ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Creating A Methodology For Calculating The Drive Of The Working Parts Of The Equipment Based On The Original Screw Sieves, Screw Housings And Screw Drums.

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ABSTRACT

The article shows that when calculating the drive of the working parts of the equipment for processing bulk materials on the basis of original screw sieves, screw housings and screw drums, it is necessary not only to take into account the mass particles of the bulk materials located by the doctor's body asymmetrically to its axis of rotation and screw drums. Summing up the power of the electric motor, spent on the rotation of the working body with a symmetrical loading and an asymmetrically mounted working body, we can calculate the power of the electric motor drive. Shown is an example of calculating the drive of a working body of equipment for processing bulk materials mounted in the form of a screw sieve, a screw drum or a screw case, provided with directionally facing each other with broken screw surfaces and screw lines.
Keywords: particles of feed components, building materials, screw housing, screw drum, screw sieve, asymmetrical loading, drive calculation.

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INTRODUCTION

In the production of building materials (expanded clay, gravel, paint, cement, concrete and mortar, gypsum), as well as feed preparation, technologies and equipment are used in which drums, bodies and sieves of cylindrical shape are used as working bodies, which are inclined in the direction of discharge, which ensures building materials. The consequence of this are: significant energy consumption due to large size, losses in the process of heat exchange and the implementation of the technological process, limited technological capabilities, complexity of operation and large mass of equipment. The elimination of these shortcomings can be the development and implementation of technologies and equipment in which the original structures of screw housings, screw drums and screw sieves with a horizontal axis of rotation will be used as working bodies, which will reduce energy consumption, improve technical and economic indicators [1, 2 , 3]. For example, in the technology of production of cement, the calcination of the particles of the raw mix, used rotary kiln, the product, which are granules of cement clinker. In industry, widely used rotary kilns with cylindrical body, which rotates slowly (0.4–1.2 rpm). In the process of preparation of cement clinker, using rotary kilns, there is a feature of transportation of raw material mixture, which is carried out by creating a slope of the body from loading to unloading. The consequence of this are: large dimensions (4.5 m×170 m; 5 m×185 m; 5.6 m×185 m), considerable energy loss in the heat exchange process, limit of technological opportunities and exploitation of a large mass. A similar situation is typical for other technologies for the production of building materials, such as furnaces for the production of expanded clay, screens for the production of gravel and plants for the separation of fractions of building materials, devices for the preparation of concrete, mills, equipment for the preparation of paint, installations for the preparation of solutions, rotating boilers for the cooking of gypsum, as well as plants for the preparation of feed [4-8].

Disadvantages in such technologies can be eliminated by using energy-saving technologies with the use of equipment, which will be used as the working bodies of the original design of screw housings, screw drums and screw sieves with a horizontal axis of their rotation, which will provide a horizontal arrangement of the equipment, and thus reduce energy consumption, reduce the size of the equipment and weight, simplify maintenance, will increase the speed of rotation of the working bodies, reduce the load of the device, driving the working bodies, reduce the power of the drive. Screw surfaces and screw grooves located in the working bodies in the form of screw housings, screw drums and screw sieves, contribute to the movement and increase the intensity of interaction of particles of bulk materials with each other and with the screw surface of the working body.

Currently the imperfection is due to an insufficient research of methods of calculation of the drive of the working bodies of the equipment for handling bulk materials on the basis of original designs of screw sieves, helical screw housings and reels, difficulties arise when designing such equipment, therefore, the creation of methods of calculation of the drive of the working bodies of the equipment for handling bulk materials on the basis of original designs of screw sieves, helical screw housings and drums are task relevant and timely.

MATERIAL AND METHODS

Figure 1 shows the scheme of the installation for the separation into fractions of bulk materials with a screw drum of octahedral elements. Over the hopper in the screw drum 4, holes 11 are made to output small fractions of materials into the hopper 10. To increase the speed of longitudinal movement of the loading masses (particles of bulk materials) inside the screw rotor 4, a tension spring 12 is fixed.

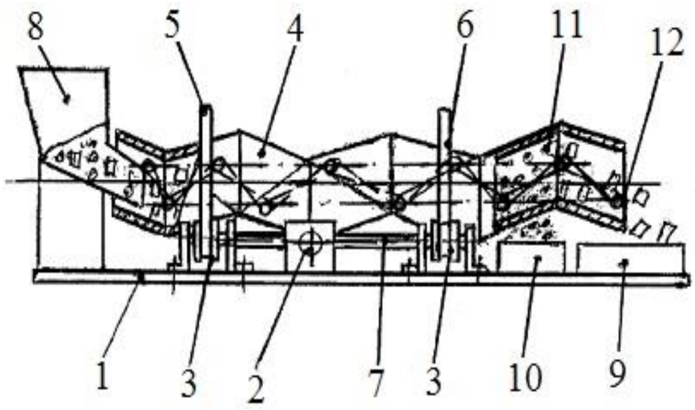

Figure 1: scheme of installation for separation into fractions of bulk materials on the basis of a screw drum mounted from octahedral elements:
1-frame; 2 - drive the main motion; 3-roller supports; 4-screw drum; 5 and 6-rim; 7-two shafts, which are fixed roller supports 3; 8 - means for loading; 9-hopper for receiving large fractions of bulk materials; 10-hopper for receiving small fractions of bulk materials; 11-holes for removing small fractions of bulk materials; 12-tension spring

The screw drum 4 (figure 2) is made of sections 1 mounted from six equilateral triangles 2 connected by their faces 3. As a result of the connection of the sections with each other, a multi-entry surface is formed along the perimeter of the screw drum with three right screw lines 4-5-6-7-8-9-10 of the main direction and three left screw lines 11-12-8-13-14-5-15 of the opposite direction, with a step equal to the main direction, which in figure 2 are shown by thickened lines. In such a helical drum, the area of the passage section along the length in one step of the helical lines changes twice in each section, for example from sections assembled from six triangles in the form of octahedrons from hexagon to triangle and again to hexagon (figure 2, sections A-A, B-B, C-C), which violates the stationarity of the movement of particles of bulk materials in the helical drum.

The helical lines on the outer surface of the screw drum have the same position designations with the corresponding grooves on the inner surface, with $d_{dr.}$ - diameter of the passage section of the screw drum, $D_{dr.}$ - the outer diameter of the outer perimeter of the screw drum.

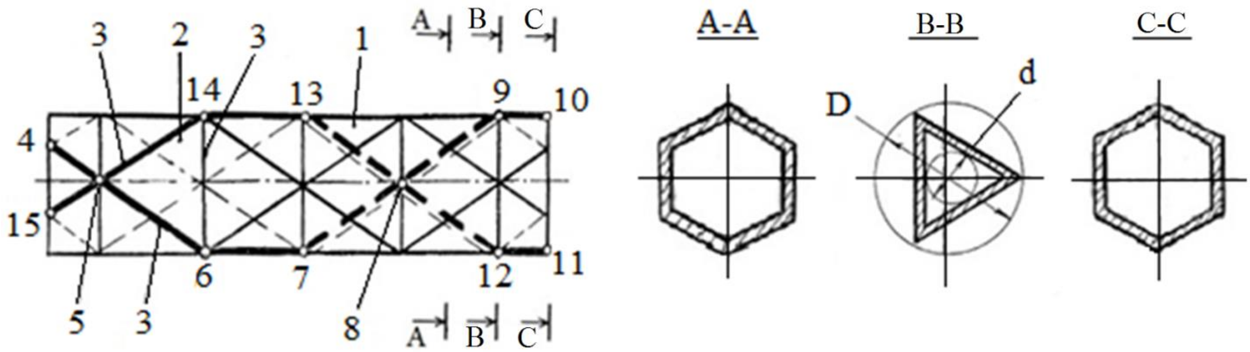

Figure 2: Working body of the installation for the separation into fractions of bulk materials on the basis of a screw drum mounted from octahedral elements, top view with the image of the cross sections A-A, B-B, C-C

Installation for the separation into fractions of bulk materials (Figure 1) works as follows. In the rotating screw drum 4, through the means for loading 8, particles of bulk materials are continuously loaded. During the rotation of the screw drum 4 particles of bulk materials make movement along the helical grooves inside the screw drum 4 with a large amplitude of movement. Large fractions of bulk materials are discharged into the bunker 9, and the small fraction through the holes 11 into the bunker 10. The amplitude of the movement of the particulate materials is determined not only by the bore diameter of the screw drum 4, but also by the frequency of rotation.

During the rotation of the screw drum 4 particles of bulk materials face up the inner screw surface and move in the direction of unloading. Under the action of gravitational forces, they move towards each other at certain, different angles and to the walls of the rotating screw drum 4. At the same time, each portion of the particles move in their direction vector towards the discharge direction, which greatly intensifies the process of their interaction with each other and with walls of the screw drum 4, increases productivity and expands technological capabilities. The speed of movement of particles of bulk materials can be regulated by a tension spring 12 installed inside the screw drum 4, which can ensure the reliability of the longitudinal movement of particles of bulk materials inside the screw drum 4 along its longitudinal axis, their separation into fractions, unloading. However, as experiments have shown, the mass of the load (particles of bulk materials) in practice are located asymmetrically to the axis of rotation of the screw drum, so there are difficulties in designing such original equipment and calculating the drive, as well as choosing the optimal power of the electric motor. We have developed a method for calculating the drive of working parts of equipment for processing bulk materials on the basis of original designs of screw sieves, screw housings and screw drums.

For example, it is set to ensure the separation into fractions of particles of bulk materials. We take the average proportion of bulk materials $j_{av.}$=1600 kg/m^3.

Suppose that the screw drum 4 consists of octahedrons, the number of which determines its length. Denoting the edge of the octahedron-a (figure 3), the apophem – S determine the volume of the octahedron, which can be calculated by the formula (1). For design reasons and given performance we take the octahedron side=0.4 m, then the volume of the screw rotor mounted from 9 octahedrons will be equal to:

$$V = 9 \cdot a^3 \cdot \sqrt{2}/3 = 0,576 \cdot 0,4714 \approx 0,272 \text{ m}^3 \qquad (1)$$

The number of octahedrons is determined by the required design and technological parameters of the process, namely the length of the L_{dr} screw drum. and its outer diameter is D_{dr}.

From the condition of filling the volume of the screw drum K_{dr}= 0,55, the mass of particles of bulk materials inside the screw drum can be determined by the dependence.

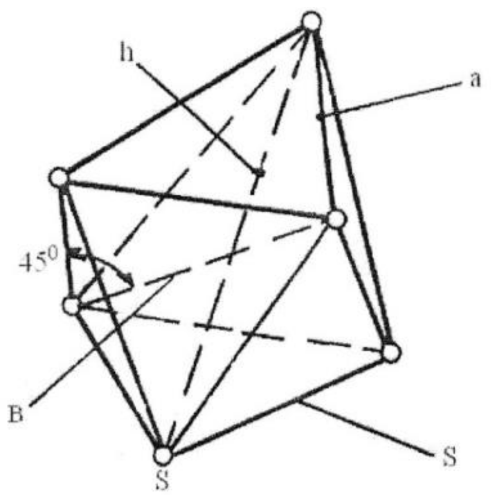

Figure 3: One of the octahedra, visual image

$$m_1 = 0\ 55 \cdot V \cdot \rho \qquad (2)$$

where: density ρ corresponds to the average specific gravity of bulk materials filling the helical drum. Then:

$$m_1 = 0,55 \cdot 0,272 \text{ m}^3 \cdot 1600 \text{ kg/m}^3 \approx 240 \text{ kg} \qquad (3)$$

The area around the perimeter of the screw drum, which includes 9 octahedra, with sides in the form of six equilateral triangles with a side of 0.4 m, i.e. 54 equilateral triangles. The area of one equilateral triangle is equal to $S_1 = a^2 \cdot \sqrt{3}/4 = (1{,}73/4) \cdot a^2 = 0{,}432 \cdot 0{,}16\ m^2 = 0.06912\ m^2$. Then the area of the entire side surface of the screw drum $S_{dr.}$ will be equal to: $S_{dr.} = 0{,}06912 \cdot 54 m^2 \approx 3{,}75\ m^2$. Taking from structural considerations the thickness of the walls of the screw drum is equal to 0.0003 m, we obtain that the volume of the metal from which the barrel of the screw drum is made is $3{,}75\ m^2 \cdot 0{,}003\ m = 0{,}01125\ m^3$ and then the mass of the screw drum is equal:

$$m_2 = 0{,}01125\ m^3 \cdot 1600\ kg/m^3 \approx 18\ kg \quad (4)$$

We have previously obtained a dependency $D_{dr.} = 1{,}16 \cdot a = 0{,}464$ m, this size corresponds to the inner diameter of the rims 5 and 6 (figure 1).The outer diameters of the rims of the design considerations taken equal to 500 mm When the thickness of the rim is equal to 0.015 m, the volume of one of the rim equal $0{,}001635\ m^3$, and the weight of one rim m_3 = 13 kg.

In this way:

1. The mass of particles of bulk materials inside the screw rotor – m_1 =240 kg;
2. Screw drum weight m_2= 18 kg;
3. The mass of two rims rigidly fixed on the outer diameter of the screw drum –$2m_3$ = 26 kg.

Therefore, under the condition of uniform distribution of particles of bulk materials inside the screw drum, the total mass m of the screw drum assembly will be equal to:

$$m = m_1 + m_2 + 2 \cdot m_3 = 284\ kg \quad (5)$$

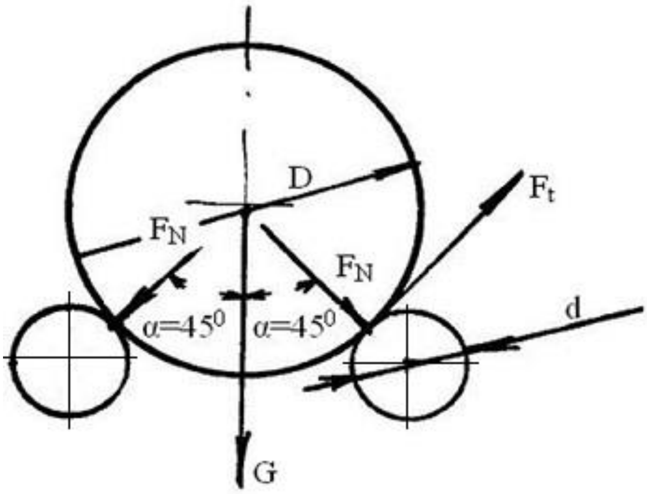

Figure 4: Diagram of the forces acting during the rotation of the screw drum

The pressing force of the screw drum to the support rollers, provided that the bulk materials in the non-particles are evenly distributed (Figure 4), can be determined:

$$F_N = \frac{K \cdot F_t}{f} = \frac{K \cdot T_1(i+1)}{f \cdot D};$$

$$F_N = G \cdot \cos\alpha \ ,(6)$$

where G = 284 · 9,81 ≈ 2786 H

F_N= 2786· cos45° ≈ 1464 H

From here we determine the torque on the shaft of the support rollers:

$$M = \frac{F_N \cdot f \cdot D}{K \cdot u} = \frac{1464 \cdot 0{,}21 \cdot 0{,}51}{1{,}3 \cdot 2.5} \approx \frac{157}{3.25} \approx 49 \text{ H} \bullet \text{ m} \qquad (7)$$

where f – friction coefficient, f = 0,21;

d – diameter of the leading skating rink, d= 0,2 m;
K – load factor, margin of cordon K = 1.25–1.5, take K = 1.3;
u –gear ratio from the screw drum to the support rollers u = 2,5.

At n_r = 70 rpm and taking into account that u = 2.5, the support rollers 3 (figure 1) should rotate at a speed of n = 175 rpm, then:

$$\omega = \frac{\pi \cdot n}{30} = \frac{3{,}14 \cdot 175}{30} = 18{,}3 \left(\frac{1}{c}\right) \qquad (8)$$

$\eta_t = \eta_1 \cdot \eta_2 \cdot \eta_3 = 0{,}63;$
$\eta_1 = \eta_3 = 0{,}9;$
$\eta_2 = 0{,}7.$

The transmission of torque M on the shaft of the rollers 3 involves the double rotation of the transmission and the gearbox, therefore taking into account the efficiency, with a symmetrical arrangement of the loading of particles of bulk materials, the power of the electric motor N, through which it is possible to rotate the support rollers 3 and a helical drum with a total mass m = 284 kg, can be determined using the dependencies:

$$N = \frac{M \cdot \omega}{\eta_t} = \frac{49 \cdot 18{,}3}{0{,}63} \approx 1424 \text{ W} \qquad (9)$$

In fact, the mass of loading particles of bulk materials is located in the screw drum asymmetrically relative to the axis of rotation. Therefore, it should be assumed that the calculated power of the electric motor for the operation of the installation will not be enough. To test this assumption, we consider a section of a screw drum with a plane perpendicular to the axis of rotation (Figure 5) with the designation of values used in the calculations, for example, ϕ is the angle of the free surface, α is half the angle of the free volume segment of the screw drum, m_1 – mass loading particles of bulk materials. The OS radius is denoted by "e" and its value is determined by the formula:

$$e = 0{,}424 \cdot (1 - K_v) \cdot D = 0{,}424 \cdot 0{,}45 \cdot 0{,}5 = 0{,}09 \text{ m} \qquad (10)$$

The moment created relative to the axis of rotation of the screw drum by asymmetrical loading of particles of bulk materials is determined by the dependence:

$$M_1 = x_e \cdot m_1 \cdot g = 0{,}055 \cdot 240 \cdot 9{,}81 \approx 130 \text{ H} \cdot \text{m}, \qquad (11)$$

where m_1 –mass of particles of bulk materials inside the screw drum;
x_e –projection of the segment of OS on the horizontal axis, determined by the dependence:

$$x_e = e \cdot \sin \phi = 0{,}095 \cdot 0{,}5736 = 0{,}055 \text{ m} \qquad (12)$$

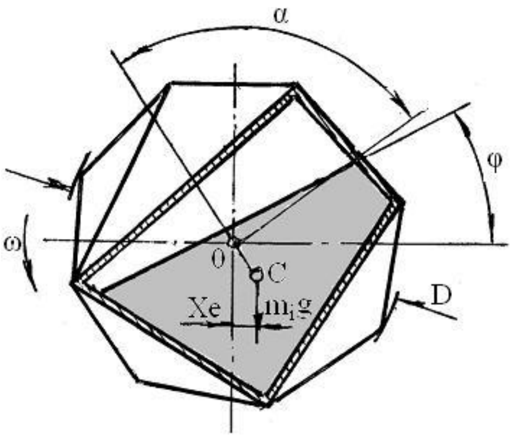

Figure 5: Scheme for the calculation of the installation for the separation into fractions of bulk materials

Knowing the moment M_1 generated by the loading of the screw drum, we determine the power of the electric motor necessary to overcome the moment created by the asymmetric loading of bulk materials about the axis of rotation of the screw drum:

$$N_1=\frac{M1\cdot\omega}{\eta_t}=\frac{130\cdot 18{,}3}{0{,}63}\approx 3777\ W \quad (13)$$

Thus, summing up the power of the electric motor to rotate the screw drum from the effects of symmetrical and asymmetrical loading, we obtain the value of the total power of the electric motor installation:

$$N_{tot.}=N + N_1= 1424 \ +3777\approx 5.25\ kW \quad (14)$$

Select the directory for the nearest electric motor in the series:

ADM112M4, N = 5.5 kW, n = 1500 rpm.

RESULTS AND DISCUSSION

1. As a result of the research conducted, a method for calculating the drive of the installation for fractionation of bulk materials with working bodies in the form of helical drums mounted from hollow octahedra has been proposed.

2. The technique has been tested when calculating equipment drives based on screw housings, screw drums and screw sieves not only for the construction industry, but also for calculating the drive when designing equipment for preparing feed.

CONCLUSION

To determine the total power of the electric motor and the working parts of the equipment based on the original designs of screw sieves, screw housings and screw drums, it is necessary to take into account in the calculations not only the effect of symmetrical, but also asymmetrical loading, including the moment created by asymmetric loading of loose particles.

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