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RESEARCH OF THE PROCESS OF KNEADING DOUGH IN DOUGH MIXER OF CONTINUOUS ACTION

Tymchyshyn Andrii - Student
Department Machines and apparatus of food and pharmaceutical productions,
National University of Food Technology, Ukraine
E-mail: andriitymchyshyn12@gmail.com

Assoc.prof. Vitalii Rachok, PhD
Assoc.prof. Yuliya Telychkun, PhD
Department Machines and apparatus of food and pharmaceutical productions,
National University of Food Technology, Ukraine
E-mail: RachokV3478@gmail.com, tvill@meta.ua

Abstract: *Mathematical simulation of the process of kneading wheat yeast dough by cam working elements in the software complex Flow Vision was carried out. The calculation grid was used to model the process. At the stage of setting of the task, the conditions of contact of interaction of the material with the working elements and the mixing chamber are specified, as well as the values of the structural and mechanical characteristics of the dough. During the study, the distance between the cam working elements were placed in the range from 2 to 10 mm (2-4-6-8-10 mm), the inspection speed was used in the range from 20 rpm to 100 rpm (20- 40 60-80-100 rpm). After settings all the necessary parameters in the program complex the stage of calculating and visualizing of the kneading the yeast dough process begins. For pseudoplastic fluids with variable product viscosity (non-Newtonian fluid), the shear stress is gradual. The distribution of the shear stress in the yeast dough in the process of kneading by the cam working elements was investigated and, as a result, the distribution of mechanical load for each position of the cam working elements in the kneading chamber. Studies related to the influence of the distance between the cams and the speed of rotation of the working element on the process of kneading the yeast dough.*

Keywords: *Modeling, Dough, Kneading, Cam*

INTRODUCTION

The development of a continuous-action dough-mixing machine is accompanied by the choice of a rational configuration of the working element. Rationalization is realized by analyzing the various configurations of the working element and its effect on the kneading process. Imitation modeling aims to calculate the values of certain characteristics of a process that develop over time, by reproducing the flow of this process on a computer via its mathematical model (Hackenberga, S., Vogelb, C., Scherfb, K.A., Jeklea, M., Beckera, T., 2019; Tozattia, P., Hopkinsa, E.J., Briggsb, C., Huclb, P., Nickerson M. (2019). Imitation modeling of the yeast dough kneading process was performed using Flow Vision software. During projecting of the process of dough mixing, there is a range of issues related to the type of working elements is supposed to be chosen. On the basis of theoretical searches and obtained experimental results, after comparative analysis of working elements, it was decided to simulate the process of kneading yeast wheat dough using cam working elements (Lamrinia, B., Della, G., Treleac, T., Perrotc, N., Trystram, G., 2012). Obtaining information about the process of mixing at any point in the mixing tank using simulation modeling and the results of a physical experiment allow to project an effective working element in a high-tech continuous mixing machine (Lia, H., Thompsona, M., O'Donnellb, K., 2014).

The research methodology is based on the information technologies of designing of processes of elastic-viscous-plastic deformation of thixotropic dispersed materials using modern computer technologies.

EXPOSITION

We conducted studies on the effect of the distance between the cams and the speed of rotation of the working element on the kneading process of yeast dough. The distance between the cam working elements was changed from 2 mm to 10 mm (2-4-6-8-10 mm), the rotation speed was changed in the range from 20 rpm to 100 rpm (20-40-60-80-100 rpm). Simulation modeling of the kneading process was performed in the Flow Vision software package.

Based on the results, after parametric modeling of the kneading process by the cam working elements, a linear dependence of the speed of movement of the dough in the working chamber was obtained (Fig. 1).

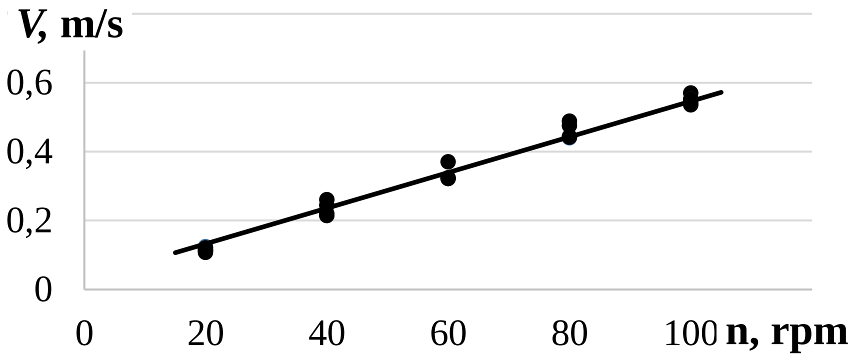

Fig. 1. Variation of mixing speed, depending on the distance between the cams and the speed of rotation of the working element.

It has been investigated that with increasing the speed of the working element, the speed of movement of the dough in the mixing chamber increases, under these conditions of the mixing process the distance between the cam working elements does not affect the speed of mixing.

The change in the mixing speed [V = m/s], depending on the distance between the cams and the speed of rotation of the working element, is determined by the mathematical formula:

$V = 0{,}005n + 0{,}03$, [m/s]

The simulation data on the change in pressure in the mixing chamber were analyzed, which made it possible to obtain the dependence of the pressure on the rotation speed of the working element and the different distance between the cams (Fig. 2).

It was found that with increasing the speed of the working element, the pressure in the mixing chamber increases. The maximum pressure values are 16560 PA at a distance between cam working elements of 2 mm and a rotational speed of 100 rpm, a minimum of 555 PA at a distance between cam working elements of 10 mm and a rotation frequency

The change in pressure [P = Pa] in the mixing chamber, depending on the distance between the cams and the speed of rotation of the working element is of a power character and is described by the formula:

$P = (73 - 6{,}9\text{S}\,)n^{0{,}03S\,+\,1{,}14}$, [Pa]

where, S is the distance between the cam working elements, mm; *n* is the speed of rotation of the working element, rpm.

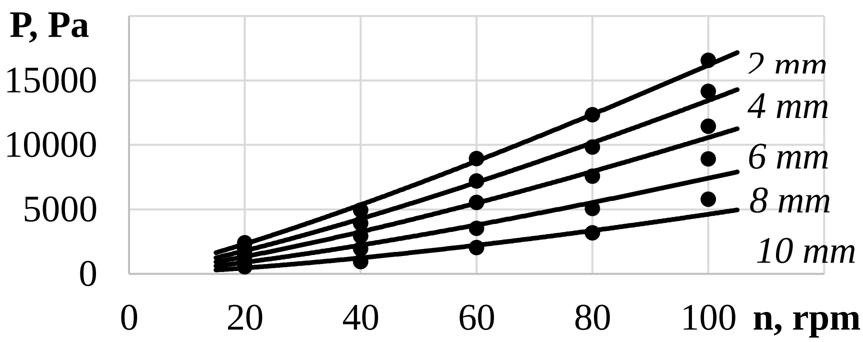

Fig. 2. Changing the pressure in the mixing chamber, depending on the distance between the cams and the speed of rotation of the working element.

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Based on the obtained results, a graph of viscosity change in the mixing chamber was constructed, depending on the distance between the cams and the rotation speed of the working element (Fig. 3).

The parts of the kneading chamber that achieve the lowest viscosity are considered to be most effective during mixing. Increasing the rotation speed of the working element leads to an increase in the speed of movement of the dough in the work chamber, which in turn leads to a decrease in the viscosity of the dough and a decrease in energy costs during the kneading process.

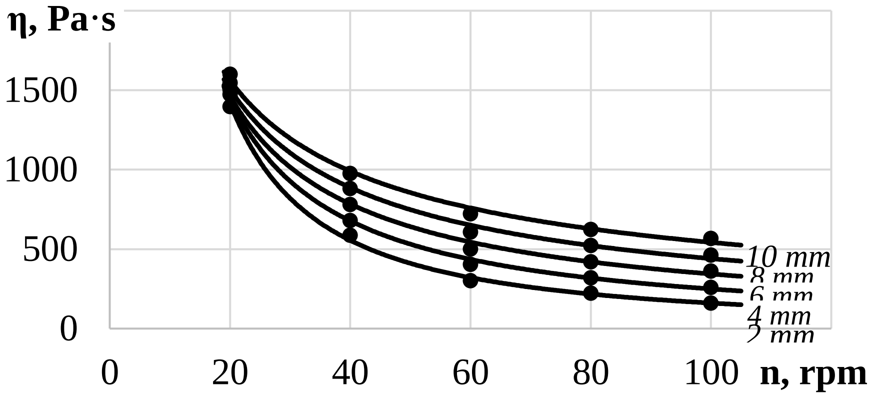

Fig. 3. The viscosity change in the kneading chamber, depending on the distance between the cams and the rotation speed of the working element.

It has been investigated that with increasing rotation speed, the viscosity of the dough [η = Pa · s] decreases in the kneading chamber. The decrease in viscosity is also affected by the reduction of the distance between the cam working elements, as the distance between the cams during the kneading process will decrease the viscosity of the dough.

The mathematically obtained dependence is described as:

$\eta = (201431 \cdot S^{-1,4}) n^{0,09S\,-\,1,4}$,   [Pa·s]

where, S is the distance between the cam working elements, mm; n is the speed of rotation of the working element, rpm.

Thus, a simulation parametric model of the yeast dough kneading process allowed us to study in detail the processes occurring in the dough mixing chamber, the dependence of the flow motion on the design and configuration of the cam working elements, and the rotational speed.

CONCLUSION

The dissipation distribution in the kneading chamber and the temperature change during the kneading process were investigated. At a rotation speed of the working element of 60 rpm, the temperature of the yeast dough rises to 5 °C, which is acceptable during kneading of the dough.

Mixing speed, dough viscosity, and mixing chamber pressure were investigated. With increasing rotation speed of the working element, the speed of mixing the dough in the mixing chamber increases. Increasing the rotational speed from 20 rpm to 100 rpm increases the pressure in the kneading chamber and reduces the viscosity of the yeast dough.

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