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STUDYING AND IMPROVING THE CONTINUOUS PROCESS OF KNEADING YEAST DOUGH

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Abstract: *A study of the process of kneading wheat yeast dough with cam working was conducted. The aim is to determine the rational configuration of structural elements for continuous kneading of dough at different levels of frequency of the working elements rotation and the distance between them.*

The kneading of wheat yeast dough by cam working elements is investigated. Mathematical modeling was performed using the Flow Vision software package based on the simulation of three-dimensional motion of liquids and gases in technical structures, as well as for the visualization of flow curves by computer graphics. Physical modeling was performed via experimental setup with cam kneading elements.

As the rotational speed of the working elements increases from 20 to 100 rpm, the mixing speed increases from 0.1 to 0.6 m/s, the distance between the cams does not affect the mixing in the specified range. The maximum values of pressure reach 16560 Pa for the distance between the cam working elements 2 mm and a speed of 100 rpm, the minimum 555 Pa for the distance between the cam working elements 10 mm and a speed of 20 rpm. In the mixing chamber, the highest-pressure values are formed in the contact zone of the cam working elements with the wall of the mixing chamber and in the contact zone of the two cams. The dependence of the viscosity in the mixing chamber on the speed of rotation of the working element is of a power nature and with increasing speed from 20 to 100 rpm decreases from 1600 to 320 Pa·s. Parts of the mixing chamber in which viscosity values in the range from 320 to 960 Pa·s are achieved are considered to be the most effective during mixing. Reducing the viscosity of the dough involves reducing energy costs during kneading.

To increase the carrying capacity of the cam working elements, improve mixing and reduce heat consumption, it is rational to use cam working elements with a variable pitch and a variable position of the cams at α = 45° or a combined cam working element using a screw auger at the beginning of the working element.

Keywords: *Modeling, Mixing, Yeast Dough, Kneading, Cam.*

INTRODUCTION

To determine the exercise of calculating the motion of liquids, it is necessary to formulate and solve a system of differential equations: energy, continuity, motion, change of density and rheological properties. Equation data for non-compressible liquids but cannot adequately describe the process of movement of the yeast dough are used in the literature, as several researchers prove that the dough is compressed due to the significant content of the gas phase.

The considered mathematical models of the movement of wheat yeast dough allow to simulate the process of kneading wheat yeast dough and can be used for simulation in the software complex Flow Vision. To simulate the process of kneading the yeast dough by the cam working elements, the software program "Flow Vision" was selected, which is designed to simulate the three-dimensional motion of liquids and gases in technical and natural objects, as well as to visualize curves of currents by computer graphics. To simulate the process of kneading the wheat yeast dough, an incompressible fluid model was chosen, which describes the flow of a viscous fluid at small and large (turbulent) Reynolds numbers, followed by its visualization.

To load the geometry of the working elements, we use the filter "Element Movement in the Geometry Template", in which we enter the mass of the kneading element, the matrix of inertia, the angular velocity and the primary location. The next step in the simulation is to establish the boundary conditions of the problem. At the "Input" border, we set the "Normal Speed" boundary condition; on the border “Cam working element” we establish the “Logarithmic law”; at the Exit boundary we set the Free Exit boundary condition. The next step of entering the input parameters is to build a grid in the calculation area, which is used to select a uniform grid along the guides x, y, z.

To obtain reliable results, it is necessary to enter the parameters of numerical calculation, which determine the program step by time and take into account the action of gravity. These settings are specified in the “General Settings” tab. Several methods were used to visualize the obtained results in the Flow Vision software package: visualization of scalar fields, individual numerical values, velocity vector fields.

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. The simulation results were obtained in the form of graphical images with a color scale of distribution of variables with numerical values (Figs. 1, 2, 3).

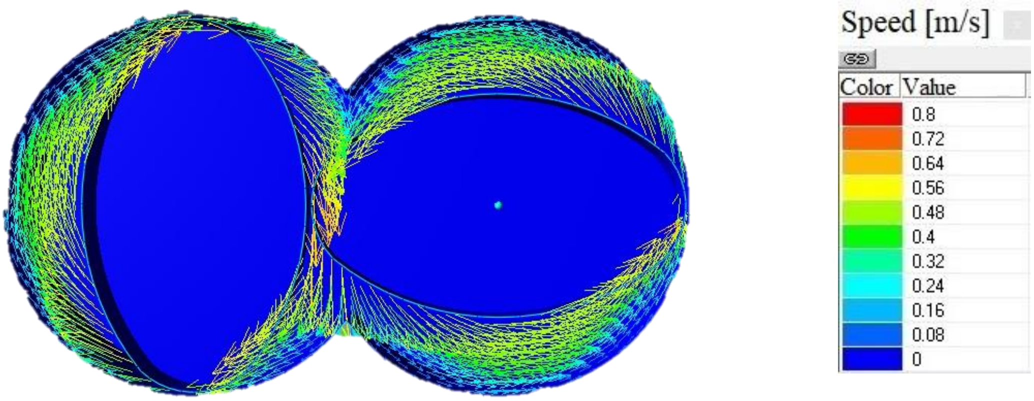

Fig. 1 Visualization of the speed of movement of the dough in the mixing chamber during simulation parametric modeling of the cam working elements in the software complex Flow Vision.

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.

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.

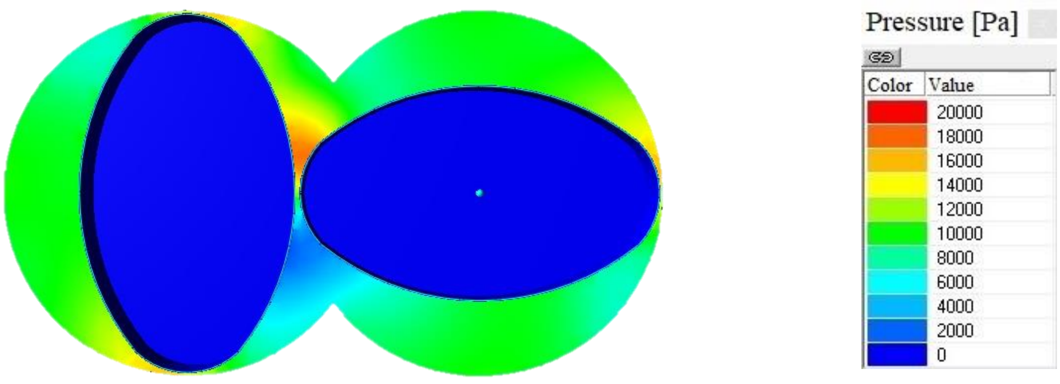

Fig. 2 Visualization of pressure in the mixing chamber during simulation of parametric modeling of cam working elements in the software complex Flow Vision.

The simulation data on the change in pressure in the mixing chamber were analyzed (Fig. 2), 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. It was found that with increasing the speed of the working element, the pressure in the mixing chamber increases. The pressure in the chamber is also affected by the distance between the cam working elements, the smaller the distance, the greater the pressure in the chamber. 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 20 rpm.

We obtained the viscosity distribution of the kneading chamber at different rotational speeds and working element distances. The simulation results confirmed the pseudoplastic nature of the test, which is explained by the variable numerical viscosity data of the dough in the kneading chamber (Fig. 3). 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.

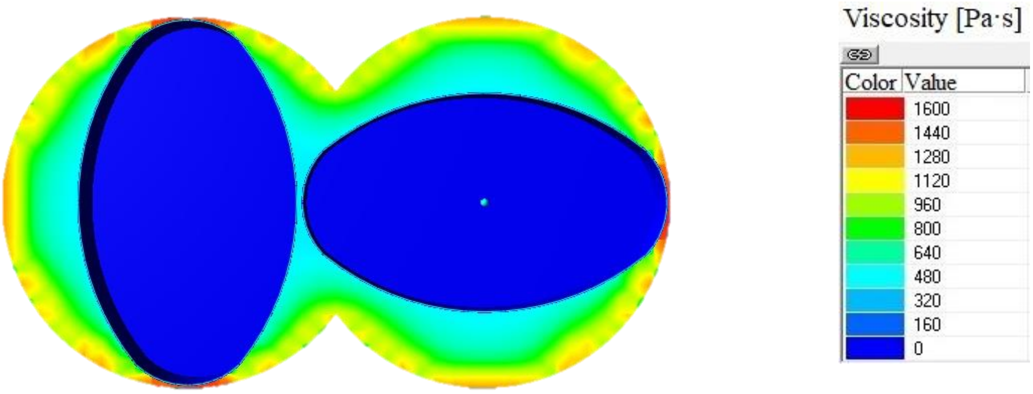

Fig. 3 Visualization of the change in viscosity in the mixing chamber during simulation parametric modeling of the cam working elements in the software program Flow Vision.

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.

CONCLUSION

The simulated parametric model of the kneading process by cam working elements has been developed that allows to perform design calculations effectively in case rational structural and technological parameters selection. The use of the presented scientific and methodological developments will greatly speed up and economically save the process of creating reliable technological equipment for kneading yeast dough.

Changes in the shear stresses of the yeast dough in the mixing chamber, in the area of engagement of the working elements and close to the contact with the walls of the mixing chamber are studied. 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.

Based on the simulation modeling of the yeast dough kneading process, effective working elements for kneading yeast dough in a continuous kneading machine are proposed.

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