Department of Mining, Dressing and Transporting Machines AGH

Belt Conveyor Theory

Piotr Kulinowski, Ph. D. Eng.
Piotr Kasza, Ph. D. Eng.

piotr.kulinowski@agh.edu.pl
12617 30 92
B-2 ground-floor room 6

consultations: Mondays 11.00 - 12.00

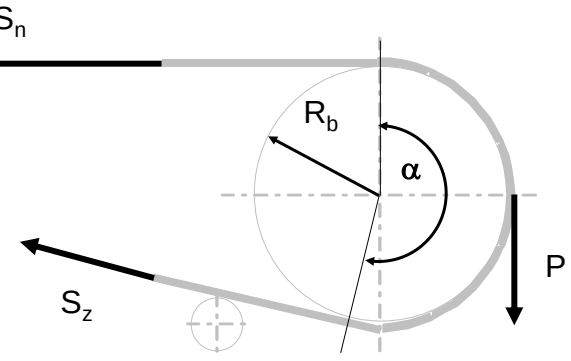
Belt drives - history

Euler-Eytelwein formula

$$P = S_n - S_z$$

$$\frac{S_n}{S_z} \le e^{\mu \cdot \alpha}$$

Euler-Eytelwein



$$M_n = R_b \cdot P$$

$$P_{max} = S_z \cdot e^{\mu \cdot \alpha} - S_z$$

$$M_{max} = R_b \cdot S_z (e^{\mu \cdot \alpha} - 1)$$

α	– angle of wrap [rad]
μ	– 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

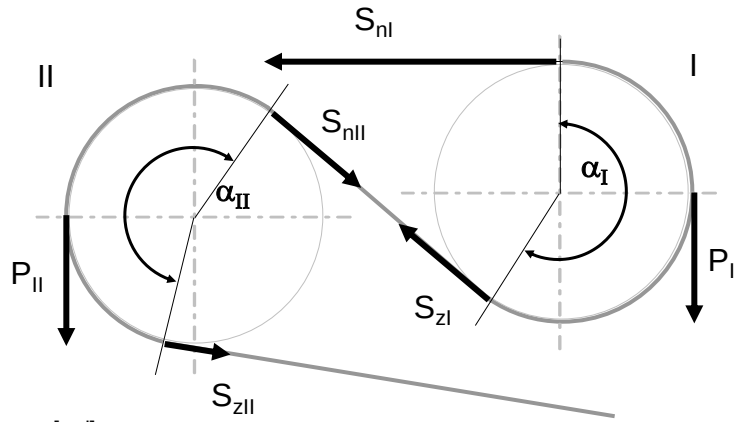
$$P_{max} = S_z (e^{\mu \cdot \alpha} - 1)$$

$\alpha \uparrow$ **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



α	– angle of wrap [rad]
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P	– driving force[N]
$S_{z,n}$	– belt tension [N]
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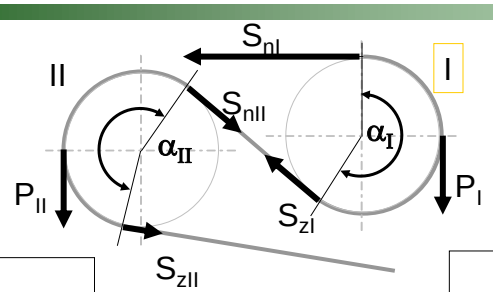
$$S_{nII} = S_{zI}$$

necessary condition!

Zasada sprzężenia ciernego napędu wielobębnowego



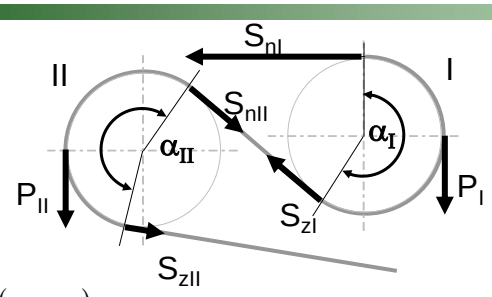
$$\frac{S_{nII}}{S_{zII}} \le e^{\mu\cdot\alpha_{II}}$$

$$\frac{S_{nI}}{S_{zI}} \le e^{\mu\cdot\alpha_{I}}$$

$$e^{\mu\cdot\alpha_{II}} \cdot S_{zII} = \boxed{S_{nII} \quad = \quad S_{zI}} = \frac{S_{nI}}{e^{\mu\cdot\alpha_{I}}}$$

$$\frac{S_{nI}}{S_{zII}} = e^{\mu\cdot\alpha_{I}} \cdot e^{\mu\cdot\alpha_{II}} = e^{\mu\cdot(\alpha_{I}+\alpha_{II})}$$

Zasada sprzężenia ciernego napędu wielobębnowego



$$\frac{S_{nI}}{S_{zII}} = e^{\mu\cdot(\alpha_I+\alpha_{II})}$$

$$P = P_I + P_{II} = S_{nI} - S_{zI} + S_{nII} - S_{zII} = S_{nI} - S_{zII}$$

$$\boxed{P_{max} = S_z\left(e^{\mu\cdot(\alpha_I+\alpha_{II})} - 1\right)}$$

Static Characteristics of the Tensioning Device

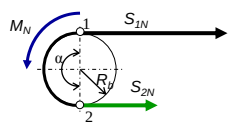
- Belt sag

$$S_{min} = \frac{g\cdot(m_t + m_u)\cdot l_g^2}{8\cdot f_u}$$

- Drive

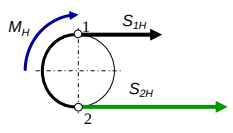
- driving

$$M_N \le R_b \cdot S_{2N}\left(e^{\mu\alpha} - 1\right)$$

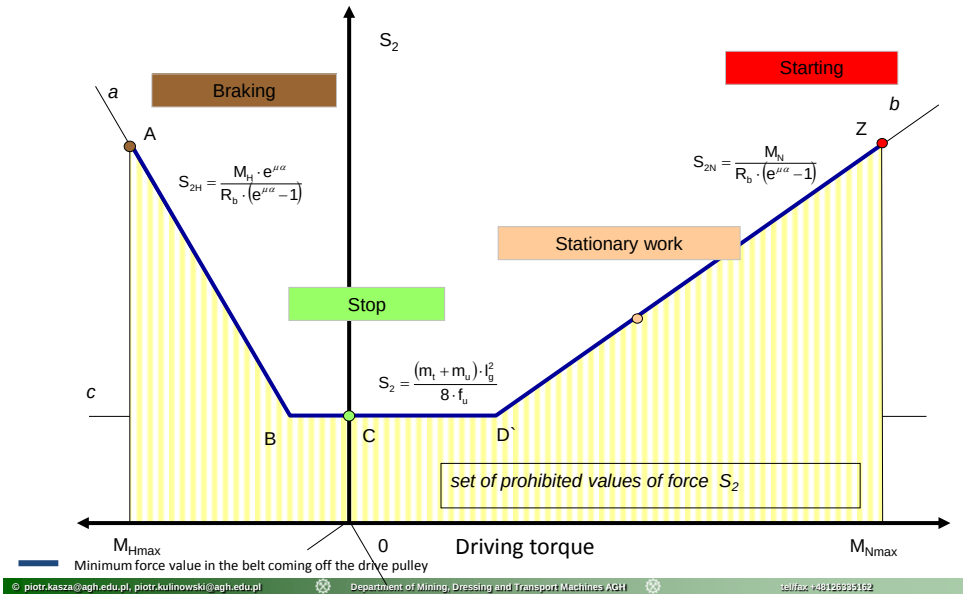


- braking

$$M_H \le R_b \cdot S_{1H}\left(e^{\mu\alpha} - 1\right) = R_b \cdot S_{2H}\,\frac{e^{\mu\alpha} - 1}{e^{\mu\alpha}}$$



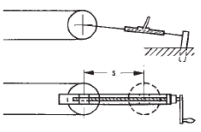
Static Characteristics of the Tensioning Device



Types of take-up devices used in belt conveyors

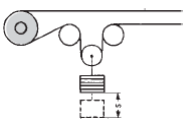
Those with a fixed position of the tensioning pulley during conveyor operation – so called fixed take-up device;

- Fixed take-up

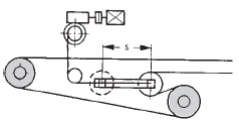


Those with a changing position of the tensioning pulley during conveyor operation

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



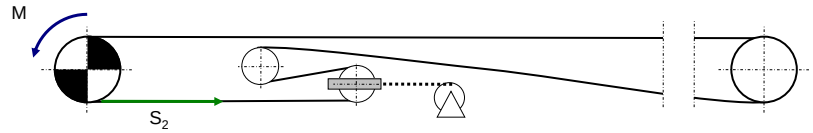
  - Regulated take-up winch



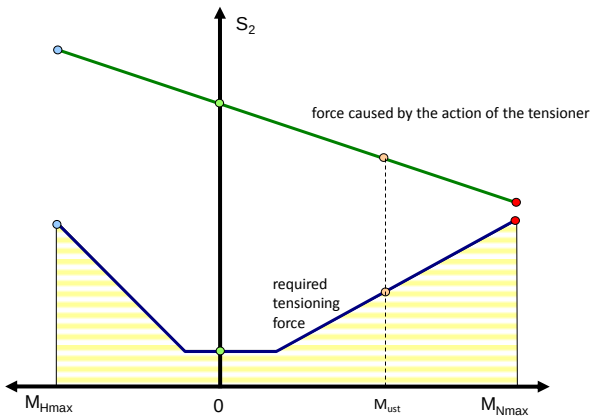
  - Follow-up

Fixed Take-up Device

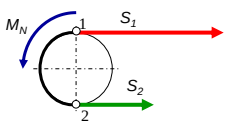
– with a constant position of the tensioning pulley during conveyor operation.

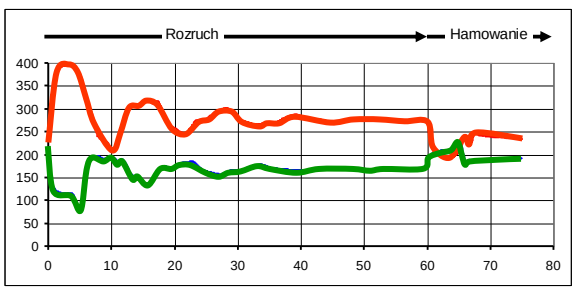


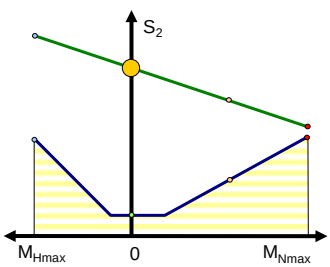
With a tensioning pulley periodically moved during conveyor stoppage. Elastic elongations of a belt loaded with a longitudinal force cause a reduction of forces in the zone where the belt comes off the drive pulley . This necessitates causing much greater forces of preliminary belt tensioning. Permanent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

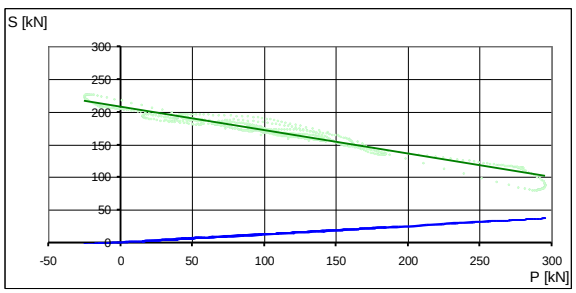


Fixed Take-up Device

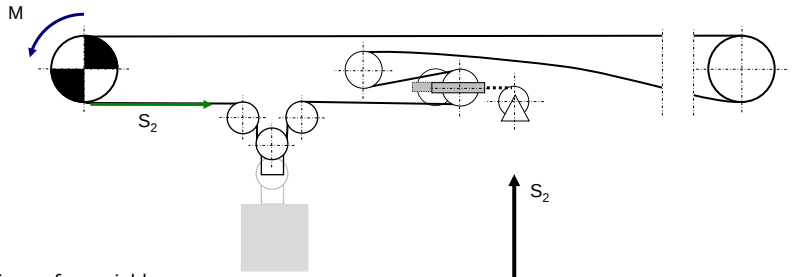




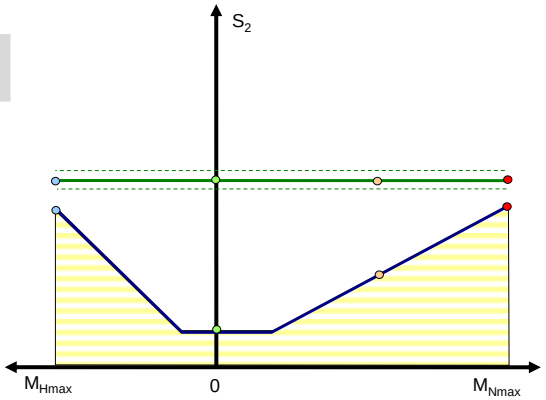




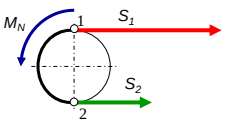
Gravity Weight

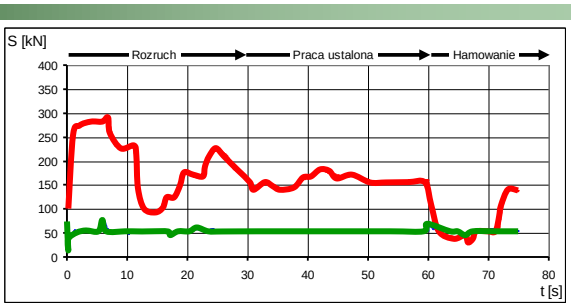


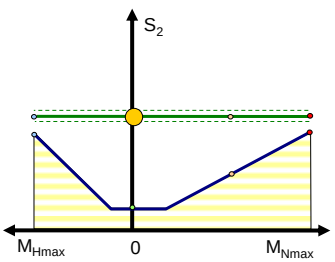
In conditions of a variable load of output on the belt, weight (gravity) devices stabilise the belt tension forces within limits conditional on the efficiency of the tackle and rope system. In non-steady-state operation of the conveyor, tensioning force changes are observed due to inertia forces and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

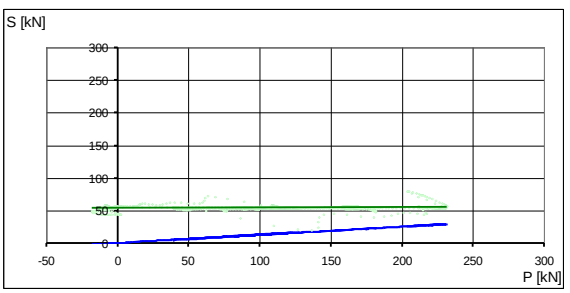


Gravity Weight

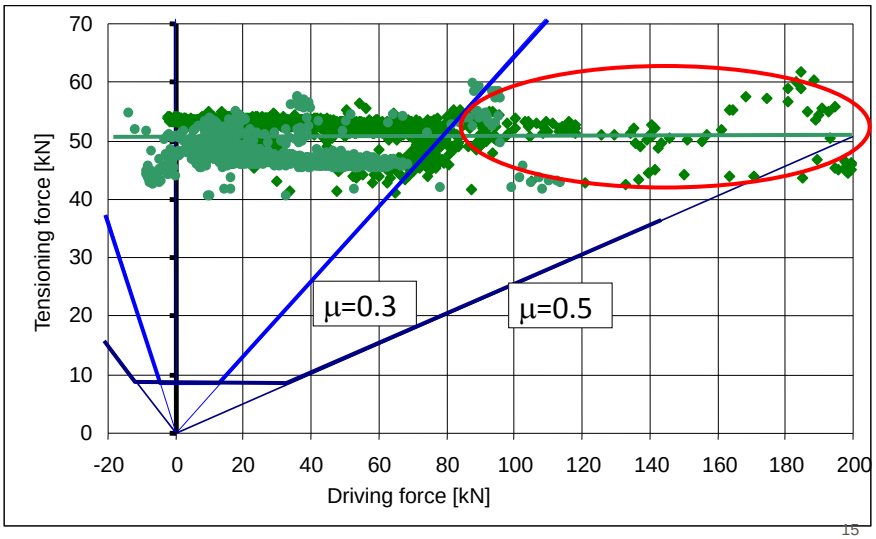






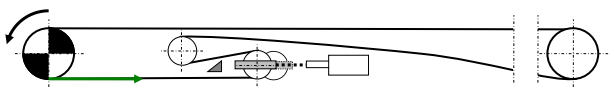


Measured Static Characteristics of the Gravity Weight

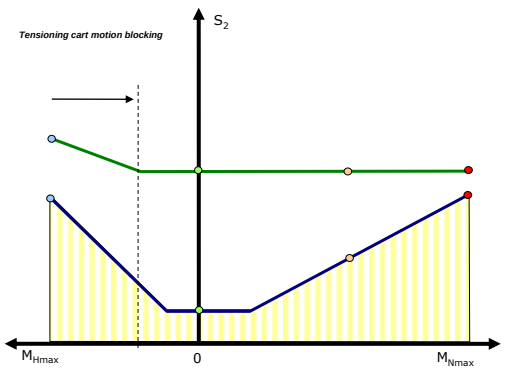


Hydraulic or pneumatic take-up devices

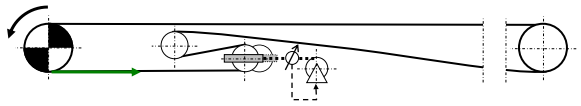
with a limited tensioning path



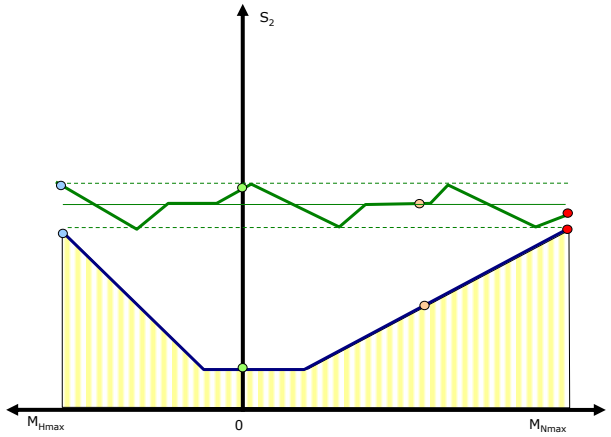
Tensioners with linear cylinders may employ various solutions: the so-called constant tension ones are connected to a trunk line with a pressurised liquid or ones with their own drive and a controlled pressure range. The characteristic feature of this type of devices is that the length of the tensioning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



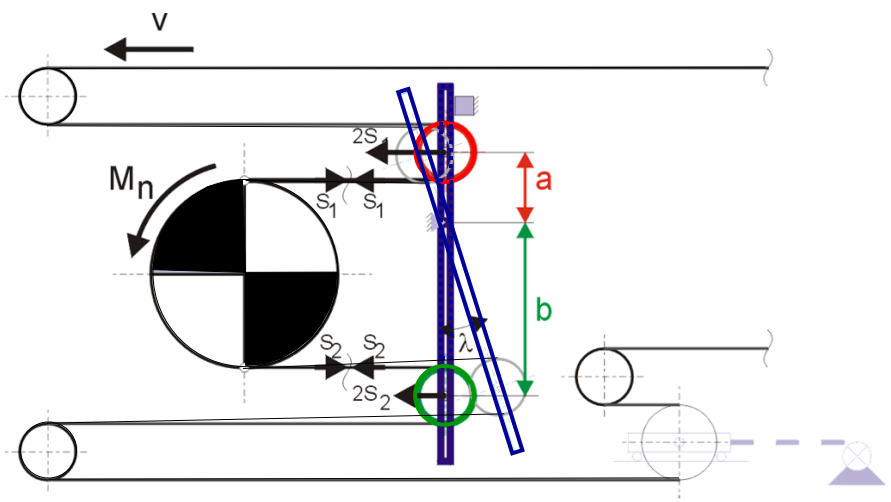
Automatic take-up devices with a periodic operation



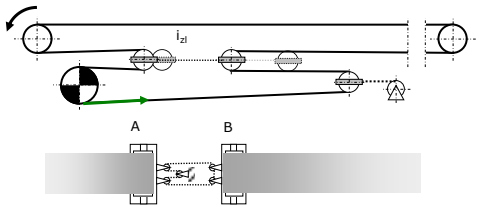
Tensioners in which the tensioning cart is pulled by the rope from a winch driven by an electric motor. They are controlled by three-position controllers, sometimes with the ability to change the force adjustment range for the duration of the conveyor start-up.



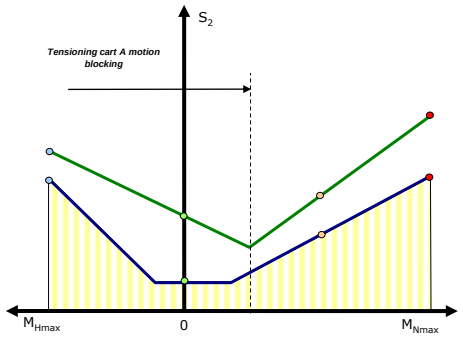
Model of follow-up, mechanical take-up devices



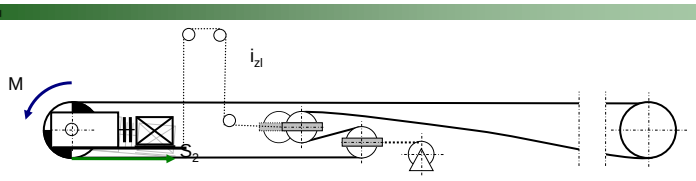
Follow-up, mechanical take-up devices

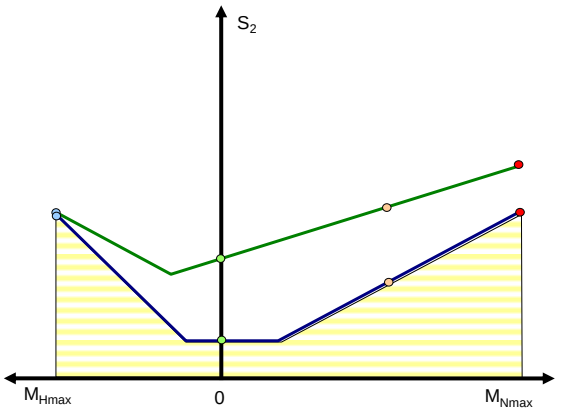


Mechanical tensioners receiving their power from the main drive of the conveyor. Two tried and tested solutions are worth mentioning here.
The first has a tilting drive system suspended from the pulley shaft hanging from a system of ropes and tackle connecting it to the tensioning cart. The tensioning 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 .

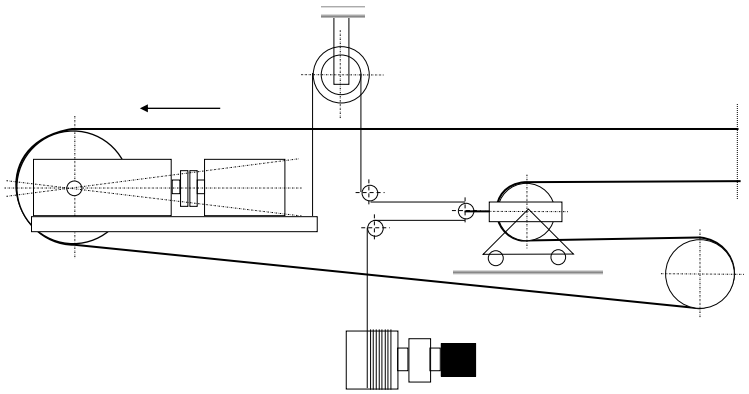


Follow-up Device





Follow-up Device



Centering belt run - Causes of belt mistracking

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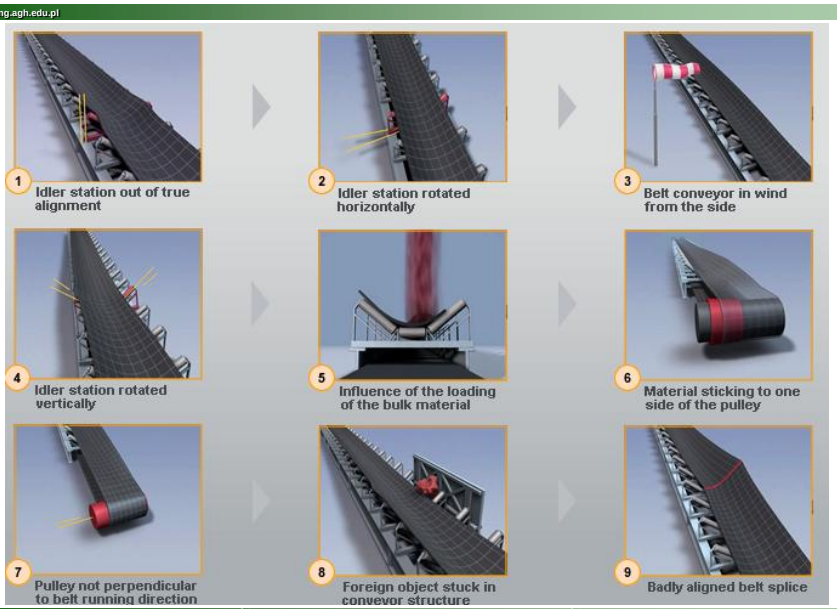
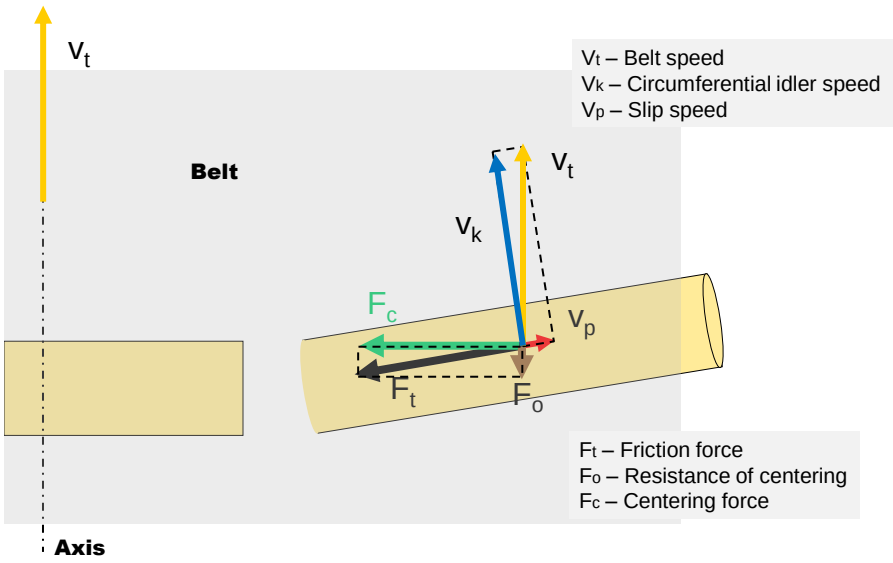


Centering belt run



V_t – Belt speed
V_k – Circumferential idler speed
V_p – Slip speed

F_t – Friction force
F_o – Resistance of centering
F_c – Centering force

Bibliography

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