THE EFFICIENCY IMPROVEMENT OF BELT CONVEYOR INTERMEDIATE DRIVE TRACTION EFFORT

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ABSTRACT
This article describes the options for increasing traction of the belt conveyor intermediate drive. The functioning principle of intermediate linear drive with pressure rollers has been described, formulas for calculating the values of traction effort have been provided, also comparative graphs, which shows the efficiency of using intermediate drive in various conditions, have been given.

Keywords: belt conveyor, linear drive, traction effort, pressure.

INTRODUCTION
The tractive effort is transferred through a conveyor belt by the friction forces generated on the frictional contact surfaces. The frictional surface of the drive pulley is the surface of the pulley, as for linear drive, the frictional surface is the contact area of the conveyor belt with the intermediate drive. Transmitted tractive effort should be sufficient for overcoming resistant forces; however it shouldn’t cause slipping underneath the conveyor belt.

Belt conveyor with an intermediate drive is a closed loop load-carrying belt, in which there are one or more intermediate linear drives in the form of short belt conveyors, and the upper branch of their belt is in force frictional contact with the load-carrying conveyor belt. Each intermediate drive overcomes the resistance of only its own interval section.

MAIN PART
As a result the belt tension diagram for conveyor with intermediate drive (Figure-1, b) significantly changes, characterized by a decrease in the maximum belt tension, compared with tension diagram for one head drive conveyor (Figure-1, a). This is clearly seen in Figure-1, c.

Figure-2 shows relative efficiency of the intermediate linear drive depending on the angle of the conveyor and its load occupancy.
Figure-2. The efficiency of transferring traction effort of intermediate drive depending on the angle of conveyor inclination (a, b) and the load occupancy (c):

(a) theoretical, throughout the whole range of angles; (b) at significant range of angles of conveyor inclination; (c) depending on the intermediate drive load occupancy.

It is assumed here that the weight of the load is 91% of the distributed load, and the belt weight is 9% of the distributed load*. The calculation formula is as follows:

\[ F = (q_{\text{load}}k_{\text{load}} + q_{\text{belt}})\cos \alpha, \]

where \( q_{\text{load}} \) and \( q_{\text{belt}} \) are linear load and belt weight, respectively, kg/m, \( k_{\text{dp}} \) - the load occupancy ratio of the intermediate drive length; \( \alpha \) - angle of conveyor inclination.

Figure-2 shows that the efficiency of intermediate drive is reduced linearly depending on the degree of load occupancy, and the dependence on the angle of inclination is sinusoidal. At an angle of inclination of 18° efficiency loss is 5%, and at the double angle of inclination of 30° efficiency loss three times greater - 13%. That is a nonlinear dependence.

Engineering companies increase the length of the intermediate drives to compensate for the loss of efficiency. Figure-3 shows the required length of the intermediate drive, which is needed to sustain 100% of the traction ability of the intermediate drive relative to a reference (which runs at an inclination of 0°).

Figure-3 shows that at angles less than 5°, you can ignore the drop in traction ability and at angles above 15° drop in efficiency is becoming more prominent. However, at the maximum angle of the belt conveyor inclination of 18° drop in efficiency is about 7%, to compensate which conveyor should be extended the at the same 7%, while costs of lengthening intermediate drive represent only consumption of belt (2 × 7% = 14%) without affecting the other parameters (power, the number of engines, power consumption, etc.).

Figure-2, c shows how the traction capacity of the intermediate drive drops to 10% when there is no load on it, and this means that the intermediate drive is not able to transmit tractive effort in case the main conveyor belt is not properly pressed to the intermediate drive belt. Intermediate linear drive with pressure rollers for belt conveyor has been developed to eliminate this disadvantage (patents of the Russian Federation № 2487071, №2456570, №2476851).

Tractive effort of intermediate linear drive transferred to the belt is provided not only by the frictional force of the normal components of the transported load and belt weight, but also due to an additional pressure conveyor and drive belts to each other using the pressure rollers. The required effort of conveyor and drive belts pressure is provided by bolts with packing nuts.
The additional tractive effort transferred to the conveyor belt by the proposed intermediate linear drive is determined by the formula:

\[
P = 2 \cdot p \cdot n \cdot b \cdot f \cdot 2(h \cdot D - h^2)^{0.5},
\]

where \( P \) – additional tractive effort, kN; \( p \) – maximum usable pressure between the pressure rollers, kPa; \( n \) – the total number of rows of the pair of pressure rollers; \( h \) – the width of the pressure rollers, m; \( f \) – the friction coefficient between the conveyor and drive belts; \( D \) – the outer diameter of the pressure rollers, m.

The total tractive effort (N), which is realized by linear drive, could be determined by one of the following formulas, respectively, for a given linear drive length (L) or a given number of rows of pressure rollers (n):

\[
W = L \times f \times (k \times q + q_{belt}) \times \cos \beta + 2 \times h \times \Delta \times p,
\]

\[
W = n \times f \times [g \times f \times (k \times q + q_{belt}) \times \cos \beta + 2 \times h \times \Delta \times p],
\]

where \( L \) – length of intermediate drive, m; \( \Delta \) – length of the base of the pressure rollers deformed elastic rims in the areas of contact with the sides of the conveyor belt load-carrying branches, m; \( q \) – linear load weight, kg/m; \( q_{belt} \) – linear belt weight, kg/m; \( \beta \) – angle of conveyor inclination; \( l \) – idlers and pressure rollers spacing on the load-carrying conveyor belt branch, m; \( k \) – coefficient taking into account the operating mode of the conveyor, which determines the degree of the belt load occupancy along the conveyor (0 ≤ \( k \) ≤ 1).

Figure-4 shows the relative efficiency of such a drive in dependence on the angle of the conveyor inclination and its load occupancy. The effectiveness of the intermediate drive without pressing elements has been shown for comparison (Figure-4, a).

The efficiency of transferring traction effort by this type of drive doesn’t depend on the angle of conveyor inclination or load occupancy of the conveyor section with intermediate linear drive. In relative terms, this kind of intermediate drive always provides a constant tractive ability at its maximum level.

CONCLUSIONS

Increasing drives tractive ability, independence of the conveyor angle of inclination, reducing thus their length significantly improves technical and economical performance and extend the field of multidrive belt conveyor application, therefore work on improving the design of intermediate drives continue to be carried out not only in Russia but also worldwide.

REFERENCES


[2] Tarasov, Yu.D. and Trufanova, I.S. Patent 2456570 Russian Federation, MPK G01M 17/00, B65G15/00. Stand for investigation of the parameters of the belt conveyor with the placement of belt conveyor lower run with the possibility of interaction with the idlers of load-carrying.


