PURPOSE AND OBJECTIVES OF THE STUDY

The aim of this work is to increase the efficiency of the preparation of high protein concentrated feeds by developing a rational press - extruder and substantiating its design conditions.

Research Objectives:
1. To conduct an analysis of technologies and technical means for pressing and granulation;
2. Conduct theoretical studies of the preparation of concentrated feed;
3. Experimentally confirm the theoretical aspects of the process of pressing granulated feed;
4. To give an economic assessment of the decisions made and to develop a methodology for calculating the main structural - operational parameters of the press extruder.
Technological scheme for the preparation of feed based on insoluble soybean residue

Preparation of feed based on insoluble soy residue

Drying

Extrusion mixing

Mixing

Issuing
Press - extruder for the preparation of feed

- a - extruder press; b - four feather knife; c – knife.
- 1 - housing in the form of a hollow surface; 2 - inner surface with profiled guides; 3 - auger with variable pitch; 4 - four feather knife; 5 - molding cone; 6 - annular gap; 7 - regulating washer; 8 - knife; 9 - hopper - feeder.
Screw surface selection

The surface of rotation for the considered screw surfaces has the form

\[ X = u \cos \varphi; \quad Y = u \sin \varphi; \quad Z = d \]
\[ (R_2 \geq u \geq R_1) \]

Where, \( d = \delta/2 \) for the upper surface \( P_1 \);
\( d = -\delta/2 \) for the lower surface of \( P_2 \).
Selection of screw surfaces in terms of manufacturability of their manufacture

The rotation surface for L1 is

\[ X_1 = u \cos \varphi; \quad Y_1 = u \sin \varphi; \quad Z_1 = (R_2 - u)\tan \alpha; \]

For L2

\[ X_2 = u \cos \varphi; \quad Y_2 = u \sin \varphi; \quad Z_2 = -(R_2 - u)\tan \alpha; \]

The helical surface P1 is described by the equations

\[ X_1 = u \cos \varphi; \quad Y_1 = u \sin \varphi; \quad Z_1 = (R_2 - u)\tan \alpha + c(\varphi)\varphi; \]

The helical surface P2 is described by the equations

\[ X_2 = u \cos \varphi; \quad Y_2 = u \sin \varphi; \quad Z_2 = -(R_2 - u)\tan \alpha + c(\varphi)\varphi; \]
Theoretical foundations for calculating screw presses

\[ Q = m \cdot n \cdot S_{non} \cdot s \]  

The number of calls of the screw;

\[ Q = \pi \cdot m \cdot (R_2^2 - R_1^2) \cdot (s - \frac{\Delta b}{\cos \alpha}) \cdot n \cdot \frac{\rho 60}{1000} \]  

\[ \rho = \frac{(D^2 - d_i^2)}{(D^2 - d_i^2)} \cdot \int_0^l \frac{M}{t} \cdot dt \]  

\[ V = s \cdot (z - 1) + \sum_{i=1}^z \Delta b \cdot \int_0 S_{non} dt \]  

Performance for screw press with variable pitch and shaft diameter

\[ Q = 0.188 \cdot m \cdot \omega \cdot \int_0^l (R_{2i}^2 - R_{1i}^2) \cdot (s - \frac{\Delta b}{\cos \alpha}) \cdot \gamma \frac{M_i}{s_i(z-1)+\sum_{i=1}^{M_i} \Delta b_i S_{non i} dt} \cdot \beta \cdot k_n \]  

\( \omega \) - angular speed, c⁻¹;

\( R_{2i} \) и \( R_{1i} \) - outer and inner radius of the screw in the i section, м;

\( \rho \) - density (bulk density) of OKM, кг / м³;

\( D \) - is the outer diameter of the screw, м;

\( d_i \) и \( d_i \) - Internal diameter of the screw at the initial and final moment of passage OKM, м;

\( S_{non} \) - rotational speed, рад/мин;

\( m \) - number of entries;

\( M \) - mass of extruded material, кг;

\( n \) - screw pitch, м.

\( \gamma \) - the pressing factor, which characterizes the ratio of the final and the original density of the OKM, or the ratio of the original volume to the final volume when the OKM passes the entire length of the press chamber.
Determination of power on the press extruder drive

The OKM cross-sectional area at level Z is equal to the area of a circle of radius R2 minus the area of two curved sectors B1OA1 and B2OA2,

\[ s = \pi R_2^2 S_{B_1OA_1} - S_{B_2OA_2} \]  \hspace{1cm} (6)

determined the density of OKM

\[ \rho = \rho_0 \frac{1}{e^{-b\varphi}(1 - b_k\varphi)} \]  \hspace{1cm} (7)

friction force

\[ A = v \cdot dF_{mp} \]  \hspace{1cm} (8)

The required power on the motor shaft is determined by the formula

\[ N = \frac{v \cdot S \cdot \omega}{1000 \cdot 2 \cdot \pi \cdot \eta} \cdot \rho_0 \frac{1}{e^{-b\varphi}(1 - b_k\varphi)} \]  \hspace{1cm} (9)

\( \rho \) - OKM density, kg / m³; \quad \( A \) - the work spent on moving the material along the axis of the screw, Nm

\( S \) - Cross-sectional area of the material, m²; \quad \( \omega \) - angular velocity of the screw, s⁻¹;
Factors and levels of their variation

<table>
<thead>
<tr>
<th>Level</th>
<th>Factors</th>
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<th>The length of the extrusion chamber Lk, mm</th>
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<tbody>
<tr>
<td></td>
<td>• The angular velocity of the screw ( \omega ), s(^{-1} )</td>
<td>• Screw pitch s, mm</td>
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<td></td>
<td>• Coef. friction f</td>
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<tr>
<td>X(_1)</td>
<td>X(_2)</td>
<td>X(_3)</td>
<td>X(_4)</td>
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<td>Lower(-1)</td>
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<td></td>
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<td>900</td>
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</tbody>
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for OKM temperature:

\[
T = 50,142 - 0,672 \omega - 5,637s + 1,169f + 1,733 L_k - 0,058\omega s - 0,215\omega f - 0,024\omega L_k + 0,678s f + 0,065s L_k + 0,021L_k^2 + 0,187s^2 + 0,564f^2 - 0,019L_k^2
\]

For energy intensity:

\[
N = 31,823 - 0,399\omega - 1,057s - 7,627f - 0,551L_k + 0,049\omega f + 0,003\omega L_k + 0,062f L_k + 0,05\omega^2 + 0,225f^2
\]
1. The analysis of research materials from foreign and domestic literary sources shows that the use of soy protein in animal feed diets is a promising direction. However, despite this, at present, the mechanization of the concentrated feed preparation process using soy protein has not been resolved. All this leads to a large expenditure of labor, energy, a decrease in the nutritional value of feed and, as a result, a decrease in the productivity of animals.

2. Theoretical studies of the technological process of the press-extruder for the preparation of final feeds using soy protein made it possible to justify the structurally-operational parameters: the energy intensity of the process is 0.048 ... 0.05 kW / kg, productivity 230 ... 250 kg / h, screw pitch 0.04 ... 0.045 m.

3. The implementation of the proposed technology through a press extruder allows you to get an annual economic effect of 50,502 rubles at the present costs, the limit price is 284,944 rubles along with a 1.6-fold reduction in energy costs.