non-dimensional variables into $\theta(\bar{z},Fo)=\dfrac{u(z,\tau)-u_p}{u_p}$; $\bar{z}=\dfrac{z}{R}$; $Fo_m=\dfrac{a_m\tau}{R^2}$;

Equation system in the variables received is

$$\frac{\partial\theta(\bar{z},Fo_m)}{\partial Fo_m}=\frac{\partial^2\theta(\bar{z},Fo_m)}{\partial\bar{z}^2}; \qquad 1.$$

$$\theta(\bar{z},0)=\theta_0(\bar{z}),$$

$$\theta(0,Fo_m)=0,$$

$$\theta(1,Fo_m)=0, \qquad 2.$$

The solution of the problem is received by the method Laplace's integral transformation. Equation solution 1 in the field of images is as follows:

$$\theta(\bar{z},S)=A\,sh\sqrt{S}\bar{z}+B\,ch\sqrt{S}\bar{z}-\frac{1}{\sqrt{S}}\int_0^{\bar{z}}\theta_0(\bar{z})\,sh\sqrt{S}(\bar{z}-x)\,dx. \qquad 3.$$

where $\theta(\bar{z},S)$ is the application of the Laplace transformation to a function $\theta(\bar{z},Fo_m)$.

2 and 3 coefficients are determined from boundary conditions. Taking the condition

$$\theta(\bar{z},S)=\frac{1}{\sqrt{S}\,sh\sqrt{S}}\left\{\int_0^{\bar{z}}\theta_0(\bar{z})\,sh\sqrt{S}(1-\bar{z})\,sh\sqrt{S}x\,dx+\int_{\bar{z}}^{1}\theta_0(\bar{z})\,sh\sqrt{S}\bar{z}\,sh\sqrt{S}(1-x)\,dx\right\}.$$

Under the condition

$$\theta(\bar{z},Fo_m)=\sum_{n=1}^{\infty}2\sin(\pi n\bar{z})\int_0^1\theta_0(\bar{z})\sin(\pi nx)\,dx\cdot\exp(-\pi^2n^2Fo_m). \qquad 4.$$

The expression 4 is the solution of boundary problem of moisture transfer in the plate that has non-uniform initial distribution and may be applied for the analysis of the case in which moisture content initial distribution is defined by assymetric function. The calculation results for the expression for two cases,(2) a) the plate size does not change during drying process; b) the plate division into two parts takes place with equal time intervals in agreement with the value of numaber F_{om}= 0,004, with the moisture content field determined at the end of the next time interval being taken as initial condition for the calculation of the next step.

RESULTS AND DISCUSSION: As can be seen initial conditions alteration as a result of the plate division leads to severe intensification of mass transfer process: drying time is reduced as much as three times in this case that agrees with the results of the experiments carried out and verifies the adequacy of physical model process solution. Proceeding from the results of both theoretical and experimental investigations a drying-and-grinding apparatus for drying meatbone flour is designed and constructed, its industrial testing gave positive results (table 1).

Production and economic characteristics of basic and developed plant. Table I.

No.	Specifications	Units	Basic variant KBM 4.6	Variant offered CDA - 600
1.	Capacity vs.dr.wt.	kg h	100	600
2.	Specific power consumption	KWh / kg.dr.wt.	0.57	0.37
3.	Production area	m^2	2.52	0.7
4.	Specific quantity of metal per 1 kg of dr.wt.	t / h	0.68	0.19
5.	Specific moisture lost	kg.m. m^3h	82.5	164.8

CONCLUSION: System approach to the description of complex phenomena while combining drying and grinding processes of moist material in one apparatus has been developed. System analysis is applied as investigation strategy and mathematical simulation as investigation method. The results of boundary problem solution of moisture conduction in the plate with initial assymetric distribution of moisture content are given. Proceeding from the generalized equation the investigation method of dimension and specific surface alteration of the material being processed as well as thermal physical and structural mechanical characteristics of the material have been elaborated. As a result of theoretical and experimental studies a drying-and-grinding apparatus for drying moist material is designed.

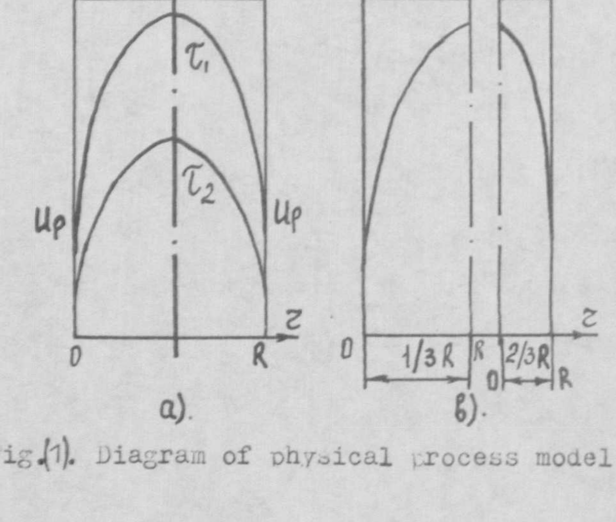
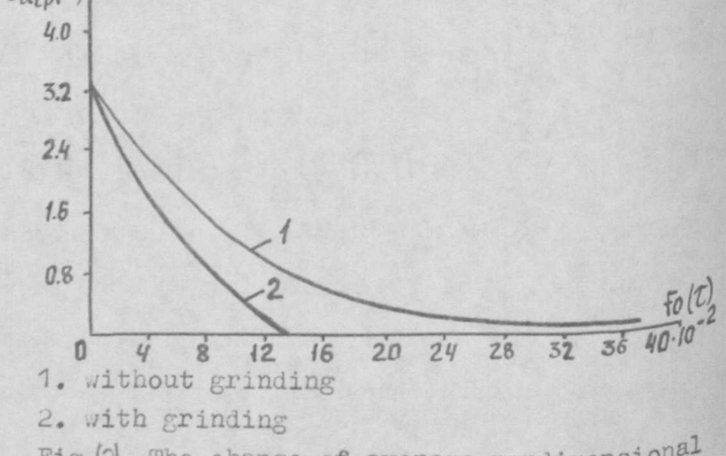


Fig.(1). Diagram of physical process model



1. without grinding
2. with grinding

Fig.(2). The change of average nondimensional moisture content in the plate with the time