SAT–LCR-P-2-BFT(R)-16

MODELING OF THE PROCESS OF KNEADING THE YEAST DOUGH BY MODERN WORKING ELEMENTS

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Abstract: *The scheme of the mathematical modeling of the process of mixing of the yeast dough in a dough machine of continuous action is developed. Based on the results of simulation of the mixing process, cam operating elements, the distribution of strain of displacement and dissipation of yeast dough in the working chamber were obtained. As the angle of the position of the cam element increases on the shaft, there is an increase in the shear stress. The greatest indices of shear stress occur in the area of cam clamping elements and in the contact area of the cam with the walls of the case, numerical values reach within 7000-8000 Pa. For the rest of the camera, the displacement stress reaches 1000-3000 Pa. Distribution of dissipation shows that in parts of the working chamber there is the formation of heat in the area of flow. With the increase of the angle of the cam of the cam element, there is a gradual increase in temperature. At the site of mixing 12 pairs of cams, the temperature of the yeast dough increases by almost 5° C. Taking into account that before the simulation, the initial temperature reached t = 30° C, and upon completion of the mixing process did not exceed 35° C, the pastry preparation parameters were observed. The greatest heat release occurs in the area of the cam clamping elements.*

The results of mathematical modeling are confirmed by physical experiments on a test dough mixing machine of continuous action, an error within 5%.

Keywords: *Dough, Cam, Kneading, Modeling, Rotation, Dissipation*

INTRODUCTION

The cam elements are gaining widespread acceptance, we have carried out a series of experimental studies that prove their effectiveness during the kneading process. During the viscous flow, the deformation is proportional to the stress imposed by Newton's law, and after the removal of the load is not restored. Plastic deformation is created under stress that exceeds a certain limit value (the boundary of flowability), to which the material behaves as visco-elastic.

During mixing flour with water, the components of the flour form a hydrated bonded mass - a dough. Hydrated medium, which is a dough, the presence in this mass of introduced fermentable microflora is triggered by a system of complex biochemical, microbiological, colloidal and other processes.

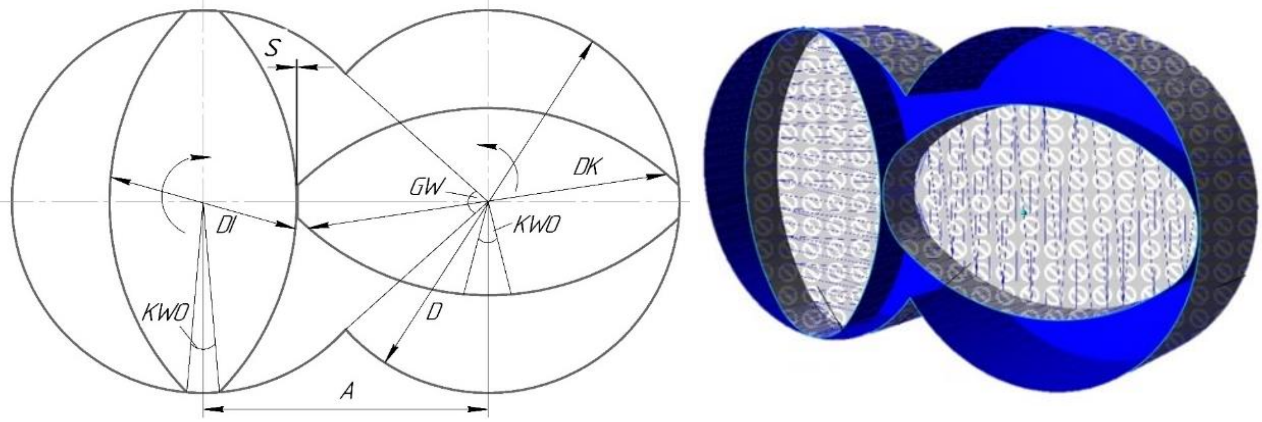
The cam working elements are becoming more widely used, but almost non-exploratory, requiring in-depth study and detailed analysis. By way of a critical analysis of literary sources on the subject of the process of mixing, the directions of development and improvement of this issue were identified, thus a deep and systematic study requires the problem of qualitative and intensive mixing of yeast dough in continuous-dough machines of continuous action.

EXPOSITION

The dough is considered as a complex colloidal system, consisting of several continuous and periodic phases. Solids and liquids (gluten and water) in the dough are continuous phases, starch grains and gas formed during fermentation of the dough - a periodic phase. As a result, the physical properties of the dough are characterized by parameters of solids, liquids, gases and indicators resulting from the interaction of these phases.

Mathematical dependencies, geometric dimensions of the chamber, geometrical sizes of cam operating elements, frequency of rotation, and experimental data obtained after a physical experiment were given to calculate and simulate the simulation of the process of mixing the yeast dough with cam operating elements.

To simulate the process, a calculated grid was used. The cam working elements rotated with a frequency of 60 rpm in the opposite direction and changed the angle by 45° (Figure 1). After the mechanical action by cam operation elements the share rate and dissipation were calculated via the software complex.



2D model **3D model**

Fig. 1. Specified geometric dimensions mixing chamber and located therein cam working elements

Modeling of the process of mixing the yeast dough by the cam operating elements passes with a rotational speed of 60 rpm in a dual capacitive capacity. The cam's working elements turn to meet each other by kneading the yeast dough, moving the yeast dough in the crucible with the use of cam-like elements is depicted in Figure 2.

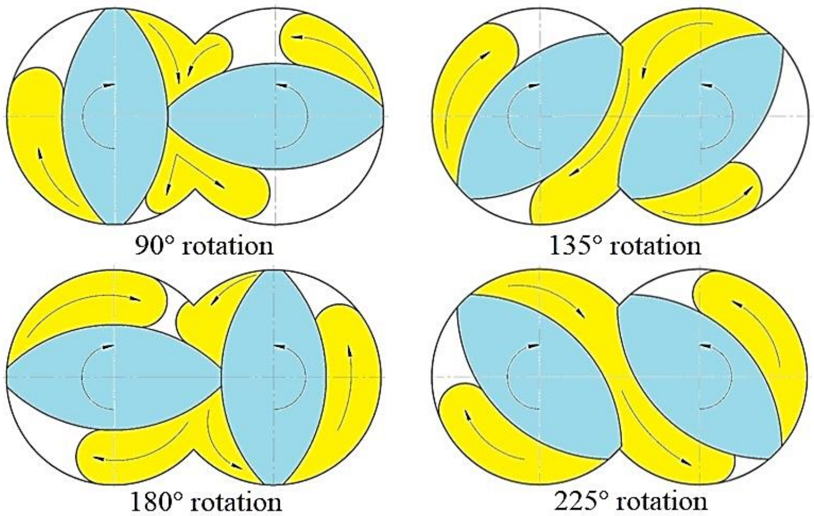


Fig. 2. Moving the yeast dough in the crucible with the use of cam operating elements

Simulation of the process of mixing the yeast dough is needed for further calculation of the design, technological parameters and recommendations for the design of the working element and dough machine in general. Using simulation, we will determine the range of variation of the bias voltage and dissipation parameters.

The purpose of which is to establish the rational value of the selected parameters in order to achieve the maximum effect from their effect on the process of kneading.

The initial data and boundary conditions were entered for simulation modeling of the process of mixing into the software complex, namely, to the calculation blocks: material properties, geometry and status of the process of mixing.

In the properties of the material, a two-component mixture with the properties of the pseudoplastic fluid was chosen. Geometric data are given in the geometry block and in the calculation parameters the counter-rotation of the cam's working bodies is selected. The mixing process status is selected as complete, not stable, alternating during mixing.

To study the shear stress, four basic positions of the cam's working elements were selected, then these provisions are repeated on the shaft of the working element.

On the greater part of the working volume there are not large indicators of shear stress (Figure 2). The greatest indices of shear strain during modeling of the process of mixing the yeast dough are observed in the field of interaction of the working element with the wall of the case and in the zone of engagement of the working elements.

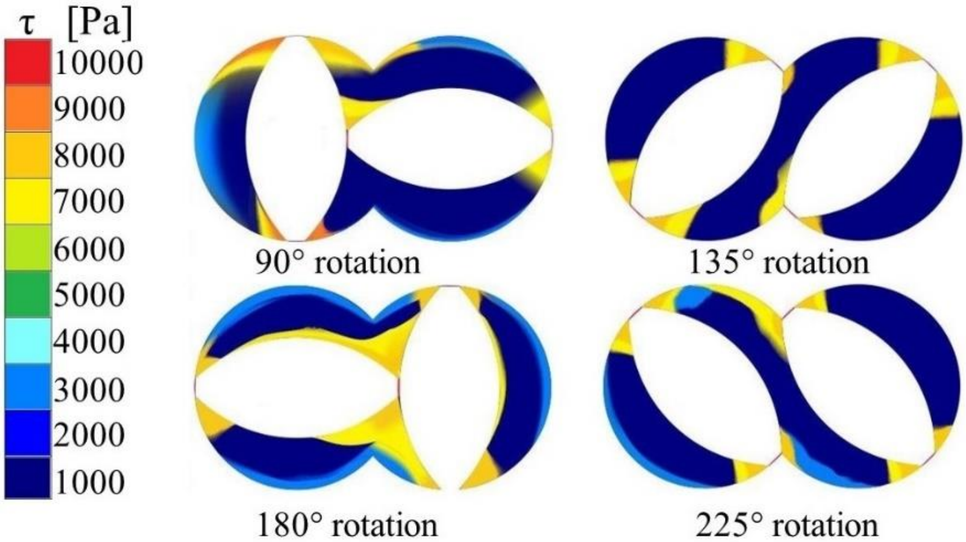


Fig. 3. Change in the shear stress [τ, Pa] in the mist chamber in the process of mixing the yeast dough by the cam working elements

In the area of the engagement of the working elements and at the contact with the walls of the chamber, the shear stress values reach from 7000 to 8000 Pa. For the rest of the chamber, the displacement strain reaches 1000-3000 Pa.

The dissociation is proportional to the displacement velocity squared. Due to dissipation, the conversion of the kinetic energy of the stream into the heat occurs due to internal friction of the yeast dough with the working elements and the case.

The yeast dough is mixed in 12 pairs of cams, which are shifted at an angle of 45°, for the dissipation process it was decided to consider the process of kneading in the example of 3-6-9-12 pair of cams, since at the beginning of mixing there were noticeable changes in dissipation. By means of simulation, distribution of dissipation in the microscope was considered in the process of mixing the yeast dough with the cam operating elements (Figure 3).

Distribution of dissipation clearly shows in which parts of the working chamber is the formation of heat in the flow area. In the area of kneading 3 pairs of cam (180° rotation), there is no significant heat release, then during the mixing due to internal friction of the yeast dough with the working elements and the case there is an increase in the conversion of the kinetic energy of the stream into the heat and the temperature of the yeast dough increases.

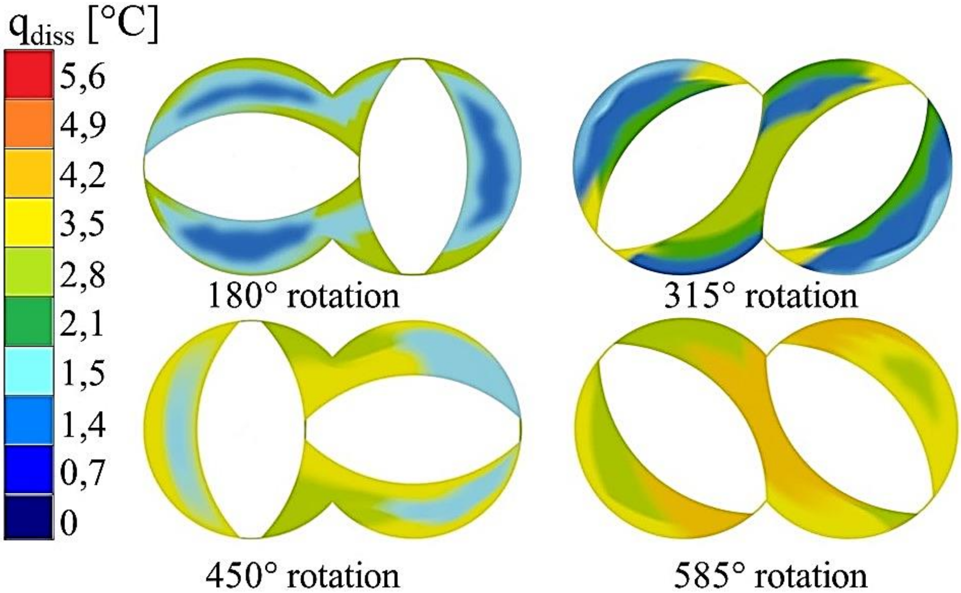


Fig. 4. Distribution of dissipation [q_{diss}, ° C] in the chamber in the process of mixing the yeast dough by the cam working elements

At the stamping site 12 pairs of cams, the temperature of the yeast dough increases by almost 5° C, thus taking into account that before the start of the simulation, the initial temperature was set to t = 30° C, then at the end of mixing, this temperature in the yeast dough reaches almost 35° C. The greatest amount of heat is observed in the sphere of cam involvement of the working elements.

The simulated parametric model of the process of mixing by cam operating elements, which allows to carry out design calculations effectively when choosing rational structural and technological parameters, is developed. Using the presented scientific and methodological developments will significantly accelerate and economically save the process of creating reliable process equipment for mixing yeast dough.

CONCLUSION

It was investigated the change of the stresses of the shift of the yeast dough in the stirring chamber, in the region of the contact between the working elements and at the contact with the walls of the chamber, the shear stresses reach from 7000 to 8000 Pa, and the rest of the shrinkage chamber displaces a strain of 1000-3000 Pa. On the basis of simulation modeling of the process of mixing the yeast dough, effective working elements are proposed for mixing the yeast dough in a dough machine of continuous action.

REFERENCES

Brandner S., Becker T., Jekle M. (2018), Wheat dough imitating artificial dough system based on hydrocolloids and glass beads, Journal of Food Engineering, 223, pp. 144-151.

Zhang D., Mu T., Sun H. (2017), Comparative study of the effect of starches from five different sources on the rheological properties of gluten-free model doughs, Carbohydrate Polymers, 176, pp. 345-355.

Rachok V., Telychkun V., Shtefan Y., Telychkun Y., Damyanova S. (2019) Modeling of the process of kneading the yeast dough by cam operating elements, Ukrainian Food Journal, Volume 8, Issue 2. pp.355–367.

Wang Y., Ye F., Liu J., Zhou Y., Zhao G. (2018), Rheological nature and dropping performance of sweet potato starch dough as influenced by the binder pastes, Food Hydrocolloids, 85, pp. 39-50.