WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 4, Issue 5, May, 2023

DETERMINATION OF THE COMPRESSION FORCE WHEN FASTENING THE DOUGH LAYERS

Nurmukhamedov A. M. [1],
Abdullayeva S. Sh. [1],
Abdullaev A. Sh. [1],
Hadjibaev A. Sh. [1]
Tashkent Institute of Chemical Technology 1
sadshon1975@yandex.ru

Abstract
The solution to the problem of developing modern technology and equipment for the production of flour confectionery is to save material resources when creating equipment and in the production of products. Rheology plays an important role in solving this problem, allowing you to create resource-saving technologies and equipment designs. In this paper, theoretical and practical issues related to the processes of mechanical processing of dough for national flour products with stuffing, taking into account its rheological properties, are considered.

Keywords: flour confectionery, rheology, dough layer, bonding process, compression, fastening roller.

The production of flour confectionery products is one of the most important branches of the food industry, the level of development of which directly affects the life of the population. Currently, the food industry produces about 5 thousand types of bakery and confectionery products. Changing and improving the assortment, as well as increasing the volume of production is provided by an increase in capacity. This can be done as a result of technical re-equipment and reconstruction of existing enterprises, updating and modernization of equipment, replacement of obsolete equipment, early introduction into production of the latest achievements of science and technology, construction of new large enterprises. One of the most important directions for improving product quality and increasing production efficiency in the bakery industry is the creation of a rational structure of industry enterprises, mechanization and automation of production processes based on the latest technologies [1].

To solve the problem of developing modern technology and equipment for the production of flour confectionery, it is necessary to save material resources when creating equipment and in the production of products. Rheology plays an important role in solving this problem, which makes it possible to create scientifically-based equipment designs and rational technologies [2].

This paper provides a solution to theoretical and practical issues related to the processes of mechanical processing of dough for national flour products with stuffing and taking into account its rheological properties.

Fig.1 shows the bonding of two layers of dough with the shoulders 5 of a rotating roller, which is the process of gradual compression of these layers along the vertical axis. The diagram of the velocities of an arbitrary point of the roller shoulder at the boundary of contact with the test during its rotation is shown in Fig.2. Here:

υ_0 - circumferential speed of the roller ;

υ_x - the speed of the roller point along the axis X;

υ_y - the speed of the roller point along the axis Y;

α - the angle of capture by the fastening roller of the dough layers;

$\alpha_т$ - the current angle of rotation of the point of the fastening roller during compression;

ω_t - the angle of rotation of the roller in time t;

ω - angular velocity of the roller.

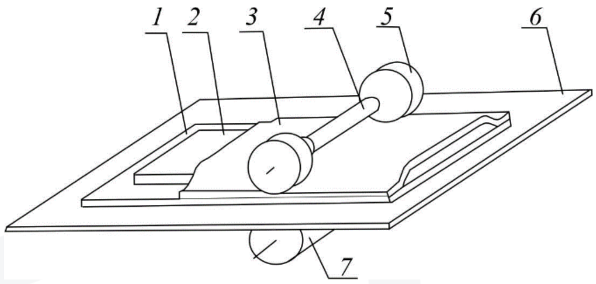

Fig.1. The node of the longitudinal fastening of the dough layers.
1 – lower layer of dough; 2 – filling; 3 – upper layer of dough; 4 - fastening roller; 5 – working surface of the fastening roller; 6 – conveyor belt; 7 – support roller.

The total initial thickness of both layers of dough H_0, and the final one, after bonding $H_к$. The gap between the fastening roller and the conveyor belt b. Due to elastic recovery after bonding the dough layers $H_к > b$. When the layers are bonded, the flow of the dough occurs in directions parallel to the axis of the roller.

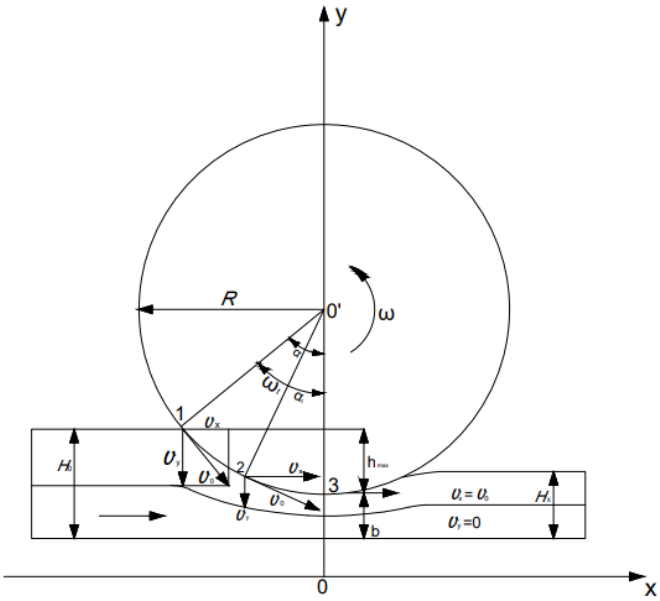

Fig.2. Diagram of the speeds of the point of the working surface of the rotating roller.
Considering the horizontal movement of the dough layers at a speed equal to the circumferential velocity of the point on the working surface of the butt of the fastening roller (Fig.2), due to which there is no sliding between the working surface of the roller and the dough layer, the bonding process can be represented as a process of vertical compression of the dough. In accordance with this, we take the scheme of gradual compression of the text by a vertically descending wedge as a physical model of the bonding process (Fig.3). We take the lower surface of the wedge to be elementary and the area of its projection onto the plane XOZ determined by the formula:

$$dS = L \cdot dl \cdot \cos\alpha, \qquad (1)$$

where L - the width of the wedge equal to the width of the shoulder of the fastening roller,
dl - the thickness of the wedge equal to the length of the elementary arc of the circle of the fastening roller;
β - angle of inclination of the end of the wedge to the axis OX.
Vertical wedge, successively passing through the positions 1, 2, 3 (fig.3), gradually compresses the dough layers in the direction of the axis OУ. At the same time, the compression rate of the dough by the descending blade is reduced to $\upsilon_y = 0$. The angle of inclination of the end of the wedge to the OX axis also decreases from β_{max} до $\beta = 0$.
When considering the fastening of the test according to the given physical model, we assume that the flow of the test along the axes OH and OZ does not affect the bonding process.

To simplify the task of determining the compression force when fastening the dough layers, we accept the following assumptions:

1. We consider the fastening roller to be an absolutely rigid body and there are no elastic deformations in it.
2. The process of fastening the dough layers is assumed to be isometric.
3. The deformation of the transport belt along the OY axis is neglected. Due to its insignificance compared to the deformation of the dough.
4. In the range of pressures acting during bonding, the layers of dough for national flour products with stuffing are represented as an elastic-viscous inertial body of finite thickness.

The resistance of the dough in this case consists of the resistances along the end and side surfaces of the wedge [3].

Using the theorem on the change in the kinetic energy of a solid, it is possible to determine the amount of lowering of the wedge into the dough.

$$\frac{m\upsilon_{к}^{2}}{2}-\frac{m\upsilon_{н}^{2}}{2}=\sum A_{к}, \qquad (2)$$

where $\upsilon_{к}$ - the speed of the wedge movement at the end of text compression;
$\upsilon_{н}$ - the speed of the wedge movement at the beginning of text compression;
$\sum A_{к}$ - the sum of the work of all the forces acting on this compression;
m - the mass of the equivalent cargo. We will call an equivalent load a load that reproduces a deformation curve similar to the deformation curve when the layers are compressed.

According to [3] we write

$$\sum A_{к} = A_1 + A_2 + A_3, \qquad (3)$$

where A_1 - operation of the load applied to the wedge;
A_2 - the work of the resistance force on the end surface of the wedge;
A_3 - the work of the resistance force on the side surface of the wedge.

$$A_1 = P \cdot h_{max}, \qquad (4)$$

P is the compression force of the dough layers by the wedge during bonding;
h_{max}- the value of the full lowering of the wedge during compression (Fig.5);

$$A_2 = -P_{т} \cdot h_{max}, \qquad (5)$$

$P_{т}$ - the resistance force on the end surface of the wedge ;

$$A_3 = -\int_0^{h_{max}} P_{б} \cdot dh, \qquad (6)$$

$P_{т}$ - the resistance force along the side surface of the wedge.

Since, when fastening the layers, the dough slightly protrudes beyond the shoulder of the fastening roller and at the same time practically does not come into contact with

WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 4, Issue 5, May, 2023

the side surface of the shoulder, the resistance force along the side surface of the wedge can be assumed to be zero, i.e. $P_б = 0$. It follows that

$A_3 = 0$.

Substituting expressions (4) and (5) into equation (3), we obtain

$$\frac{m(\upsilon_к^2-\upsilon_н^2)}{2} = (p - p_т)h_{max}\,, \tag{7}$$

hence the compression force is defined as

$$p = \frac{m(\upsilon_к^2-\upsilon_н^2)}{2h_{max}} + p_т, \tag{8}$$

In the final position of lowering the wedge, the speed of its movement is zero, i.e. . $\upsilon_к = \upsilon_y = 0$ (fig3). After that, equation (8) takes the form

$$p = -\frac{m\upsilon_н^2}{2h_{max}} + p_т \tag{9}$$

The first term of the right side of equation (9) is the inertial component of the total force of resistance to the movement of the wedge $P_и$, that is, you can write

$$P_и = -\frac{m\upsilon_н^2}{2h_{max}} \tag{10}$$

$$P = P_и + P_т \tag{11}$$

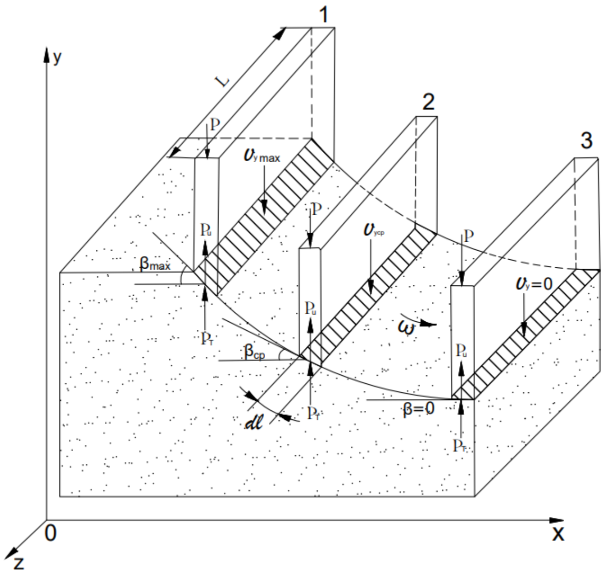

Fig.3. Physical model of the bonding process of dough layers.

As a result of this scientific work, a device for molding flour products with stuffing is proposed, in which the entire process of molding and fastening is mechanized. On the basis of experiments, the influence of mechanical compression of the dough by the rolls of the machine was investigated, it was revealed that the fastening of two layers of dough by the collars of a rotating roller is a process of constant compression of these layers along the vertical axis. As a physical model of the bonding process of dough layers, a scheme of gradual compression of the elastic-viscous mass by a vertically descending wedge can be adopted. The strengthening of compression during the bonding of the dough layers is spent on overcoming the forces of inertia and the end resistance of the wedge.

References

1. Ауэрман Л.Я. Технология хлебопекарного производства. /Под ред. Л.И. Пучковой. – СПб: Профессия, 2003. – 416 с. ISBN 5-93913-032-1.
2. Андреев А.Н. Применение реологии в разработке ресурсосберегающей технологии и оборудование для производства хлебобулочных и мучных кондитерских изделий // Научный журнал НИУ ИТМО. Серия «Процессы и аппараты пищевых производств». 2010. №1.
3. Kumar R., Kuluor N.R. In: Advances in Chemical Engineering. Ed. By T.B.Drew, G.R.Corelet, I.W.Hoopers, T.Verneulon. V.8. – New York – London: Acad. Press, 1970. – P.265-369.