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STUDY OF THE DEPENDENCE BETWEEN THE BELTS WIDTH AND THE LOADING METHOD OF GRANULAR MATERIALS IN THE CASE OF CONVEYORS BELT

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Abstract: *In this study we will focus on the problems that arise due to the high travel speeds that the piston of a hydraulic motor develops during operation. These speeds lead to an increase in the value of the kinetic friction coefficient.*
The study of the dependence of belt width on the loading method of the material on the belt of equipment for transporting granular materials is essential for optimizing the efficiency and safety of belt conveyors. Here are some important aspects:
1. Belt width: This influences the transport capacity and the stability of the material on the belt. A wider belt can transport a larger amount of material but also requires a more robust support system.
2. Loading method: The way in which the material is loaded on the belt affects the weight distribution and the stability of the transport. Uniform loading prevents the accumulation of material and reduces the risk of skidding or blocking.
3. Type of material: The properties of the transported material, such as density and friction angle, influence the choice of belt width and loading method. Granular materials with high friction angles require belts with special surfaces to prevent them from slipping.
4. Belt configuration: Belts can be flat or trough-shaped, depending on the conveying needs. Trough-shaped belts are more effective for conveying granular materials because they offer greater stability.
These aspects are essential for the efficient design and operation of belt conveyors in various industries.

Keywords: *conveyor belt, granular materials*

1. INTRODUCTION

Continuous transport installations ensure the uninterrupted transport of a continuous flow of loads (which can be powdery, granular, solid materials, various parts, etc.), from one point to another point, located at the same level or at a different level [1].
Depending on the operating principle, continuous transport installations can be divided into two groups:

a) Conveyors with flexible traction elements, such as: belt, plate, scraper or suspended conveyors, escalators for people and elevators.

b) Conveyors without flexible traction elements, such as: helical, inertial, gravitational or pneumatic conveyors.

For the present study, the conveyor is part of the category of continuous conveyors with flexible traction element. The flexible traction member (belt) is constructed from a series of plates, usually made of steel sheet, sometimes also of wood, supported between two traction chains of the type: with plates, bushings and rollers [1, 2].
Conveyors with flexible traction members can be divided into [2]:

a) conveyors that work only horizontally or that go up or down at a small angle, smaller than the sliding angle of the transported materials.

b) conveyors that work mainly vertically or with a small inclination to the vertical axis.

c) conveyors that can work at any angle, including the horizontal or vertical direction.

Figure 1 shows a conveyor belt used to pick up and transport granular and powdery materials [3].

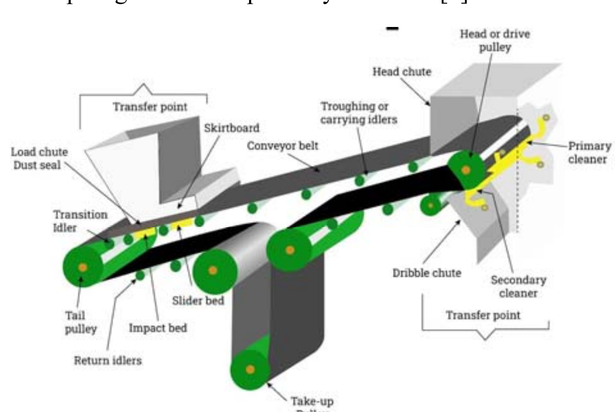

Figure 1. ***Belt conveyor representation [3]***

2. DESCRIPTION OF THE INSTALLATION AND EXPERIMENTAL PART

For the present study, a granular material is considered, transported on a technological flow, in the building materials industry. We will study the dependence of the productivity of the conveyor with edge plates for two different ways of loading and placing the granular material on the conveyor belt [4, 5].
In the case of loading granular material onto the conveyor axis, the cross-section through the material is composed of the area of the rectangle A_1 and the area of the triangle A_2, regardless of whether the borders are fixed or mobile (figure 2) [6, 7].

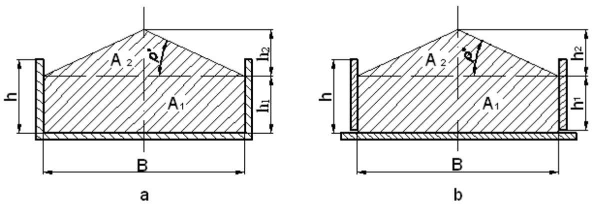

Figure 2. ***Loading granular material onto the conveyor axis***
a – plates with fixed edges; b – plates with movable edges

Considering the coefficient whose values are given in Table 1, the total area of the material section is determined by the expression [7]:

$$A_t = A_1 + A_2 = B \cdot h_1 + \beta \cdot \frac{B \cdot h_2}{2} \text{ [m}^2\text{]} \quad (1)$$

Where:

A_1 - the area of the cross-section of the material at the height of h_1

A_2 - the area of the cross-section of the material at the height of h_2

B - the width of the deck, [mm].

Table 1.

Conveyor slope [º]	Slabs without edge	Slabs with fixed or movable edge
< 10º	1,0	1,0
11º ÷ 20º	0,90	0,95
> 21º	0,85	0,90

The height h_1 is determined by the expression:

$$h_1 = \Psi_1 \cdot h \text{ [m]} \quad (2)$$

Where:

Ψ_1 - the filling coefficient in the rectangular section area.

Choose: $\Psi_1 = 0{,}7$

$h =$ The total height of the curb is chosen, [m];

The height h_2 is determined by the expression:

$$h_2 = \frac{B}{2} \cdot tg\rho \text{ [m]} \quad (3)$$

Where:

ρ - the angle that the inclined sides of the triangular cross-section of material make with the horizontal, [º];

The angle of inclination is determined by:

$\rho = 0{,}5 \cdot \rho_m$ [º]

Where ρ_M = the natural slope angle of the moving material, in [º]

For anthracite: $\rho_m = 27°$

Result: $\rho = 0{,}5 \cdot 27° = 13{,}5°$

The height h_2 will be:

$$h_2 = \frac{B}{2} \cdot tg(0{,}5 \cdot \rho_m) \text{ [m]}$$

Knowing all this, the total surface area of the material section is determined by the expression:

$$A_t = B \cdot \left[h \cdot \Psi_1 + \frac{\beta \cdot B}{4} \cdot tg(0{,}5 \cdot \rho_m) \right] \text{ [m}^2\text{]} \quad (4)$$

The weight of the material per linear meter of belt is determined by the expression:

$$q = 1000 \cdot \gamma \cdot A_t \text{ [kg/m]} \quad (5)$$

Where:

γ - volumetric material's weight.

For anthracite: $\gamma = 900$ kg/m

The conveyor productivity is determined by the expression:

$$Q = 3{,}6 \cdot q \cdot v \text{ [t/h]} \quad (6)$$

Where:

q - the weight of the material per linear meter in the transport direction in [kg/m].

v - the speed of the material in [m/s].

Knowing all this, the productivity calculation expression becomes:

$$Q = 3600 \cdot B \cdot \gamma \cdot v \cdot [\Psi_1 + 0{,}25 \cdot \beta \cdot tg(0{,}5 \cdot \rho_m)] \text{[t/h]}$$

To simplify this expression, we will approximate:

$$h = 0{,}25 \cdot B \text{ [m]}$$

$$Q = 900 \cdot B^2 \cdot \gamma \cdot v \cdot [\Psi_1 + \beta \cdot tg(0{,}5 \cdot \rho_m)] \text{ [t/h]}$$

Where:

$\gamma = 900$ [kg/m] for anthracite – volumetric weight of the material

$v = 0{,}4$ [m/s] - conveyor speed

$\beta = 0{,}95$;

$\rho_m = 27°$;

$\Psi_1 = 0{,}7$.

Knowing the productivity $Q = 120$ [t/h], the belt width can be determined, the above relationship becomes:

$$B = \frac{1}{30} \cdot \sqrt{\frac{Q}{\gamma \cdot v \cdot [\Psi_1 + \beta \cdot tg(0{,}5 \cdot \rho_m)]}} \text{ [m]} \quad (7)$$

$$B = \frac{1}{30} \cdot \sqrt{\frac{120}{0{,}9 \cdot 0{,}4 \cdot [0{,}7 + 0{,}95 \cdot tg(0{,}5 \cdot 27)]}} = 0{,}632 \text{ [m]}$$

If the material is loaded across the entire width of the deck, the cross-section through the material looks like in figure 3.

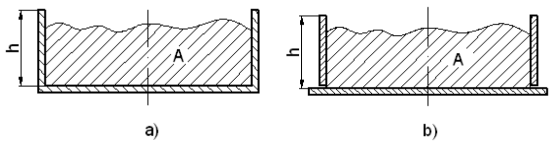

Figure 3. Cross-section of the loaded material
a – plates with fixed edges; b – plates with movable edges

In this case the section of the material has the surface area given by:

$$A = B \cdot h \cdot \Psi_2 \quad [m^2] \tag{8}$$

where:

Ψ_2 - filling coefficient in the given rectangular cross sectional area of the slabs and curbs.

Choose: $\Psi_2 = 0{,}8$; $(\Psi_2 = 0{,}80 \div 0{,}85)$

The weight of the material per linear meter of tape is determined by:

$$q = 1000 \cdot \gamma \cdot A_t \quad [kg/m] \tag{9}$$

Substituting into the productivity expression, it becomes:

$$Q = 3600 \cdot B \cdot h \cdot \Psi_2 \cdot \gamma \cdot v \quad [t/h] \tag{10}$$

To simplify this expression, it will be approximated by:

$$h = 0{,}25 \cdot B \quad [m]$$

$$Q = 900 \cdot B^2 \cdot \Psi_2 \cdot \gamma \cdot v \quad [t/h]$$

$$B = \frac{1}{30} \cdot \sqrt{\frac{Q}{\Psi_2 \cdot \gamma \cdot v}} \quad [m] \tag{11}$$

$$B = \frac{1}{30} \cdot \sqrt{\frac{150}{0{,}8 \cdot 0{,}9 \cdot 0{,}4}} = 0{,}76 \quad [m]$$

It is observed that for the same imposed productivity, in the case of loading the material on the entire width of the belt, the calculated width of the belt is greater.

It is possible to impose both productivity and belt width if the other parameters that directly influence it are modified, for example the height of the curbs or the transport speed.

3. CONCLUSIONS

The study of the dependence of belt width on the loading method of the material on the belt of equipment for transporting granular materials has numerous practical applications in various industries. Here are some of them:

1. Mining industry: Optimizing the belt width and loading method can improve the efficiency of ore transportation and reduce operating costs. A well-designed belt can transport more material with fewer interruptions.

2. Agricultural industry: In agriculture, belt conveyors are used to move grains, seeds and other agricultural products. The study helps in designing belts that minimize product losses and damage during transportation.

3. Food industry: In food processing plants, belt conveyors are essential for moving ingredients and finished products. Optimizing the belt and loading can improve the hygiene and efficiency of production processes.

4. Construction Industry: Belt conveyors are used to move construction materials such as sand, gravel, and cement. The study contributes to the design of systems that can handle large volumes of material without blockages or failures.

5. Recycling Industry: With the increase and awareness of the population's involvement in the recycling process, the need to improve this process and even automate it has arisen. In recycling centers, belt conveyors are used to move recyclable materials. Optimizing the belt and the loading method can increase the efficiency of sorting and processing various types of materials.

These applications demonstrate the importance of this study in improving the efficiency and reliability of belt conveyor systems in various industrial sectors.

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