

Influence of friction force in the port of screw of granulator upon variation of temperature of grained product

Investigate the effect of the frictional forces on the temperature change of the plasticized fodder mixture during its movement along the channel of the propeller granulator. Methods. Continuous media mechanics, thermodynamics and integral calculations. Results The dissipation of mechanical energy for the work of screw feed granulator with variable geometric parameters of the propeller is considered. Conclusions As a result of theoretical studies of the process of the movement of plasticized feed in the channel of the propeller of the feed granulator, an expression was obtained of the change in its temperature due to the work of frictional forces on the material of the working organs of the granulator.

Key words: granulator, dissipation, fodder mix, plasticization, friction.

Heat treatment of fodder products contributes to increasing their nutritional value, decontaminating and destroying molds, reducing the concentration of nitrates [4]. At the same time, it has long been determined [1] that the optimum temperature of heating the feed is 70 - 80 ° C, since due to prolonged exposure to temperatures above 82 ° C, there are irreversible changes [3], which impair the quality of the protein and result in a further decrease in the effectiveness of the action of digestive enzymes in animals. Analysis of recent research and publications. Significant development of the theory of material processing in screw devices has been obtained in works devoted to the development of processing technologies for food products [15], polymer materials [5] and metals [12]. Sufficiently studied the issues of optimizing the movement of material in screw working bodies [7]. The solution of the problems of high viscosity media and compositions in technological equipment channels is closely related to the problems of energy dissipation [8]. Our earlier theoretical studies have made it possible to determine the influence of the structural and technological parameters of the working bodies of propeller feed granulators and feed material properties on the change in the temperature of the plasticized feed mixture due to the work of viscosity forces. It is obvious that the increase in the internal temperature of the fodder mixture will occur not only due to the work of the viscosity forces. One of the main causes of dissipation of energy in the movement of material in the channel of the propeller granulator is also the work of friction feed on the materials of the working bodies - a screw and a working chamber. This work is devoted to the study of the effect of the friction forces on the temperature change of the plasticized feed at its flow along the channel of the propeller granulator. Moreover, the general version of the structural execution of the screw, in which the geometric parameters of its channel (depth and width), linearly vary depending on the length of the screw is considered.

Fig. 1. Scheme of motion of the material element in the channel of the propeller granulator with variable parameters of the screw: p - pressure in the screw channel, Pa; P_0 - initial pressure in the channel of the propeller (atmospheric for bunkering feedstock), Pa; H_t is the pressure created by the matrix of the granulator, Pa; Q - lateral pressure, Pa

Fig. 2. Scheme for determining the lifting angle of the screw channel base

The purpose of the research is to investigate the influence of the working process parameters on the temperature change of granulated feed material. Materials and methods of research. For conducting theoretical studies, methods of continuum mechanics, kinematics, thermodynamics, differential and integral calculations were used. The following assumptions are made in this paper: plasticized feed mixing in the process of movement along the screw channel is isotropic; The channel of the screw of a rectangular cross section is considered as a scan on the screw line formed by rotation of its center of mass. Research results. In accordance with the theorem of kinetic energy [6], the change of the latter equals the work of external forces, and in this case the work of frictional forces: where ΔE_k is the change in kinetic energy, J; A_{TR} - work of

friction forces, J ; F_{tr} - friction force, N; l_8 is the length of the scan (on the screw line) of the screw channel of the granulator, m. According to the first start of thermodynamics [11], the decrease in the internal energy of the mass of the constant volume is equal to the amount of heat allocated and is proportional to the change in the temperature of the mass, that is: where AQ is the amount of heat, J; S_u - specific heat capacity of feed mix, J / (kg-K); P - density of feed mix, kg / m³; V - volume, which occupies fodder mixture in the channel of the propeller granulator, m³; ΔT is the change in the temperature of the feed mix, K, from which it can be written: As stated in [2], the widest use among screw machines was found in machines with a rectangular and trapezoidal section of the screw. To determine the friction strength of the feed mixture on the surfaces of the working bodies, consider the flow of the feed element in the rectangular channel of the propeller granule shown in the diagram (Fig. 1), with the depth and width of the screw channel varying linearly depending on its length. In turn, on the basis of Fig. 1 expression of frictional material on the walls of the channel of the propeller granulator and the surface of the working chamber can be written as: Fig. 1. Scheme of motion of the material element in the channel of the propeller granulator with variable parameters of the screw: p - pressure in the screw channel, Pa; P_0 - initial pressure in the channel of the propeller (atmospheric for bunkering feedstock), Pa; H_t is the pressure created by the matrix of the granulator, Pa; Q is the lateral pressure, Pa; λ , λ' - the coefficients of friction of the feed mixture, respectively, on the material of the working chamber and the screw of the granulator; P - the coefficient of lateral pressure; W_0 - initial value of the channel width of the screw, m; H_0 - initial value of the depth of the channel of the screw, m; $K_{N\omega}$ - coefficient of change of width of a channel along the length of a screw; K_n - coefficient of channel depth change along the length of the screw; Δn - the length of the screw, m; N - the angle of lifting the basis of the screw channel, rad. (Fig. 2); Δn - the angle of narrowing the walls of the channel of the screw, rad. (Fig. 3). From the analysis of the function of the screw line formed by rotating the center of mass of the intersection of the screw channel around its axis, it is possible to write the relation between the length of the screw and the corresponding length of the screw line:

Where D - outer diameter of the screw, m; T - width of the wall of the screw, m. Analyzing Fig. 2 and 3, we will write: To determine the pressure in the channel of the screw, we use the dependence proposed [8]: where X - coefficient, taking into account the influence of the structural-mode parameters of the granulator

Fig. 2. Scheme for determining the lifting angle of the screw channel base

Fig. 3. Scheme for determining the angle of narrowing the walls of the screw channel to change the pressure in the screw channel. Given the dependencies (5 - 7), the expression (4) will look like:

Fig. 4. Influence of the diameter and length of the screw on the value of the friction force on the surfaces of the working bodies of the granulator used by us in the future for carrying out experimental studies (for example, with the parameters: $k_n = 0,0375$; $k_{\omega} = 0,0488$; $H = 0,01212$ m; $\Delta n = 0,01678$ m; $t = 0,005$ m; $D = 0,08$ m), it can be argued that neglecting the component of (5) $1 / p^2$ leads to a slight change in the value of the parameter a . Thus, for the given geometric parameters of the screw, the value of the parameter a , excluding the component $1 / p^2$, will change by 0.517% ($a = 9.84098$ and $a = 9.79004$ respectively). Consequently, taking into account assumptions, the expression (8) will look like:

So, given the accepted assumptions expression (8) becomes: integrating expression (9) given that at $1 = 0 = 0$ F_{mr} gives expression to record desired friction force: $2l | Lr_0 |$ Calculate the value of expression (8) can be numerically. To find the natural solution of this integral, it is necessary to assume some assumptions. Yes, because material for the manufacture of a rotor and working chamber granulator is preferably steel, suppose that $\lambda = \lambda' = H$ Since the coefficients k and Prince Ratios and (5) have values less than two orders for squares ratios (5) for the "typical" (by definition [10]) screws, in particular for screws, where E_i - Integral indicative function of the form $x e^*$ The character of the obtained dependence (10) is given in Fig. 4. According to some researchers [14, 15, 16], specific heat of feed and food can be determined by dependencies: $s_u = 1,424tu + +$ The $1,549tp$ in paragraph (11) $1,675tzh + + + 4,187t 0,837tz^{\Delta}$ Oh, where - the mass fraction of carbohydrates in the feed mixture; T_p is the mass fraction of protein in the feed mixture; T_j - mass fraction of fat in the ferrose-mashi; T_z - mass fraction of ash in the feed mixture; \bullet mass fraction of water in the feed mix. The coefficients before the dependence members (11) are the values of the specific heat of the corresponding components. The total volume occupied channel Forage mixture screw presses, determined by the formula: $V = P | (H - CED) (W_0 - kdai) x$ (12) Thus, we have received all the components of the expression (3) enabling Determine the temperature change of the granulated feed mixture due to the work of the frictional forces in the channel of the screw of the granulator.

Conclusions

As a result of theoretical studies of the flow of plasticized feed in the channel of the screw feed granulator, an expression was obtained of the change in its temperature due to the work of the friction forces of the feed mixture on the material of the working organs of the granulator. A number of assumptions made in the process of work testifies to the need for empirical confirmation of the results of research.

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