How to Calculate Conveying Capacity of Conveyor - Safety Ratio of Belt -

1. Calculating Effective Tension

1A. How to Calculate Pulley Mass on Return Side

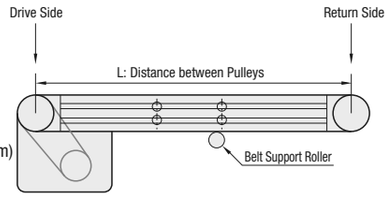
* Calculation formula for Flat Belt Head Drive Conveyor
* The calculation methods for Center Drive and other conveyors are different.

Formula 1

$$Wr=1/4[\pi\cdot(D^2-d^2)]\cdot Lr\cdot Wr1\cdot n/1000^2$$

Wr : Pulley Mass on Return Side (kg)
Wr1 : Pulley Unit Mass = 2.8 g/cm³

n : No. of Pulleys on Return Side (n)
π : Pi (3.14159)
D : Pulley O.D. on Return Side (mm)
d : Pulley I.D. on Return Side (mm)
Lr : Pulley Length on Return Side (mm)



Head Drive Conveyor Image

1B. How to Calculate Effective Tension of Belt

* The effect from belt support rollers is ignored.

Formula 2

$$Te=\{[(Wg+Wb\cdot L\cdot B/1000^2)\cdot\mu1]+(Wr+Wb\cdot L\cdot B/1000^2)\cdot\mu2]\}\cdot g$$

Te : Effective Tension (N)
Wg : Workpiece Mass (kg) Total mass of the workpiece loaded onto a flat belt
Wb : Belt Unit Mass (kg/m²) [Select from "Belt Specification" from **P. 1279**~]
L : Length between Pulleys for Conveyor in Use (mm)
B : Belt Width (mm)
g : Gravitational Acceleration = 9.80665m/s²

μ1 : [Select from Table 1]
μ2 = 0.2* [From Table 1 on **P. 2252**]
* For Head Drive Conveyor, Pulley + Steel Sheet Support

Table 1 - Friction Coefficient of Belt and Base Plate (Reference Value)

Table Material	Friction Coefficient μ1	
	Flat Belt	Timing Belt
Stainless Steel	0.40	0.30
Aluminum	-	-

2. Determining Allowable Tension and Safety Ratio of Belt

2A. How to Calculate Tight Side Tension of Belt

Formula 3

$$F_{M1}=[e^{\mu0\cdot\theta}/(e^{\mu0\cdot\theta}-1)]\cdot Te$$

F_{M1} : Tight Side Tension (N)
e : Base of Natural Logarithm (2.71828)
θ : Contact Angle of Belt and Pulley = 3.14 (rad) [Contact angle of the head drive conveyor should be 180°]
μ0 : [Select from Table 2]

Table 2 - Friction Coefficient of Drive Side Pulley and Belt

Pulley Surface Condition	μ0
Flat Belt and Pulley	0.20
Stainless Steel Belt and Pulley	0.20
Sprocket and Plastic Chain	1.00
Timing Belt and Pulley	1.00

2B. How to Calculate Initial Tension per Belt Unit

Formula 4

$$F_{M2}=Te+Tc\cdot B$$

F_{M2} : Initial Tension of Belt (N)
Te : Effective Tension of Belt (N)
Tc : Initial Tension per Belt Unit (N/mm) [Select from Table 3]
B : Belt Width (mm)

Table 3 - Initial Tension per Belt Unit

No. of Plies	N/mm
1	0.15
2	0.30
3	0.45

2C.How to Calculate Safety Ratio of Belt Compare F_{M1} and F_{M2} and use the larger value as the maximum tension "F_M" to calculate maximum tension per belt unit "C".

$C=F_M/B$

Formula 5

$$S=\sigma/C$$

C : Max. Tension per Belt Unit (N/mm)
F_M : Max. Tension (N)
B : Belt Width (mm)
S : Safety Ratio of Belt (Determination of the safety ratio varies depending on your operating conditions, etc.)
σ : Allowable Tension of Belt (N/mm) [Select from "Belt Specification" from **P. 1279**~]

How to Calculate Conveying Capacity of Conveyor - Maximum Speed of Conveyor and Calculation Example -

3. Calculating Belt Speed

3A. Calculate the power requirement using Formula 6.

Formula 6

$$P=Pm\cdot\eta/1000$$

P : Power Requirement (kW)
η : Machine Efficiency = 0.5
Pm : Motor Output (W)

3B. Calculate the maximum belt speed under load using Formula 7.

Formula 7

$$V=102\cdot60\cdot P\cdot g/Te$$

V : Belt Speed (m/min)
g : Gravitational Acceleration = 9.80665m/s²

*1 The maximum rotation speed of the belt is the upper limit. This maximum speed varies depending on the conveyor type, power supply frequency, and gear head deceleration ratio.

3C. Max. Belt Speed at No-load

Formula 8

$$Vmax=[(Vm/i)\cdot(\pi\cdot DD/1000)]/(Pd1/Pd2)$$

Vmax : Max. Belt Speed (m/min)
Vm : Motor Synchronous Rotation Speed (rpm) [1500rpm@50Hz/1800rpm@60Hz]
i : Motor Gearhead Reduction Ratio
DD : Outer Diameter from Pulley Center to Belt Surface (mm)
Pd1/Pd2 : [Select from the gear ratio in unit for each conveyor model]

Calculation Example: As an example, calculate the safety ratio and the maximum speed of a belt for the conveyor "SVKA".

A. Calculate the pulley mass using Formula 1.

Pulley O.D. on Return Side =28.6mm
Pulley I.D. on Return Side =8.2mm
Pulley Length on Return Side =63mm
Pulley Unit Mass = 2.8g/cm³
No. of Pulleys on Return Side =1
π: Pi (3.14159)
Wr ≈ 0.10 kg...From Formula 1

B. Calculate the effective tension of the belt using Formula 2.

Mass of Workpiece = 5kg
Belt Unit Mass = 1kg/m²
Te = 20.42 N....From Formula 2
Unit Length =2000mm
Belt Width = 50mm
Friction Coefficient of Belt and Base Plate =0.4
Friction Coefficient of Belt and Pulley =0.2

C.Using Formula 3 and Formula 4, calculate the tight side tension of the belt "F_{M1}" and the initial tension by design "F_{M2}" to determine the maximum tension "F_M".

Friction Coefficient of Belt and Pulley =0.2
Initial Tension per Belt Unit = 0.15
F_{M1}≈43.76N F_{M2}≈27.92N
$F_M = F_{M1}$ or F_{M2}, whichever is larger = F_{M1}
F_M ≈ 43.76 N...Determined from Formulae 3 and 4
Contact Angle of Belt and Pulley =3.14(rad)
Belt Width = 50mm

D.Calculate the safety ratio "S" from the maximum tension per belt unit "C" to compare the result with a given safety standard value.

C≈0.88
S ≈ 4.57...From Formula 5
When Safety Standard Value is "2", S > 2 ∴ Compliant
Safety Ratio S > Safety Standard Value: Compliant
Safety Ratio S < Safety Standard Value: NG

E.Calculate the belt speed under load using Formula 6 and Formula 7 and calculate the maximum belt speed at no-load using Formula 8 to verify that V is not greater than Vmax.

Motor Output = 6W
V = 8.41 m/min...From Formulae 6 and 7
Motor Synchronous Rotation Speed = 1500 rpm@50 Hz
Outer Diameter from Pulley Center to Belt Surface = 29.5 (Belt Thickness = 0.9)
Gear Ratio in Unit = 0.5
Vmax = 55.61 m/min ∴ V speed is compliant...Formula 8
Machine Efficiency = 0.5
Motor Gearhead Reduction Ratio = 5

Table 4 - Gear Ratio in Unit

Conveyor Type	Pd1/Pd2	Page
SVKA	0.5	**1197**
SVKB	0.5	**1199**
SVKN	1	**1201**
SVKR	1	**1203**
CVGA	0.5	**1205**
CVGB	0.5	**1207**
CVGC	1	**1209**
CVGD	1	**1211**
CVGN	1	**1213**
CVGP	1	**1215**
CVGR	1	**1217**
CVGW	1	**1219**
CVSFA	0.5	**1221**
CVSFC	0.5	**1223**
CVSFB	1	**1225**
CVSFD	1	**1227**
CVSE	1	**1229**
CVSF	1	**1231**
CVSX	1	**1233**
CVSY	1	**1235**
CVMATM	2	**1237**
CVMABM	2	**1237**
CVMASM	1	**1237**
CVMBTM	2	**1239**
CVMBBM	2	**1239**
CVMBSM	1	**1239**
CVLSA	1	**1243**
CVSJA	1	**1245**
CVSMA	1	**1247**
CVSMB	1	**1249**
CVDSA	1	**1251**
CVSTD	1	**1253**
CVGTA	0.5	**1255**
CVGTB	1	**1256**
CVGTN	1	**1257**
CVGTP	1	**1258**
CVSTC	1	**1259**
CVSTR	1	**1260**
CVSPC	1	**1261**
CVSPA	1	**1262**
CVSSA	1	**1263**
CVSA	0.5	**WEB**
CVSB	1	**WEB**
CVSC	0.5	**WEB**
CVSD	1	**WEB**
CVSN	1	**WEB**
CVSP	1	**WEB**
CVSR	1	**WEB**
CVSW	1	**WEB**
CVSTA	0.5	**WEB**
CVSTB	1	**WEB**
CVSTN	1	**WEB**
CVSTP	1	**WEB**