Department of Mining, Dressing and Transport Machines AGH

Belt Conveyors Calculations

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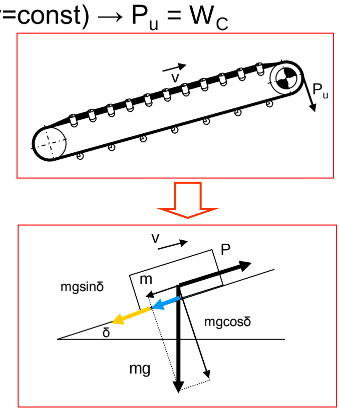
consultations: Mondays 11.00 - 12.00

Stationary work(v=const) → $P_u = W_C$



$$P = W = \underbrace{\mu \cdot m \cdot g \cdot \cos\delta}_{\text{Friction Force}} + \underbrace{m \cdot g \cdot \sin\delta}_{\text{Gravity Force}}$$

Belt conveyor:
μ → f   m → Σmi

$$P_u = W_C = f \cdot \sum m_i \cdot g \cdot \cos\delta + \sum m_i \cdot g \cdot \sin\delta \quad [N]$$

Length related mass of moving parts

- Length related mass of the material handled :

$$m_l' = \frac{Q}{3.6 \cdot v} \quad \text{or} \quad m_l' = \frac{Q_j \cdot \rho \cdot \varphi_{St}}{3.6 \cdot v}$$

ρ bulk density of the material handled

φ_{St} coefficient for determining the volume flow

- Length related mass of the rotating parts of the idlers in a conveyor section :

$$m_k' = \frac{m_{zkg}'}{l_{kg}} + \frac{m_{zkd}'}{l_{kd}} \qquad [kg/m]$$

- Length related mass of conveyor belt :

$$m_t = \frac{B}{1000} \cdot m_{tj} \qquad [kg/m]$$

Theoretical volume flow Q_j (in m3/h) (v = 1 m/s)

Belt width B in mm	Carrying idler tube length l_M in mm	Troughing angle λ of the belt						
		0°	20°	25°	30°	35°	40°	45°
500	200	39	72	79	85	90	94	97
650	250	69	132	145	155	164	171	176
800	315	108	207	226	243	257	268	276
1000	380	174	337	369	396	419	437	449
1200	465	256	493	540	580	614	640	658
1400	530	353	685	750	806	853	888	913
1600	600	466	907	993	1067	1128	1175	1208
1800	670	594	1160	1270	1365	1443	1502	1544
2000	740	739	1443	1581	1699	1795	1869	1920
2200	800	917	1802	1974	2121	2241	2332	2394
2400	870	1115	2196	2406	2585	2730	2840	2915
2600	940	1332	2628	2880	3094	3268	3399	3486
2800	1000	1568	3104	3402	3654	3859	4012	4113
3000	1070	1824	3615	3961	4255	4492	4670	4788
3200	1140	2099	4164	4563	4902	5174	5379	5513

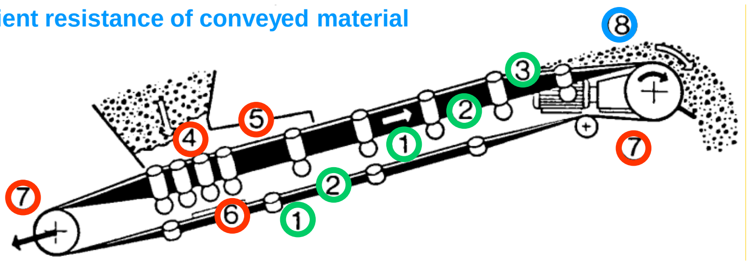
Motional Resistances

1. rolling resistances of the idlers
2. flexing resistance of the belt
3. flexing resistances of the bulk material
4. acceleration resistance and frictional resistance between material handled and belt
5. chute frictional resistance
6. scraper resistance
7. deflection resistance due to belt bending
8. gradient resistance of conveyed material

W_G - Primary Resistances

W_S - Secondary Resistances

W_H - Gradient Resistance



Friction value f for top and bottom run together

Characteristic	Classification of the characteristics		
Inner friction of the material handled	medium	minor	high
Alignment of the conveyor	medium	good	bad
Belt tension	medium	high	low
Operational conditions (dusty, sticky)	medium	good	bad
Idler diameter	108 to159	> 159	< 108
Spacing of idler stations in top run in m	1.0 to 1.5	< 1.0	> 1.5
Spacing of idler stations in bottom run in m	2.5 to 3.5	< 2.5	> 3.5
Belt speed in m/s	4 to 6	< 4	> 6
Troughing angle in °	25 to 35	< 25	> 35
Ambient temperature in °C	15 to 25	> 25	< 15
Friction value f	guiding value ≈ 0.020	result in	
		a decrease	an increase
		of the friction value f	
		down to	up to
		≥ 0.010	≤ 0.040

Note:
Higher safety in the design of the drive units is achieved
– with motor-operated drive units by selecting a higher f value,
– with generator-induced operation of the drive units by selecting a smaller f value.

Secondary Resistances - Coefficient C(L)

The total secondary resistances FN result from the sum of locally limited motional resistances in the top run and return run, particularly at the head and tail of a belt conveyor system:

Bulk material feed

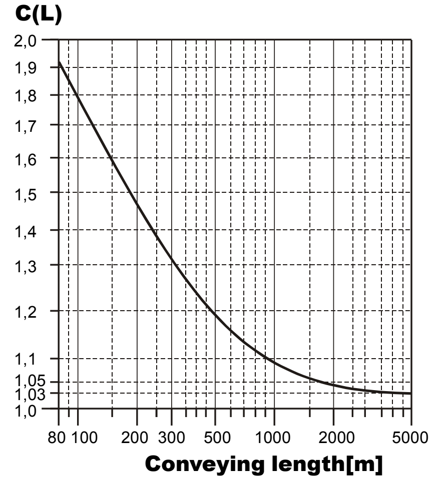
- acceleration resistance and frictional resistance between material handled and belt
- chute frictional resistance

Belt cleaner

- scraper resistance

Pulleys (not driven)

- deflection resistance due to belt bending
- resistance of the pulley bearings



Motional Resistances

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$$W_C = W_G + W_S + W_H + W_D$$

Total primary resistances :

$$W_G = f \cdot L \cdot \left[m'_k + \left(2 \cdot m_t + m'_l\right) \cdot \cos\delta\right] \cdot g \quad [N]$$

Total secondary resistances.

$$W_S = (C-1) \cdot W_G \quad [N]$$

Total gradient resistances :

$$W_H = H \cdot m'_l \cdot g \quad [N]$$

$$W_g = C \cdot f_g \cdot L \cdot \left[m'_{kg} + \left(m_t + m'_l\right) \cdot \cos\delta\right] \cdot g + H \cdot \left(m_t + m'_l\right) \cdot g \quad [N]$$

$$W_d = C \cdot f_d \cdot L \cdot \left[m'_{kd} + m_t \cdot \cos\delta\right] \cdot g - H \cdot m_t \cdot g \quad [N]$$

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Power Required

- **W_C** - total of the motional resistances in top run/return run in a steady state operation
- **v** - belt speed
- **N** - total as a result of loading conditions in a steady operating state of necessary power at the periphery of the driving pulley

$$N = \frac{W_C}{1000} \cdot v \qquad [kW]$$

$$N_C = \frac{N}{\eta^+} \qquad \text{or} \qquad N_C = N \cdot \eta^- \qquad [kW]$$

(motor operated drive) **(generator operated drive)**

Rodzaj napędu	napęd jednobębnowy η^+	napęd wielobębnowy η^+	napęd hamujący η^-
Elektrobęben	0,96		
Electromechanical	0,94	0,92	
Electromechanical + Hydrodynamic Coupling	0,9	0,85	0,95 ÷ 1,0
Hydraulic	0,86	0,80	

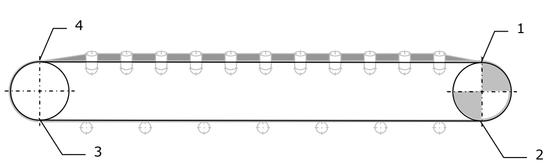
Tension calculations

$$S_2 = \frac{W_c \cdot k_p}{e^{\mu\alpha} - 1}$$

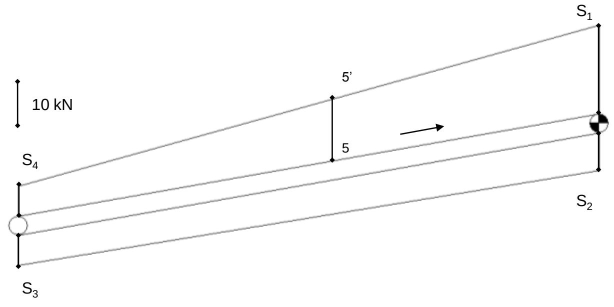
$$S_3 = S_2 + W_d$$

$$S_4 = S_3$$

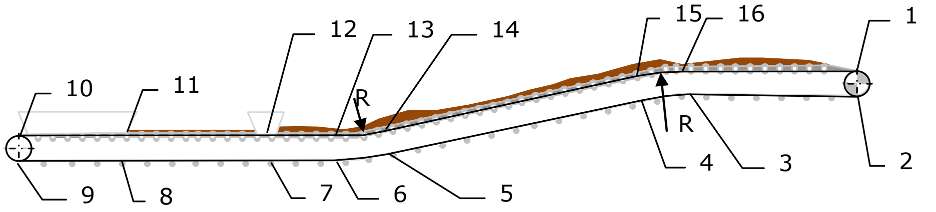
$$S_1 = S_4 + W_g$$

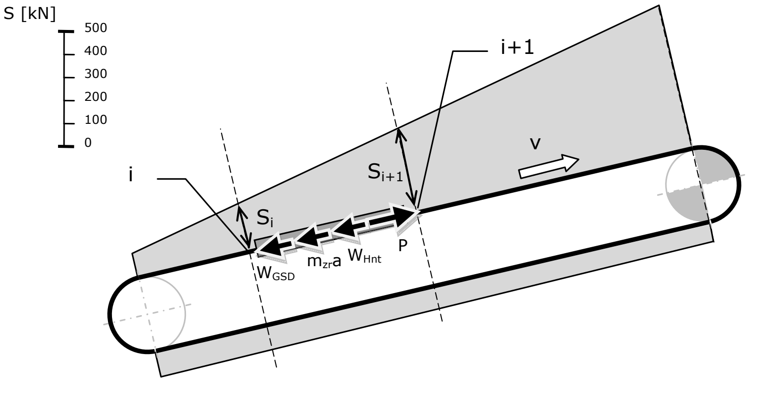


Tensions correction (belt sag) S_{max} = MAX(S_1; S_2; S_3; S_4) [N]



Sections pf belt conveyor





$$S_{i+1} = S_i + W_{GSD(i \div i+1)} \pm W_{Hn(i \div i+1)} \pm W_{Ht(i \div i+1)} \pm m_{zr(i \div i+1)} \cdot a - P_{(i \div i+1)}$$

Belt Type

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- Coefficient of belt splicing **r_p,**
- Maximum belt tension – stationary work **S_{max},**
- Safety factor – stationary work **λ_u,**

$$K_N > \frac{\lambda_u}{1-r_p} \cdot \frac{S_{max}}{B} \quad [kN/m]$$

Carcass	Splicing	Coefficient r_p
B – cotton P – poliamid E – poliester	Cold Vulcanisation	1/z
	Hot Vulcanisation	0
	Cold Vulcanisation – 1 ply	0,3
	Mechanical Splice	> 0.4
St – steel	2	0
	3	0,5(n - 2)

Carcass	Work conditions	Stationary work λ_u
Cotton, Poliamid, Poliester, Steel	good	6,7
	average	8,0
	poor	9,5

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Guide Values for Top and Bottom Cover Gauges

for Textile Carcass and Steel Cord Conveyor Belts for different Uses (in mm)

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Belt type	Use	Material handled	Top side	Bottom side
Textile carcass belts	Mobile belt conveyors	Fine bulk material, light bulk material	2	1
	Loading and unloading plants and coal handling plants	Coal, potassium, gravel, sand, fine ore	2 to 4	2
	Loading and unloading plants, gravel pits, quarries	Lump coal, rocks, rough gravel, ore, overburden	4 to 8	2 to 3
	Excavators and spreaders, crushers	Coarse lumps of rock, ore, overburden	8 to 16	3 to 4
Steel cord belts	Loading and unloading plants and coal handling plants	Coal, potassium, gravel, sand, fine ore	4 to 8	4 to 6
	Loading and unloading plants, coal mines, quarries	Lump coal, rocks rough gravel, ore, overburden	6 to 12	4 to 8
	Excavators and spreaders, crushers	Rocks in lumps, ore, coal, overburden	10 to 20	6 to 10

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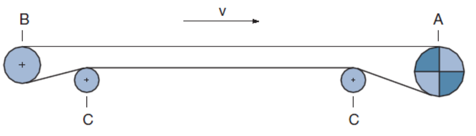
Minimum Pulley Diameters

The pulley diameters in a belt conveyor system depend on the design, on strains and on the type of splice of the conveyor belt. For determining the minimum diameters, the following pulley groups will be distinguished:

– Group A: Drive pulleys and other pulleys in the range of high belt tensions

– Group B: Deflection pulleys in the range of low belt tensions

– Group C: Snub pulleys (change in belt moving direction ≤ 30°)



The minimum pulley diameters for pulleys of groups A, B and C can be determined for four different loading factors with the parameters thickness of the belt carcass d_{Gk} and a coefficient c_{Tr}, which is determined by the material of the tensile member in the belt:

$$D_{Tr} = c_{Tr} \cdot d_{Gk}$$

Material of the tensile member	Coefficient c_{Tr}
B (cotton)	80
E (polyester)	108
P (polyamide)	90
St (steel cords)	145

A pulley diameter so obtained shall be rounded up to the next higher value of the table below.

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$D_{Tr} = c_{Tr} \cdot d_{Gk}$	Minimum pulley diameter in mm (without lagging)											
	Pulley load factor $\frac{k_{max}}{k_N} \cdot 8 \cdot 100$ in %											
	≥ 100 % pulley group			60 % to 100 % pulley group			30 % to 60 % pulley group			≤ 30 % pulley group		
	A	B	C	A	B	C	A	B	C	A	B	C
100	125	100		100								
125	160	125	100	125	100		100					
160	200	160	125	160	125	100	125	100		100	100	
200	250	200	160	200	160	125	160	125	100	125	125	100
250	315	250	200	250	200	160	200	160	125	160	160	125
315	400	315	250	315	250	200	250	200	160	200	200	160
400	500	400	315	400	315	250	315	250	200	250	250	200
500	630	500	400	500	400	315	400	315	250	315	315	250
630	800	630	500	630	500	400	500	400	315	400	400	315
800	1000	800	630	800	630	500	630	500	400	500	500	400
1000	1250	1000	800	1000	800	630	800	630	500	630	630	500
1250	1400	1250	1000	1250	1000	800	1000	800	630	800	800	630
1400	1600	1400	1000	1400	1250	1000	1250	1000	800	1000	1000	800
1600	1800	1600	1250	1600	1250	1000	1250	1000	800	1000	1000	800
1800	2000	1800	1250	1800	1400	1250	1600	1250	1000	1250	1250	1000
2000	2200	2000	1400	2000	1600	1250	1600	1250	1000	1250	1250	1000

k_{max} maximum width related belt tension force in the area of the pulley

k_N width related nominal breaking force of the belt

Bibliography

- Continuous handling equipment – Nomenclature, ISO 2148-1974
- Kulinowski, wykłady „Transport przenośnikowy”, www.kmg.agh.edu.pl
- Phoenix Conveyor Belts Design Fundamentals