ABOUT CRITICAL SPEED OF VERTICAL SCREW DOSING BULK MATERIALS

Yurieva K. S.
Scientific supervisor: assoc. prof. Shapovalov A. V.
National University of Pharmacy, Kharkiv, Ukraine
Strange.ru13@gmail.com

Introduction. Automation of production processes in the chemical, food, pharmaceutical and other industries often depends on automation of process of dosing bulk materials. The solution to this problem has great importance from the point of view of increasing productivity and improving the quality of the finished product. Classification of metering systems to constructive signs is the most extensive. It can be conditionally divided into three directions: dosing with a screw, dosing by vibration and of chamber dosing. Dosing with a screw (volumetric and gravitational) provides high accuracy and is well established when working with hard-flowing materials. The dose is measured directly from the hopper. This eliminates the operation of filling the measuring cups and stabilization of dose in technological cycles. Vibration dosing has advantages, namely the constructive simplicity and ease of adjusting the amplitude of the oscillations. But it is characterized by low productivity and the transfer of dynamic loads to the structural elements of the structure. Chamber dosing is characterized by the complexity of the design. And also additional time spent on filling the measuring cups and stabilizing the dose. Practice of operation of all these systems shows that the most suitable for dosing non-free-flowing materials are the screw-type dispensers. Namely, vertical dispensers, which moves the material down. The undeniable advantages of such dispensers are the lack of arching, the possibility of accurate dosing through small openings and simplicity of design. However, these screws, which transport the material down, have not yet found wide application in industry. Therefore, the methods for their theoretical calculation are not sufficiently developed.

Aim. One of the characteristics of efficiency of the vertical screw is the minimum necessary (critical) frequency of rotation, which ensures the transportation of the material down.

Materials and methods. The article considers an isolated particle material, which is located on the surface of the screw. On the particle acts the centrifugal force of inertia due to rotation of the screw. It throws it away from the axis of rotation. The particle motion in the radial direction is limited by the wall of the casing. Therefore, the centrifugal force presses it to the wall, from which the reaction will act on it. It is equal to the force of inertia. On a particle are also the force of gravity, the reaction surface of the screw and the friction force of the particles on the screw. The rotation of the particles along with the screw prevents friction force on the wall of the casing, which is caused by centrifugal force. The total effect of these forces under certain conditions, leads to slippage of particles along a helical surface down. It is assumed that the direction of relative sliding of the particles opposite the direction of rotation of the screw. The efficiency of the screw is provided with $n>n_{cr}$ (frequency of rotation of the screw is greater than the critical). Received power in accordance with the principle of d'Alembert form a balanced system is converging. From conditions of equilibrium of such system it is possible to obtain the minimum necessary (critical) frequency of screw rotation required to transport the material down:

$$n_{cr} = \frac{30}{\pi}\sqrt{\frac{g \cdot tg(\varphi - \alpha)}{f_c \cdot R}}\,, \qquad (1)$$

where is g – acceleration of gravity; f_c – the coefficient of friction of the material against the wall of the casing; R – the outer radius of the screw; $\varphi = arctg\, f_s$; f_s – the coefficient of friction of the material on the helical surface of the screw; α – the angle of the helix of the screw.

Results and discussion. From equation (1) follows that the critical frequency necessary for movement of cargo down increases with reducing the radius of the screw and reducing the coefficient of friction of the material against the wall of the casing. The critical frequency decreases if decreases the coefficient of friction between the transported goods and the surface of the screw. Or if the coefficient of friction between the material on the screw and the surface of the wall of the housing increases. The radius of the screw cannot be changed significantly. Therefore, to improve the efficiency of transport of material down it is necessary or reduce friction between the material and the wall of the casing, or increase the friction between the material and the surface of the screw. Formula (1) is true for elementary particles, located at a maximum distance from the center of rotation, that is at a distance R. In real conditions on the surface of the screw at the same time there is a significant number of particles, part of which is located closer to the center of the screw, that is their radius is smaller than the R. In addition, since they do not touch the wall of the housing of their braking force less than that of the particles, pressed to the wall. These circumstances take into account using correction factors, which for most of the screws, which transport the material up, summarized in tables and graphs. However, for vertical screw these factors are unknown. They must be determined from experimental studies.

Conclusions. Obtained calculation formula for calculating the minimum necessary (critical) frequency of rotation of the vertical auger providing the transportation of the material down. Prospective approach allows to dispense with the compilation and integration of the system of nonlinear differential equations of the relative motion of the particles of the material in the screw.