POWER TRANSMISSION

with

BELTS & CHAINS

Belts – Usages

The analysis of this system is very similar to that of the ideal gear train: in this case, the RELATIVE MOTION of both shafts is IN THE SAME DIRECTION

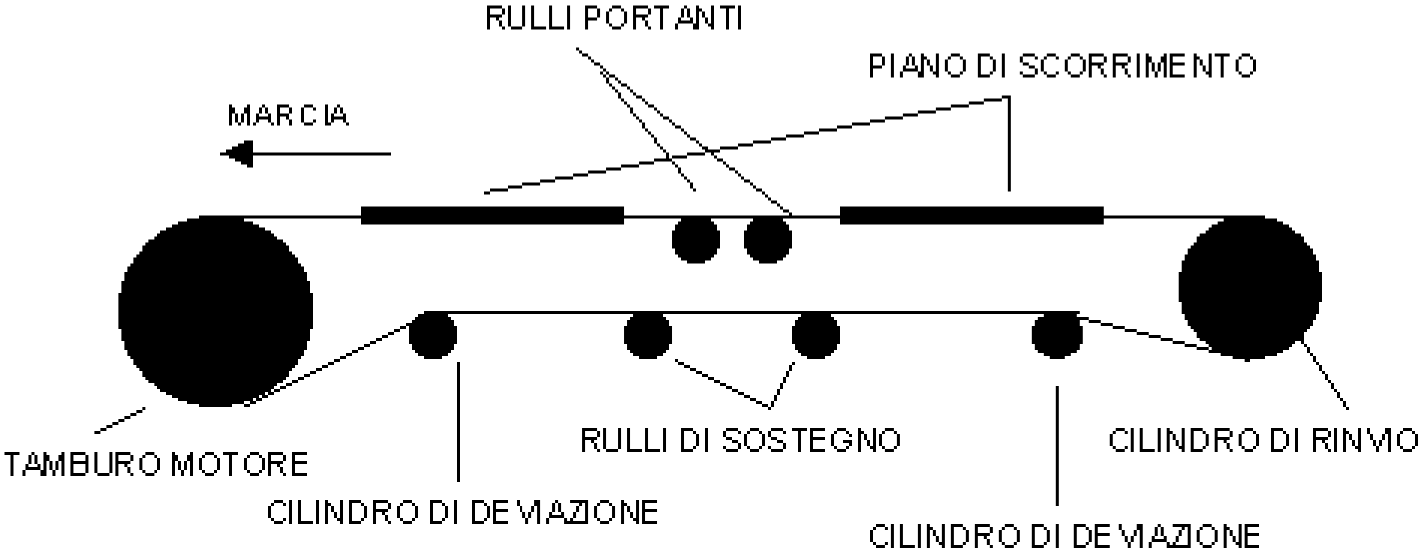
Belts are used to connect two rotating item. Usages are as source of motion (conveyors system) or as a high efficiency power transmission

-a conveyor belt is one application where the belt is adapted to continually carry a load between two points

-power transmission is achieved by specially designed belts and pulleys. The demands on a belt drive transmission system are large and this has led to many variations on the theme

Belts – conveyors

Typical construction of a belt conveyor



Belts – Power transmission

High speed

Layout of the transmission can be designed to match engineering needs.

Flat belts for power transmission

Flat belts:

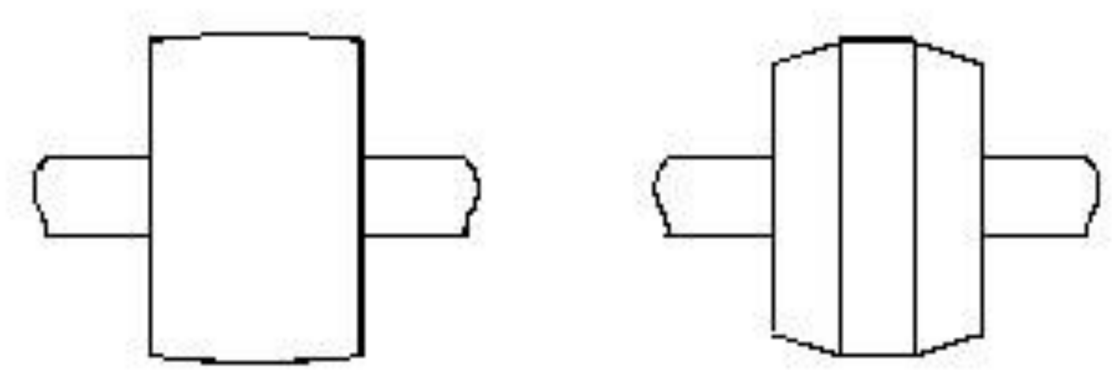
-**Simple construction**
-**Low cost**
-**High flexibility**
-**High tolerance to overload**
-**Good resistance in abhrasive environments**

-**Noisy**
-**Sliding is possible**
-**Low efficiency at low speeds**
-**Tensioning is required**

Flat belts - pulleys

Main problem for flat belts is the belt to go off the pulley.

Crowned pulleys are used to prevent off tracking

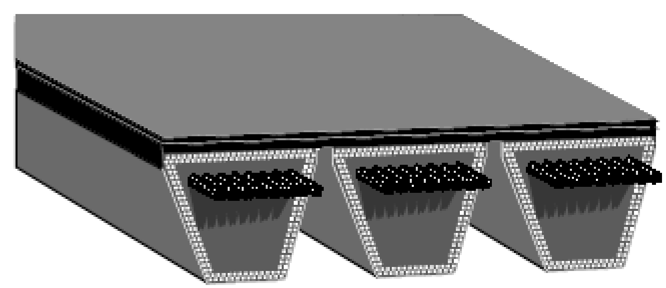


Trapezoidal belts - Overview

The "V" shape of the belt tracks in a mating groove in the pulley (or sheave), with the result that the belt cannot slip off.

The belt also tends to wedge into the groove as the load increases — the greater the load, the greater the wedging action — improving torque transmission and making the vee belt an effective solution.

For high-power requirements, two or more vee belts can be joined side-by-side in an arrangement called a multi-V, running on matching multi-groove sheaves.



Good resistance to overloads

Timing between sheaves may not be accurate

SYNCHRONOUS BELTS (TIMING BELTS)

Synchronous belts are toothed belts where timing is guaranteed by the presence of the teeth. Load is transferred both by the teeth and the belt core.

Synchronous belts – Shape of teeth

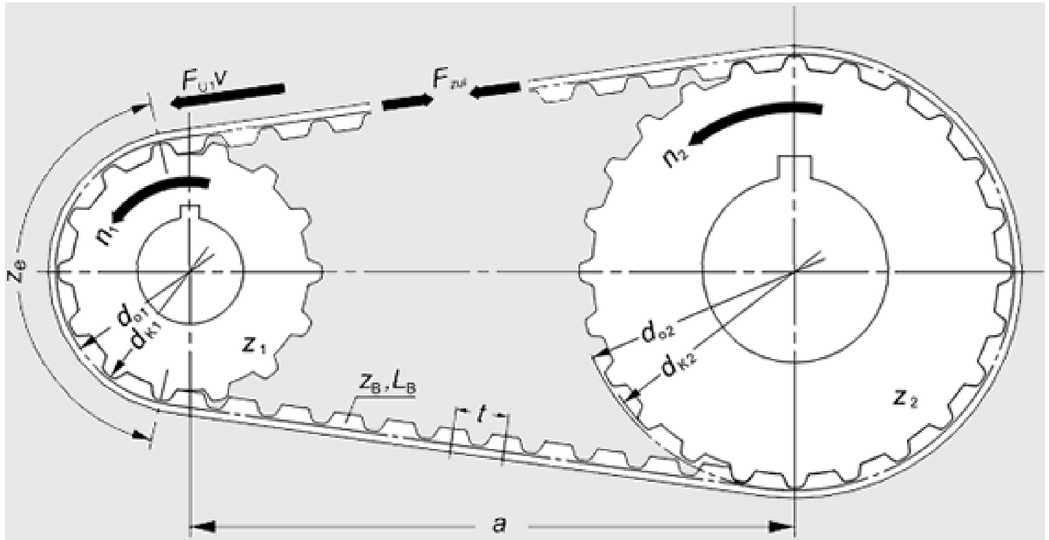
Purpose of tooth optimization is:

-Decrease of noise
-Increase of maximum load
-Increase of life (less wear)
-Increase of maximum speed

Each profile has its own characteristics

SYNCHRONOUS BELTS – TOOTHED PULLEYS

Synchronous belts – Some formulas



Peripheral force	F_U	[N]	Center to center distance	a	[mm]
specific tooth force	F_{Uspec}	[N/cm]	Belt length	L_B	[mm]
Pre-Tension force	F_V	[N]	Belt width	b	[mm]
Shaft force	F_W	[N]	Pulley width	B	[mm]
Torque	M	[Nm]	Bore, pulley	d	[mm]
Acceleration torque	M_B	[Nm]	Pitch circle diameter	d_0	[mm]
specific torque	M_{spec}	[Ncm/cm]	pulley outside diameter	d_K	[mm]
Power	P	[kW]	Span length	L_T	[mm]
specific power	P_{spec}	[W/cm]	Pitch	t	[mm]
Speed	v	[m/s]	Number of belt teeth	z_B	
Rotational speed	n	[min^{-1}]	Number of teeth in mesh	z_e	
Angular speed		[s^{-1}]	No. of teeth, small pulley	z_1	
Acceleration time	t_B	[s]	No. of teeth, large pulley	z_2	
			Number of teeth with i=1	z	
			pulley ratio	i	

Peripheral Force: $F_U = \frac{2 \cdot 10^3 \cdot M}{d_0} = \frac{19.1 \cdot 10^6 \cdot P}{n \cdot d_0} = \frac{10^3 \cdot P}{v}$

Torque: $M = \frac{d_0 \cdot F_U}{2 \cdot 10^3} = \frac{9.55 \cdot 10^3 \cdot P}{n} = \frac{d_0 \cdot P}{2 \cdot v}$

Power: $P = \frac{M \cdot n}{9.55 \cdot 10^3} = \frac{F_U \cdot d_0 \cdot n}{19.1 \cdot 10^6} = \frac{F_U \cdot v}{10^3}$

Angular speed: $w = \frac{\pi \cdot n}{30}$

Rotational speed: $n = \frac{19.1 \cdot 10^3 \cdot v}{d_0}$

Peripheral speed: $v = \frac{d_0 \cdot n}{19.1 \cdot 10^3}$

Pitch circle diameter: $d_0 = \frac{z \cdot t}{\pi}$

Belt Length for i = 1: $L_B = 2a + \pi \cdot d_0 = 2a + z \cdot t$

Belts – dynamic considerations

The variation of the tension of a belt along the driving pulley can be expressed by the following formula:

$$\frac{T}{T_2} = e^{f\theta}$$

Where:

$$T = \text{tension at pulley exit}$$

$$T_2 = \text{tension at pulley exit}$$

$$f = \text{friction factor}$$

$$\theta = \text{winding angle}$$

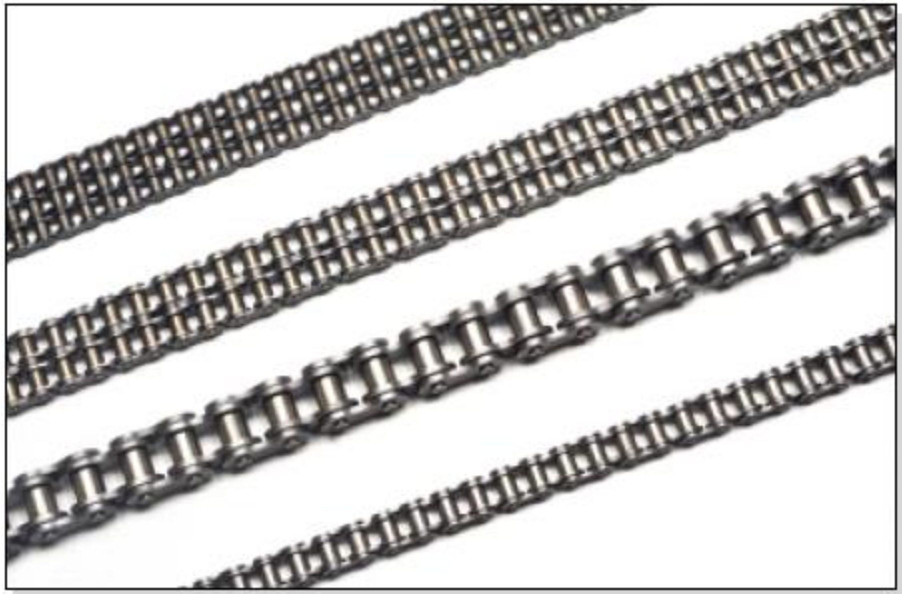
Belts – dynamic considerations

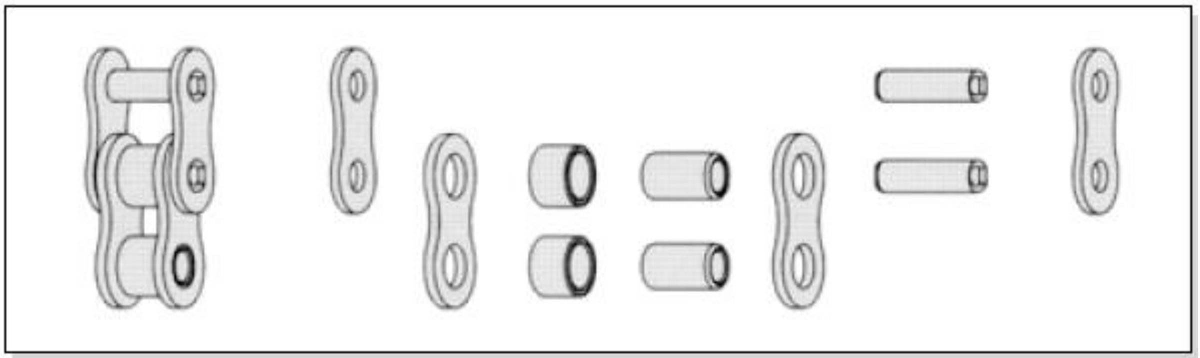
It is possible to increase the transmitted torque by:

- **increasing the friction factor**
- **increasing the winding angle -> Usage of tensioning wheels**

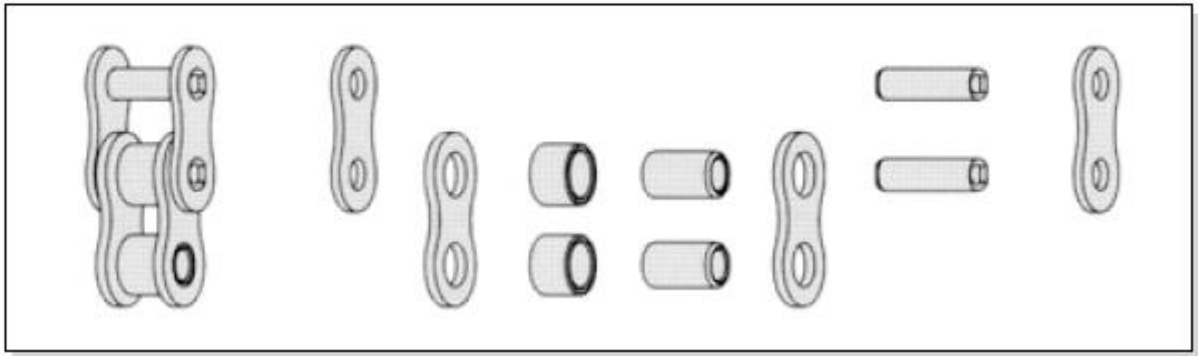
The trasmission ratio equals the ratio of the teeth of the driven pulley and of the driver pulley

Chain drives





Chain drives - definitions

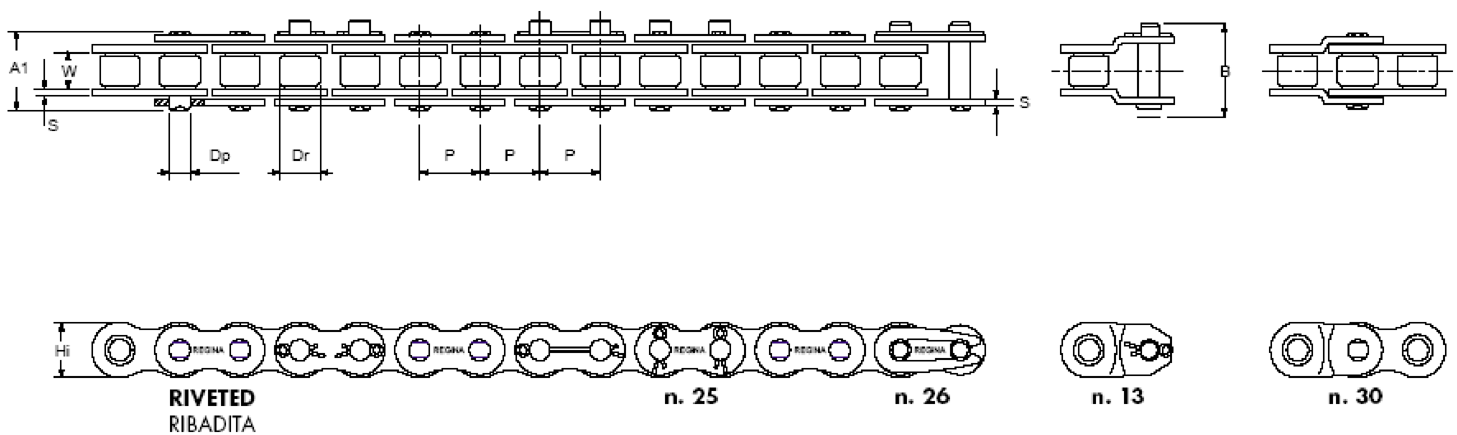


Chain = sequence of inner link and pin link articulated to form a flexible device for power transmission

Main parameters:

- **Pitch: distance between two consecutive pins**
- **Roller diameter: dimension of the outside diameter of the chain rollers**
- **Inside width: distance between the two opposite inner sides of the inner link plates**

Chain drives - dimensions



EUROPEAN SERIES - SINGLE STRAND SERIE EUROPEA - SEMPLICI

	ISO N°	**Regina Chain N°** Codice Catena Regina	**Product Range** Gamma	**Other versions of frequent use** Varianti di uso frequente	**Pitch** Passo		**Roller Diameter** Diametro Rullo	**Inside Width** Larghezza interna	**Plate** / Piastra **Height** Altezza	**Plate** / Piastra **Thickness (nominal)** Spessore (nominale)	**Pin**/Perno **Diameter** Diametro	**Pin**/Perno **Riveted Pin width** Larghezza perno ribadito	**Pin**/Perno **Overall Pin width** Ingombro Perno	**Working Surface** Superficie di lavoro	**Measuring Load** Carico di Misura	**Min. Ultim. Strength** Carico di rottura minimo	**Avg. Ultim. Strength** Carico di rottura medio	**Avg. Weight** Peso approx.	**Standard loose parts** Parti staccate standard **Conn. Link** Giunto	**Offset link** Maglia falsa
					P mm	" inches	**Dr** max mm	**W** min mm	**Hi** max mm	**s** inner/outer mm	**Dp** max mm	**A1** max mm	**B** max mm	mm²	N	kN	kN	Kg/m		
	05 B-1	105	STD	SS	8,00	0,315	5,00	3,00	7,11	0,80/0,70	2,31	8,30	13,00	11	50	4,40	4,90	0,16	26	30
X	-	C120	SPEC-DIM		9,525	3/8	6,35	3,90	8,26	1,27/1,03	3,28	11,00	15,00	22	70	8,90	9,80	0,35	26	30
X	06 B-1	C121	STD	NC - SS	9,525	3/8	6,35	5,72	8,26	1,27/1,03	3,28	12,80	19,00	28	70	8,90	9,80	0,39	26	13-30
X	06 B-1	C121CH	CHROMA		9,525	3/8	6,35	5,72	8,26	1,27/1,03	3,28	12,80	19,00	28	70	8,90	9,80	0,39	26	30
	082	50	SPEC-DIM		12,70	1/2	7,75	2,38	9,91	0,95/0,92	3,66	8,10	10,60	16	120	9,02	9,80	0,26	26	-
	081	53	SPEC-DIM		12,70	1/2	7,75	3,30	9,91	0,95/0,92	3,66	9,30	12,30	20	125	8,00	9,80	0,29	26	30
	083	54	SPEC-DIM	SS	12,70	1/2	7,75	4,88	10,30	1,40/1,40	4,09	12,90	15,90	33	125	11,60	11,80	0,43	26	30
	084	90R	SPEC-DIM		12,70	1/2	7,75	4,88	11,15	1,80/1,63	4,09	14,60	17,60	36	125	15,60	15,70	0,51	26	30
	-	124R	SPEC-DIM		12,70	1/2	7,75	6,48	11,15	1,80/1,63	4,09	16,20	19,00	42	120	14,95	16,00	0,56	26	30

Chain drives - dimensioning

Two load conditions are generally considered for chain dimensioning:

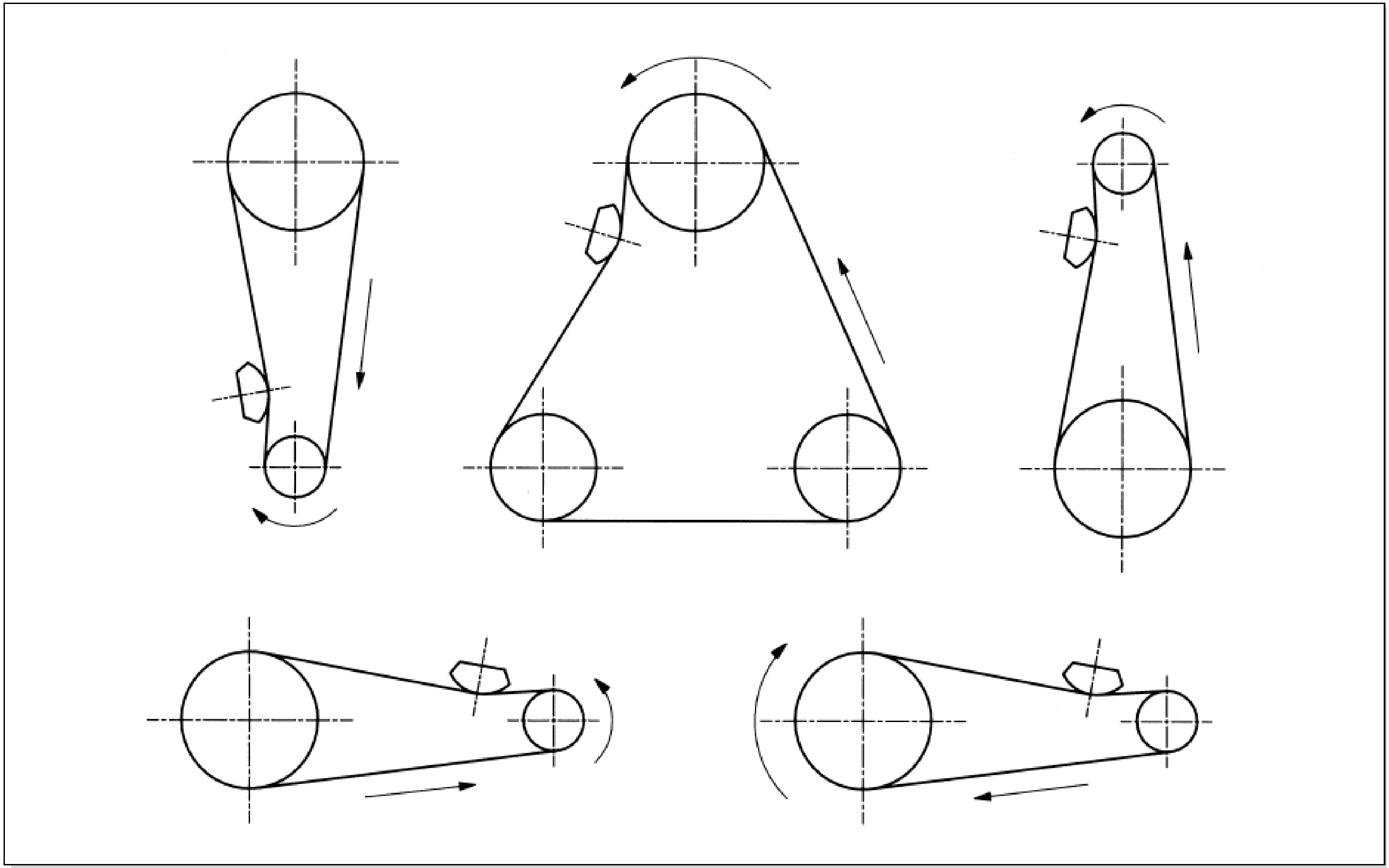
- **Normal tension in the side plates**

- **Shear on the pins**

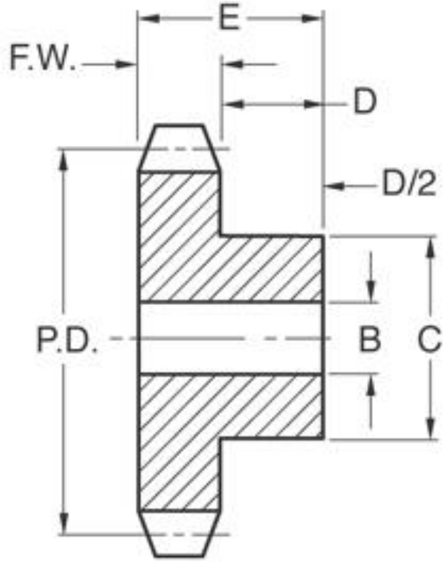
These verification may be useful to identify the load capacity of a chain installed on a mechanism

Chain drives - layout

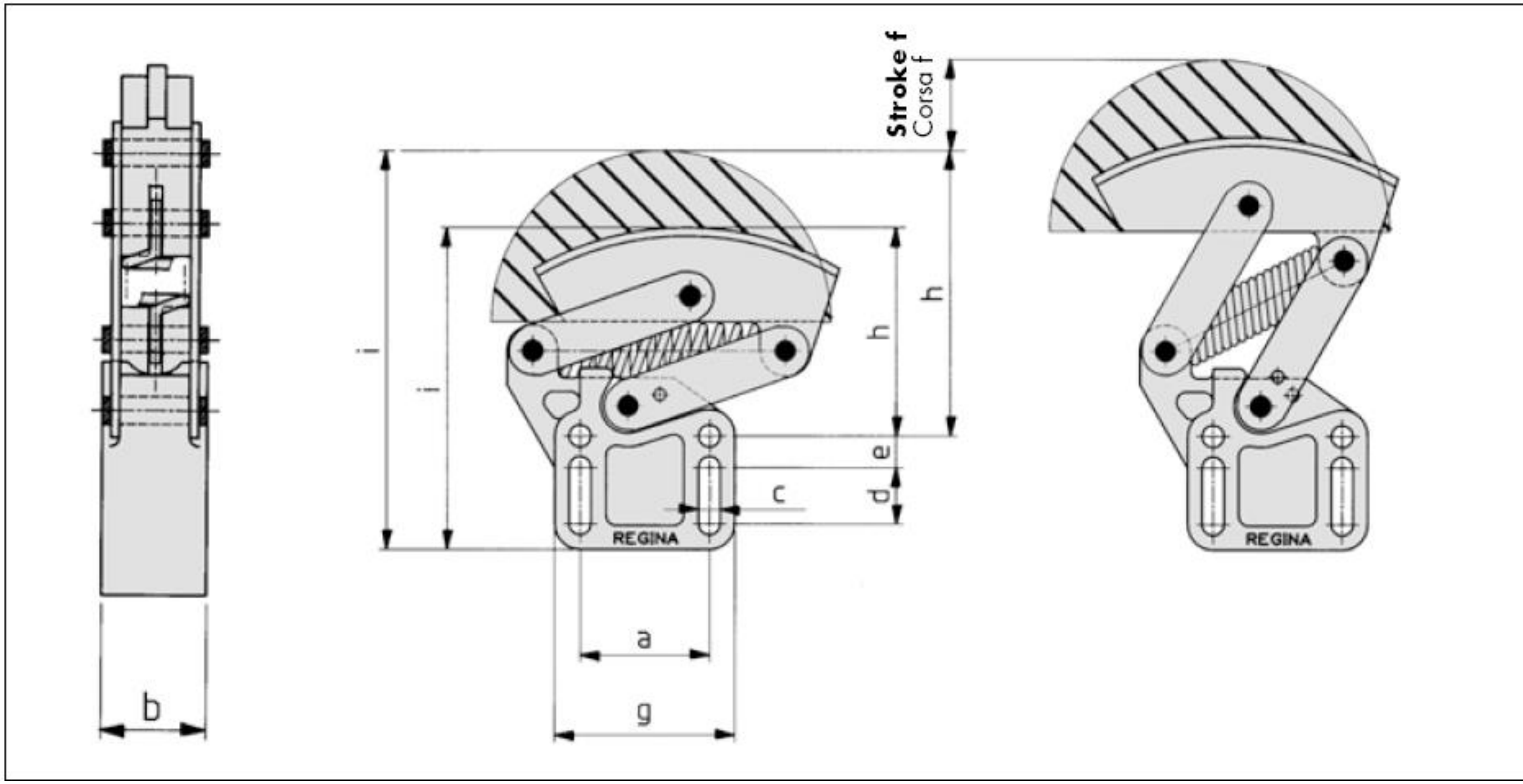
While belts can be used on 3D paths, chain only works on planar paths



Chain drives - Sprockets



Chain drives - Tensioners



Chain drives - Characteristics

Pros:

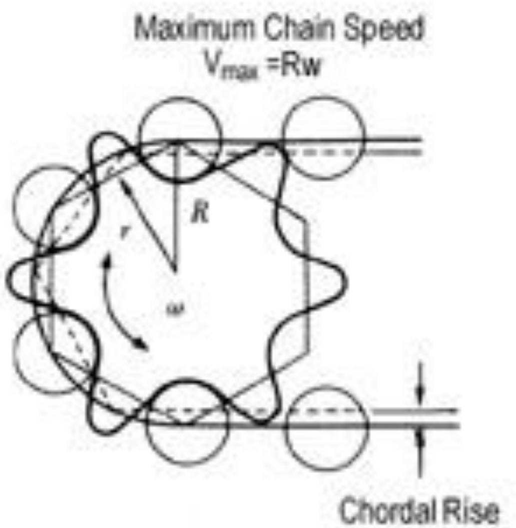
- **Good timing**
- **High loads**
- **Lower winding angle (lower center axis)**

Cons:

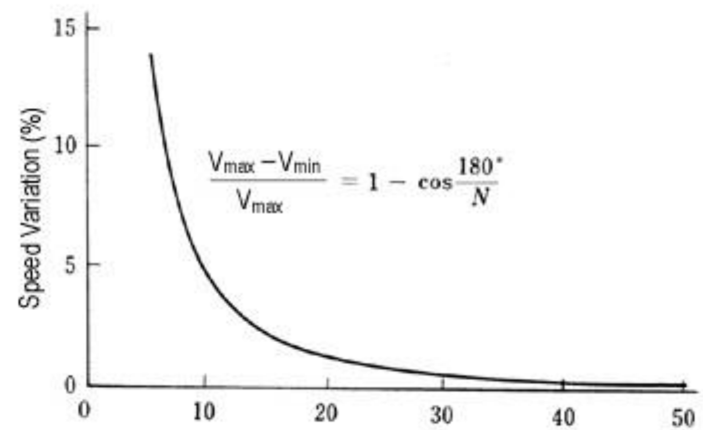
- **Cost (relative to belts)**
- **Lower speed (< 10 m/s)**
- **Frequent maintenance (lubrication)**
- **Noise**

Chain drives - Dynamic

Chordal action



Vibration is induced in the chain by the vertical movement of the chain due to the fact that it can bend only at the pitch point.



Transmissions - summary

Characteristic	Friction wheel	Spur gears	Flat belts	Trapezoidal belts	Toothed belts	Chains
Max power [kW]	80	80e3	200	350	120	400
Max torque [kNm]	5	7000	3	5	1	40
Max linear speed [m/s]	20	20	100	30	60	10
Efficiency	0.95	0.97	0.97	0.97	0.96	0.95
Power function os speed	y	n	y	y	y	y
Max ratio (1 stage)	6-18	6-10	6-8	6-10	6-10	6-10
Tensioning required	y	n	y	y	n	n
Load on bearing	high	low	high	high	low	low
Build precision	average	high	low	low	low	average
Presence of sliding	y	n	y	y	n	n
Noise	low	average	low	low	low	high
Overload limiter	y	n	y	y	n	n
Cost	low	high	low	average	average	average