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SCREW CONVEYOR FOR LOADING - UNLOADING SHIFTING CARGO

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In many studies devoted to loading, transportation and unloading processes of shifting cargo with screw conveyor the load is considered as a single material point that is transferred to the surface of the auger. The process of moving the cargo from the load box to the screw wings is not yet fully explored, although the processes taking place in that area have a significant impact on the operation of the screw conveyors.

Theoretical research has been done and it has been found that in order to increase the efficiency of loading activities of shifting cargo with screw conveyors, it is necessary to move the cargo from the load box to the maximum speed. Otherwise the material may be clogged in the coils in front of and behind the screw. As a result, a new structure of screw conveyor has been developed the application of which will reduce the energy costs of loading, transportation and unloading the shifting cargo.

Key words: cargo, shifting, auger, conveyor, screw, regime, mass.

Introduction

Numerous studies have been conducted by both CIC and other foreign authors on the processes of loading, transporting and unloading of shifting cargoes with screw conveyors. Among such researches are the works of L.M. Alexander, D.N. Bashkatov, A.M. Grigoryev, E.M. Gutyar, B.A. Katanov etc, in many of which the transported cargo is considered to be one material point which is transferred to the surface of the auger [1,2,3,4,5,6]. Such an approach can be considered justified only because the volume of transported shifting cargo is not widely studied although some work has been done in that direction. The process of moving the cargo from the load cell to the screw wings is not fully studied yet although the processes taking place in that area have a significant impact on the operation of the screw conveyors.

In case of unsuccessful structure of the load box of screw conveyor, the screw may not catch the load but throw it which undoubtedly affects the productivity and energy costs of the conveyor.Therefore, we can argue that the process of loading, transporting and unloading the cargo with screw conveyor requires further research.

It is not possible to accurately calculate the parameters and modes of operation of the auger with existing formulas and the required values are usually determined experimentally as the application of computational values leads to contradictory results for 20-60%.

At present when calculating the power required for the work of the auger, its productivity and other parameters, the speed of the auger is determined instead of the speed of the material transported by it. However, the velocity of the transported mass changes its size as the material interacts with the surface of the auger coils.

Conflict setting

While transporting shifting cargoes the peculiarity of vertical auger is the presence of some critical angular speed of screw in case of its low position the auger does not give motion to the material vertically.

The axial v_0 and perimetric v_c speeds of particles at the distane of R from auger axis will be equal to

$$v_0 = \frac{Sn}{60}\left(\cos^2\alpha - tg\varphi\cos\alpha\right), \tag{1}$$

$$v_c = \frac{Sn}{60}\left(\cos\alpha \sin\alpha + tg\varphi \cos^2\alpha\right), \qquad (2)$$

where S is auger step, n is the rolling number of shaft, φ is angle of the vector slope of absolute speed of the particles to the norm on the screw surface, α is the angle of rise of screw line.

To determine the slope angle of absolute speed to screw normal the differential equation system of the movement of the point in the screw surface edge is used. For cylinder coordinate system Dalamber equation is written as follows:

$$\left.\begin{aligned} & M\left[\frac{d^2R}{dt^2} - R\left(\frac{d\varepsilon}{dt}\right)^2\right] = -N_2, \\ & M\frac{1}{R}\frac{d}{dt}\left(R^2\varepsilon\right) = F_1\cos\alpha + N_1\sin\alpha + F_2\sin(\alpha+\varphi), \\ & M = \frac{d^2Z}{dt^2} = N_1\cos\alpha - G - F_1\sin\alpha - F_2\cos(\alpha+\varphi): \end{aligned}\right\} \qquad (3)$$

M is the forces on load particles (Fig.1), normal reaction of auger screw is N_1 which with OZ axis forms α angle, normal reaction of auger cover is N_2 which is directed to the radius, $F_1 = N_1 f$ is contact force of the particles with screw surface where f is the contact coefficient of contact forces of particles with screw surface. F_1 contact force is directed against the rolling of the screw over screw surface. $F_2 = N_2 f_1$ where f_1 is the coefficient of the particles with auger cover.

Solution of (3) equation system after installing the reactions of forces and relations in it can be presented as follows:

$$\frac{S^2n^2}{gR60^2}\left(f_1 f\cos\varphi - f_1\sin\varphi\right)\cos^2\alpha\left(\sin\alpha + tg\varphi\cos\alpha\right)^2 = -\sin\alpha - f\cos\alpha \qquad (4)$$

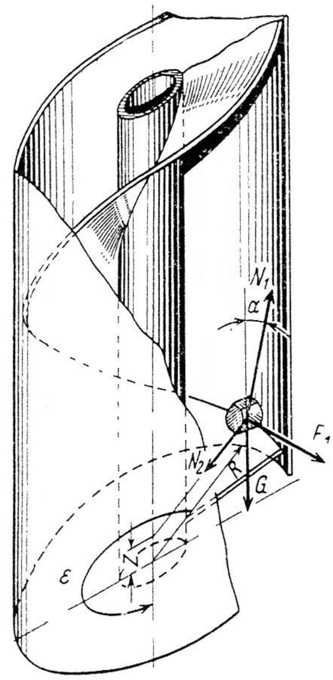

Fig. 1 Scheme of forces on material particle in vertical auger

Let us observe $\lambda = \frac{Sn^2}{g}$ coefficient which describes cinematic regime of auger. Solving (4) equation to the coefficient of cinematic regime we will get

$$\lambda = \frac{60^2}{2\pi f_1} \cdot \frac{\sin\alpha + f\cos\alpha}{\sin\alpha\cos\alpha(\sin\varphi - f\cos\varphi)(\sin\alpha + tg\varphi\cos\alpha)^2} \qquad (5)$$

To screw line rising α angle of external edge of auger corresponds certain relation of external edge of step and coil $t_0 = \frac{S}{2R_0}$ which is connected with α angle by $\alpha = arctg\frac{t_0}{\pi}$ dependence. We can see from (5) relation that φ angle is depended on t_0 relation of structural parameters, f and f_1 contact coefficients and S step of screw.

The rising angle of screw line also effects the dimension of pressure force of the load on conveyer cover. The latter depends on centrifuge force ($F_ц$), gravity force (G) and contact force of load with screw ($F_{тр.ш.}$) (Fig. 2).

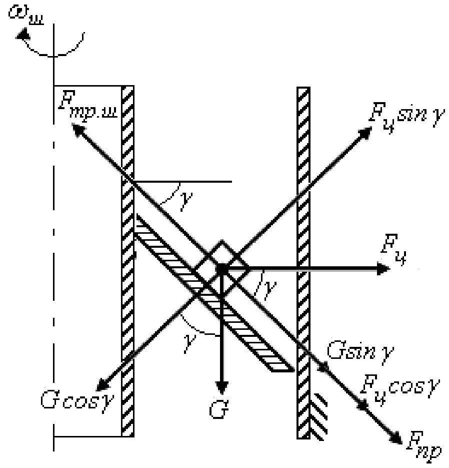

Fig. 2 Scheme of forces on material point on screw line

According to calculation scheme in Fig. 2 we obtained pressure force on conveyer cover:

$$F_{np} = m \cdot \left[\omega_ш^2 R(\cos\gamma + \sin\gamma \cdot f_ш) + g(\sin\gamma - \cos\gamma \cdot f_ш)\right], \qquad (6)$$

where γ is slope angle of screw line to screw axis.

Obtained (6) expression enables us to determine the dependence of γ angle on load transported by conveyer and screw contact coefficient.

Thus, as in (6) expression the first component is not dependent on γ angle within 5-20°, then pressure force of load on the cover will be equal to 0, if $\sin\gamma = \cos\gamma \cdot f_ш$ from which we can write

$$\gamma = arc\ tg\gamma \cdot f_ш : \qquad (7)$$

Taking into account that while preparing the screw its working surface is well processed then the contact coefficient between load and screw can be chosen within 0,2-0,3. Consequently, the slope angle to screw axis should be taken within $\gamma = 10 - 15^0$.

Research results

Theoretical research has shown that in order to increase the efficiency of loading cargo with screw conveyors it is necessary to move the cargo from the load box with the maximum speed. Otherwise, the material may be clogged in the coils in front of the screw and later in other coils.

To solve the problem it is recommended to increase the number of screw coils which will proportionally increase the speed of load transfer from the load box to the screw coils.

For this purpose we suggest to use advanced conveyer (Fig.3) made of screw (1), one input coils (2) and cover (3). On the bottom of screw there is a tip (4) with two coils (main and auxiliary), indeed the main screw (5) stretches from along all the length of the tip and the auxiliary screw (6) is somehow shorter from the main one.

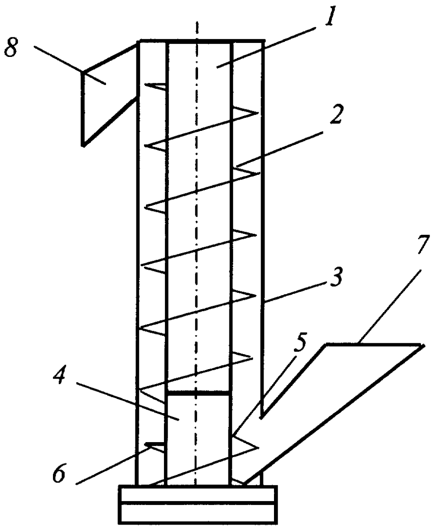

Fig. 3 Scheme of advanced screw conveyer

Screw conveyer has loading (7) and unloading (8) facilities.

The working principle of the suggested screw conveyer is simple, it works this way: shifting cargo fills into the space between the tip coils (4) from load box and transports to the main screw (5) by auxiliary screw from which it is transferred to spiral part (2) of screw conveyer (1) and thus raising reaches unloading facility.

Conclusions

1. Theoretical research revealed that during transporting shifting cargo we can provide maximum productivity when rising angle of screw line makes 10-15^0 to screw axis which corresponds to the dimensions of 1.2-1.4 of coil step according to external coils and 150-200 turn/min of screw rotation.
2. Theoretical research has shown that in order to increase the efficiency of loading cargo with screw conveyors it is necessary to move the cargo from the load box with maximum speed. Otherwise, the material may be clogged in the coils in front of the screw and later in other coils.
3. A new structure of screw conveyer was developed using which the energy costs of loading, transportation and unloading of shifting cargoes will significantly decrease.

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ՍՈՐՈՒՆ ԲԵՌՆԵՐԻ ԲԵՌՆՄԱՆ-ԲԵՌՆԱԹԱՓՄԱՆ ՊՏՈՒՏԱԿԱՎՈՐ ՓՈԽԱԿՐԻՉ

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[1]Հայաստանի ազգային ագրարային համալսարան
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Սորուն բեռների պտուտակավոր փոխակրիչներով բեռնման, փոխադրման և բեռնաթափման գործընթացներին նվիրված բազմաթիվ հետազոտություններում, բեռը դիտարկվում է որպես մեկ նյութական կետ, որը տեղափոխվում է շնեկի պարուրակի մակերևույթով: Դեռևս լիարժեք ուսումնասիրված չեն բեռնման խցիծ դեպի պտուտակի թևերը բեռի տեղափոխման գործընթացը, չնայած, որ այդ գոտում տեղի ունեցող գործընթացները էական ազդեցություն են թողնում պտուտակավոր փոխակրիչների աշխատանքի վրա:

Կատարվել է տեսական հետազոտություններ և պարզվել, որ պտուտակավոր փոխակրիչներով սորուն բեռների բեռնման աշխատանքների արդյունավետության բարձրացման նպատակով անհրաժեշտ է, որպեսզի բեռնման խցից փոխադրվող բեռը տեղափոխվի առավելագույն արագությամբ: Հակառակ դեպքում կարող է փոխադրվող նյութը խցանվել պտուտակի առջևի և այնուհետև մնացած գալարներում: Արդյունքում մշակվել է պտուտակավոր փոխակրիչի նոր կառուցվածք, որի կիրառման դեպքում կնվազի սորուն բեռների բեռնման, փոխադրման, բեռնաթափման էներգածախսերը:

Բանալի բառեր. բեռ, սորուն, շնեկ, փոխակրիչ, պտուտակ, ռեժիմ, զանգված:

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ПОГРУЗОЧНО-РАЗГРУЗОЧНЫЙ ВИНТОВОЙ КОНВЕЙЕР ДЛЯ СЫПУЧИХ ГРУЗОВ

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В многочисленных исследованиях, посвященных процессам погрузки, транспортировки и разгрузки сыпучих грузов винтовыми конвейерами, груз рассматривается как одна материальная точка, перемещающаяся по винтовой поверхности шнека. Процесс перемещения груза из загрузочной камеры к лопастям винта еще полностью не изучен, несмотря на то, что процессы, происходящие в этой зоне, оказывают существенное влияние на работу винтовых конвейеров.

В ходе проведенных теоретических исследований было установлено, что для повышения эффективности работ по погрузке сыпучих грузов винтовыми конвейерами необходимо, чтобы из загрузочной камеры груз перемещался на максимальной скорости. В противном случае транспортируемый материал может закупориться в передних, а затем в оставшихся спиралях шнека. В результате была разработана новая структура винтового конвейера, в случае применения которой снизятся энергозатраты на погрузку, транспортировку и разгрузку сыпучих грузов.

Ключевые слова: груз, сыпучий, шнек, конвейер, винт, режим, масса.

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