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XVIII
MODELING OF SOME PROCESSES OF FILLING OF MINCE WITH ONE TYPE OF SPIRAL FEEDING MECHANISM

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Summary: Created a three-dimensional model of power mechanism for submission of mince filling sausage using vacuum filling machine. Using a simulated model are ongoing at the time of product processes. The analysis of the simulation process makes it possible to study the process in depth. Based on the results can be made for establishing the optimal geometric characteristics and modes of supply mechanisms of this type.

Keywords: modeling, simulation, mince filling, vacuum filling machine.

1. INTRODUCTION

The feeding mechanisms of the vacuum-filling machines are used in the meat processing industry for forced transportation and precise dosing of the filling mass to the pushing out mechanism of the technological equipment for realizing the filling process in the producing of sausage products from chopped meat. The quality characteristics of the prepared sausages depend on the technological operations, related to the preparation of the filling mass (grinding, mixturing, etc.) as well as the filling process in sausage cover. This forces more detailed and profound study upon the work of the vacuum-filling machines as whole and the mechanisms, which construct them (feeding, pushing out, clasping, etc.).

The presence of stirring and the excessive increasing of the pressure upon the filling mass in the feeding hopper leads to sharply worsening of the work of the feeding mechanisms from technological point of view [4]. The reason for this is the pushing in air in different quantities in the filling mass. This influences on the oxidation-deoxidization potential of the medium, and as well upon the increasing of the velocity of the enzyme, chemical and oxidation-deoxidization reactions. The consequences from the complex influence of these factors have physical character and to exert considerable influence on the transfer of filling mass in the time of further technological processing, or to have chemical character, which are the color making and aroma making.

There are different constructive solutions for feeding mechanisms (with feeding spiral, with feeding screw, etc.)[4,6,7], which are used in meat processing and have different indicators in relation to productivity, technology in their producing and mostly in relation to the achieved indicators for quality of the produced meat products.

The optimization of these mechanisms is related to study of the processes, passing in them in different regimes of work and their influence upon the quality characteristics of the sausage production.

The purpose of the present work is to be simulated the processes in the feeding mechanism with feeding spiral and to be defined numerically the change of the velocity and the pressure in different kinematical parameters of operating the feeding mechanism.

2. COMPUTER MODEL

For the needs of the carried out research of the bearing of the product in different regimes of work of the feeding mechanism it is developed its three-dimensional computer model. Section of the model is shown on fig.1. In this model are included its basic elements – hopper, taking the product, spiral which moves it to the formed in the
bottom cylindrical opening and opposite spiral. The aim is to assist the right orientation of the filling mass and improving the process of its moving.

As in the physical model, also in the computer model the opposite spiral can be disposed in the hopper on different positions, described on fig.2.

![Figure 1: Section of the three dimensional model of the feeding mechanism](image1)

![Figure 2: Positions of the opposite spiral in the feeding hopper](image2)

In [3] there are formulated criterions and restrictive conditions for improving the construction of developed feeding mechanism for vacuum-filling machines. It is examined the mutual location of the single elements and it is established their optimal position for maximal productivity point of view.

The computer model is developed in graphic medium of the Solid Works system. For the need of the optimization of the regimes it is simulated also the movement of the working organs of the system in medium of Solid Works Motion. This gives the opportunity to be visualized the laws of moving of the spiral. It is made strength analysis of the spiral in Solid Works Simulation medium, which gives the opportunity to be determined its optimal geometric characteristics. The results from this analysis of the strength characteristics of the elements of the feeding mechanism on the method of end elements and determination of the safety coefficient are shown in [2].

### 3. COMPUTER SIMULATIONS

For study of the processes passing in the feeding mechanism at the time of its work, there are made computer simulations in medium of the program system Flow Vision. For the purposes of the simulations it is used the method of the end elements.

The given model describes the flowing of viscose fluid on small numbers of Max (M < 0.3), small and big (turbulent) numbers of Reynolds. In this model are included the equations of Navie-Stoks and the energy.

The model of turbulent incompressive fluid is based on the using turbulent viscosity $\mu_t$. The determination of $\mu_t$ depends on the chosen model of turbulency.

In the model are present the following equations:

1. Equation of Navie-Stoks

$$\frac{\partial V}{\partial t} + \nabla (V \otimes V) = - \frac{\nabla P}{\rho} + \frac{1}{\rho} \nabla \left( \mu + \mu_t \right) \left( \nabla V + \left( \nabla V \right)^T \right) + S$$

(1)

$$\nabla V = 0$$

(2)

where the source $S$ is equal to:

$$S = \left( 1 - \frac{\rho_{tot}}{\rho} \right) g + B + \frac{\rho}{\rho}$$

(3)

At rotating co-ordinate system, the force of rotating (Koriolis’s and centrifugal) looks like:

$$B = -2\omega \times V - \omega \times \omega \times r$$

(4)

The equation for the energy is:

$$\frac{\partial h}{\partial t} + \nabla (V h) = \frac{1}{\rho} \left( \frac{\lambda}{C_v} + \frac{\mu_t}{Pr} \right) h + \frac{\rho}{\rho}$$

(5)

For the creating of the model it is used 3D (three-dimensional) net of end elements. There are used cubic end elements.

The border conditions, for which the mathematical problem is solved are: hydraulically rough wall of all end elements.
4. RESULTS AND DISCUSSION

The object of this study is feeding mechanism with geometric and force characteristics, shown in [5]. There are carried out simulated studies of the processes, passing in the feeding mechanism on its independent work. This means that there are not included the other modules of the system for filling the sausages with filling mass.

For the purposes of the simulative studies it is used filling mass with the following indexes, shown in Table 1:

<table>
<thead>
<tr>
<th>Kind of sausage</th>
<th>Density, ρ, kg/m³</th>
<th>Viscosity, µ, Pa.s</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Teleshki”</td>
<td>990</td>
<td>60</td>
</tr>
<tr>
<td>“Kamchija”</td>
<td>998</td>
<td>130</td>
</tr>
<tr>
<td>“Veslec”</td>
<td>1005</td>
<td>310</td>
</tr>
<tr>
<td>“Servilat”</td>
<td>1010</td>
<td>410</td>
</tr>
<tr>
<td>“Ambarica”</td>
<td>1022</td>
<td>420</td>
</tr>
<tr>
<td>“Panagjurska lukanka”</td>
<td>1026</td>
<td>440</td>
</tr>
</tbody>
</table>

There are studied the following indexes of the work regime of the feeding mechanism:
1. Distribution of the velocity vectors on the longitudinal section of the feeding mechanism. The velocity vectors are determined for three frequencies of rotating of the spiral – 10 min⁻¹, 60 min⁻¹ and 120 min⁻¹.
2. Distribution of the pressure in the longitudinal central section of the hopper of the feeding mechanism at frequency of rotating of the spiral – 0 min⁻¹, 60 min⁻¹ and 120 min⁻¹.
3. Velocity profile of the stream of filling mass on the exit of the feeding mechanism at frequency of rotating of the spiral – 10 min⁻¹, 60 min⁻¹ and 120 min⁻¹.

There are represented the following graphic results from the simulation research:
Fig. 3 and 4 – Distribution of the velocity vectors of the stream at frequency of rotating of the spiral at 10 and 120 min⁻¹.
Fig. 5 and 6 – Distribution of pressure of the filling mass on the longitudinal section of the hopper of the feeding mechanism at 10 and 120 min⁻¹.
Fig. 7 and 8 – Velocity profile of the outgoing stream at frequency of rotating of the spiral at 10 and 120 min⁻¹.
Fig. 9 and 10 – The variation of the pressure on the cylindrical part at frequency of rotating of the spiral 10 and 120 min⁻¹, at maximum value of the pressure scale 1000 Pa.
Fig. 11 and 12 – Diagram of the variation of the velocity on the cylindrical part at frequency of rotating of the spiral 10 and 120 min⁻¹, at maximum value of the velocity scale 0.1 m/s.
Fig. 13 and 14 – The variation of the pressure on extension of the hopper at frequency of rotating the spiral 10 and 120 min⁻¹, at maximum value of the scale of the pressure 1000 Pa.
Figure 5: Pressure of the filling mass on the longitudinal section of the hopper of the feeding mechanism at 10 min⁻¹.

Figure 6: Pressure of the filling mass on the longitudinal section of the hopper of the feeding mechanism at 120 min⁻¹.

Figure 7: Velocity profile of the outgoing stream at frequency of rotating of the spiral 10 min⁻¹.

Figure 8: Velocity profile of the product at the exit of the feeding mechanism at frequency of rotating 120 min⁻¹.

Figure 9: Diagram of the variation of the pressure on the cylindrical part at frequency of rotating of the spiral 10 min⁻¹.

Figure 10: Diagram of the variation of the pressure on the cylindrical part at frequency of rotating of the spiral 120 min⁻¹.
5. CONCLUSION

1. At frequency of rotating of the spiral 120 min⁻¹ in the hopper arises considerable fall of the pressure and the velocity of moving of the filling mass. They are provoked from the passing of the spiral by the stopping the flow of moving static opposite spiral, disposed at the center of the hopper.
2. The biggest variations of the pressure are noticed at the places, where the windage between the spiral and the walls of the hopper is smallest.
3. With the increasing of the frequency of rotating of the spiral it grows up also the zone with increased pressure around it. More over a part of the opposite spiral, found out near the exit of the hopper (on the figure it is at right), arise undesired falls of the pressures at the exit section – the cylindrical part of the hopper.
4. With increasing of the frequency of rotating of the spiral 12 times (from 10 min⁻¹ to 120 min⁻¹) the velocity of the filling mass – the product at the exit grows up 6 times.
REFERENCES