Belt Conveyor Theory

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### Euler-Eytelwein formula

\[
P = S_n - S_z \\
\frac{S_n}{S_z} \leq e^{\mu \cdot \alpha} \quad \text{Euler-Eytelwein}
\]

\[
M_n = R_b \cdot P \\
P_{\text{max}} = S_z \cdot e^{\mu \cdot \alpha} - S_z \\
M_{\text{max}} = R_b \cdot S_z (e^{\mu \cdot \alpha} - 1)
\]

- \( \alpha \) – angle of wrap [rad]
- \( \mu \) – friction coefficient
- \( P \) – driving force [N]
- \( S_{z,n} \) – belt tension [N]
- \( M \) – driving torque [Nm]
- \( R_b \) – radius of pulley [m]

### Ways to increase the maximum driving force

\[
P_{\text{max}} = S_z (e^{\mu \cdot \alpha} - 1)
\]

- \( \alpha \uparrow \) Increasing the angle of wrap
- \( S_z \uparrow \) Increasing and stabilizing tension force
  - take-up devices
- \( \mu \uparrow \) Increasing and stabilizing the friction coefficient
Tandem drive

\[ T_{\text{III}} = S_{n1} = S_{z2} \]

necessary condition!

- \( \alpha \) – angle of wrap [rad]
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Zasada sprzężenia ciernego napędu wielobębnowego

\[ \frac{S_{n1}}{S_{z2}} \leq e^{\mu \cdot \alpha_1} \]

\[ e^{\mu \cdot \alpha_2} \cdot S_{z2} = S_{n1} \]

\[ \frac{S_{n1}}{S_{z2}} = e^{\mu \cdot \alpha_1} \cdot e^{\mu \cdot \alpha_2} = e^{\mu \cdot (\alpha_1 + \alpha_2)} \]
**Static Characteristics of the Tensioning Device**

- **Belt sag**
  \[ S_{mn} = \frac{g \cdot (m_1 + m_2) \cdot l^2}{8 \cdot l_u} \]

- **Drive**
  - **driving**
    \[ M_N \leq R_b \cdot S_{2N}(e^{\mu} - 1) \]
  - **braking**
    \[ M_H \leq R_b \cdot S_{1H}(e^{\mu} - 1) = R_b \cdot S_{2H} \frac{e^{\mu} - 1}{e^{\mu}} \]
Static Characteristics of the Tensioning Device

Types of take-up devices used in belt conveyors

Those with a fixed position of the tensioning pulley during conveyor operation – so called fixed take-up device:

- Fixed take-up

Those with a changing position of the tensioning pulley during conveyor operation:

- Moveable take-up:
  - Gravity weight
  - Hydraulic, pneumatic

- Regulated take-up winch

- Follow-up
Fixed Take-up Device
– with a constant position of the tensioning pulley during conveyor operation.

With a tensioning pulley periodically moved during conveyor stoppage. Elastic elongations of a belt loaded with a longitudinal force cause a reduction of forces in the zone where the belt comes off the drive pulley. This necessitates causing much greater forces of preliminary belt tensioning. Permanent deformations of the belt are periodically compensated by moving the tensioning pulley during conveyor stoppages.
Gravity Weight

In conditions of a variable load of output on the belt, weight (gravity) devices stabilise the belt tension forces within limits conditional on the efficiency of the tackle and rope system. In non-steady-state operation of the conveyor, tensioning force changes are observed due to inertia forces and longitudinal vibrations of the belt.
Hydraulic or pneumatic take-up devices
with a limited tensioning path

Tensioners with linear cylinders may employ various solutions: the so-called constant tension ones are connected to a trunk line with a pressurised liquid or ones with their own drive and a controlled pressure range. The characteristic feature of this type of devices is that the length of the tensioning path is limited by the length of stroke of the cylinder piston; the speed of tensioning is also limited.
Automatic take-up devices with a periodic operation

Tensioners in which the tensioning cart is pulled by the rope from a winch driven by an electric motor. They are controlled by three-position controllers, sometimes with the ability to change the force adjustment range for the duration of the conveyor start-up.

Model of follow-up, mechanical take-up devices
Mechanical tensioners receiving their power from the main drive of the conveyor. Two tried and tested solutions are worth mentioning here. The first has a tilting drive system suspended from the pulley shaft hanging from a system of ropes and tackle connecting it to the tensioning cart. The tensioning force of this device is the sum of a part of the weight of the driving system and the reaction to the driving torque. The second type of tensioners with a similar solution are those with two tensioning carts installed before and after the drive pulley in the main drive zone and connected with a rope system of a constant ratio ensuring that the friction contact between the drive pulley and the belt is correct.

Follow-up, mechanical take-up devices

Follow-up Device
Follow-up Device

Centering belt run - Causes of belt mistracking

1. Roller station out of true alignment
2. Roller station rotated horizontally
3. Belt conveyor in middle from the side
4. Roller station rotated vertically
5. Influence of the loading of the bulk material
6. Material sticking to one side of the pulley
7. Pulley not perpendicular to belt running direction
8. Foreign object stuck in conveying structure
9. Badly aligned belt splice
Centering belt run

Belt

Axis

- $V_t$ – Belt speed
- $V_k$ – Circumferential idler speed
- $V_p$ – Slip speed
- $F_t$ – Friction force
- $F_0$ – Resistance of centering
- $F_c$ – Centering force

Bibliography

- Kulinowski, wykłady „Transport przenośnikowy”,
  www.kmg.agh.edu.pl