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INDUSTRIAL PLANTS

Chapter eighteen:

Conveyors

DOUBLE DEGREE MASTER IN

“PRODUCTION ENGINEERING AND MANAGEMENT”

SEAT OF PORDENONE

UNIVERSITY OF TRIESTE

Generality

Transporters of fixed type often with continuous motion are defined **conveyors**. The term "fixed" refers to the fact that the path followed by the carriage is fixed.

The conveyors are divided into:

- **roller conveyors**, motorized or not;
- **belt conveyors**;
- **chain conveyors** (for example overhead conveyors).

These conveyors fixed are advantageous for continuous or periodic transport of materials between the established locations.

Generality

These conveyors are used for:

- form of the piles;
- storing of units load (UdC);
- serve of different levels;
- establish work plans (ad example for the assembly activities).

The general criteria for planning the conveyors must take into account the following:

- size of units transported and the relative weight;
- distances to go;
- control systems;
- capacity (units/time);
- constraints and obstacles present in the layout;
- ergonomic factors (for example noise);
- environment.

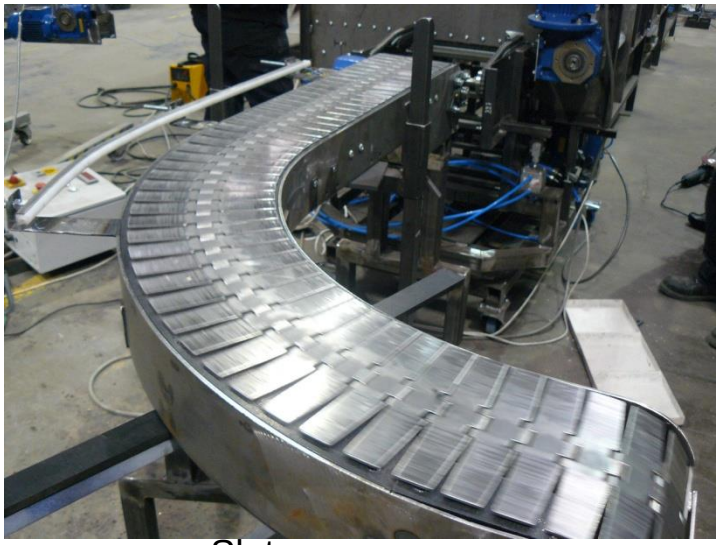
Generality

The conveyors are identifiable in the following types:

a) gravity conveyors

They are useful when the materials are transported for short distances and with simple paths. Examples are found in:

- slide conveyors;
- roller conveyors;
- slat conveyors;
- wheels conveyors.



Slat conveyors

Roller conveyors for washing machine

Generality

The conveyors are identifiable in the following types:

b) motorized horizontal conveyors

They are used in many possible configurations. Examples are found in:

- roller conveyors;
- belt conveyors;
- chain conveyors;

c) conveyor for sorting

They are used to identify necks, preparing the necks for equipment of sorting or sorting into different directions. Examples are found in:

- roller conveyors;
- belt conveyors;
- chain conveyors;

Generality

The conveyors are identifiable in the following types:

Roller conveyors of pallet

Generality

The conveyors are identifiable in the following types:

Curved belt conveyor

Generality

The conveyors are identifiable in the following types:

d) motorized overhead conveyors

They are used to overcome the constraints of layout simplifying the paths. Examples are found in:

- chain conveyors;
- truck conveyor with track;

Overhead conveyor

Chain conveyor

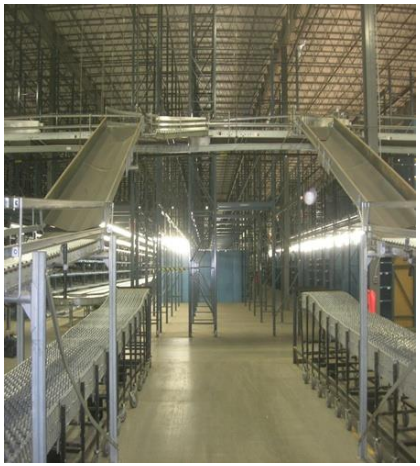
Generality

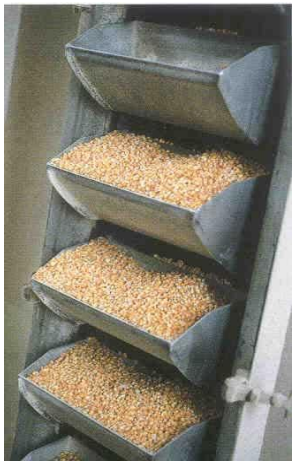
The conveyors are identifiable in the following types:

e) vertical conveyors

Are used to change the level of the loads in a continuous manner. Examples are found in:

- belt conveyors;
- chute conveyors;
- bucket conveyors;
- slat conveyors.





Roller conveyors

The **roller conveyors** are constituted by a series of rollers mounted on suitable supporting structures usually metal. Are usually employed for the transfer and accumulation of necks or rigid units (for example, ingots, sheets, plates, containers, pallets etc.) and with a supporting surface smooth to avoid stick-slip.

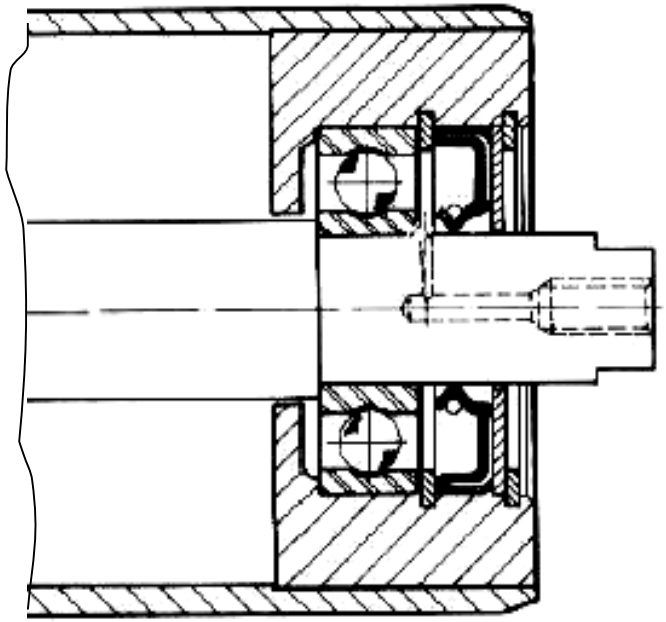
The roller conveyors can be divided into:

- **horizontal roller conveyors**: where the supporting structures are arranged in plan, whereby the movement of materials on roller tables takes place only after the intervention of man or a mechanical means;
- **roller conveyors at gravity**: the slope of the supporting structures causes the advancement of the material by gravity;
- **motorized roller conveyors**: the rotation of all or part of the rollers is provided by motors, chains and belts.

Roller conveyors

Roller conveyors

The rollers are made of tubes of steel, bare or covered with PVC, mounted on ball bearings. The bearings are keyed on a support shaft fixed, which crosses the roller and rests on the supporting structure.



Roller conveyors

The choice of the rollers depends on:

- amount and type of load, which affect on materials, lubrication and protection;
- environmental conditions, which affect on the lubrication and protection;
- conditions of operation (continuous, intermittent, maintenance level), that affect on the sizing.

The rollers in the basis of the lubrication can be classified in the following way:

- lubricated rollers during construction;
- lubricated rollers being built and fitted with grease;
- rollers are permanently lubricated.

For the determination of the load weighing on the rollers, it is considered in general that 50-75% of the underlying roller to a neck it actually bear the load.

The percentage of the rollers concerned depends on the rigidity of the base of the neck.

Roller conveyors

Given the weight of the neck P(N) and the number of rollers x which support it, the load uniform nominal Q(N) is:

$$Q = \frac{P}{x}$$

The actual load Q_e which burden on each roller depends on the quality of the surface of support of the necks.

We introduce a dimensionless coefficient K_a which takes into account the maximum load on each roller:

$$Q = \frac{P}{x} \cdot K_a$$

where:

K_a = 2 when the number of rollers subjected to the neck is x > 3 (plan of support rigid and undeformable);

K_a = 1,5 when the number of rollers subjected to the neck is $x \geq 3$, but the support surface is not rigid.

Roller conveyors

The choice of the type of roller (rollers idle) is carried out by comparing the data Q_e with the real load capacity of the rollers C_r, which depends on the static and dynamic load bearable by the same.

However, it should be:

$$\mathbf{C_r > Q_e}$$

The wheelbase (or pitch), l (mm), is the mounting distance between the rollers.

The minimum distance between rollers, to avoid stick-slip, is what allows to have always a support of at least three rollers.

Thus, if L is the length (mm) of the neck in the direction of travel:

$$I_{\min} = \frac{L}{3} - 15$$

The work environment may be dirty, dusty, corrosive and/or wet (washing in the food industry). In such situations must be foreseen protections of the bearing and suitable materials for the rollers.

Roller conveyors

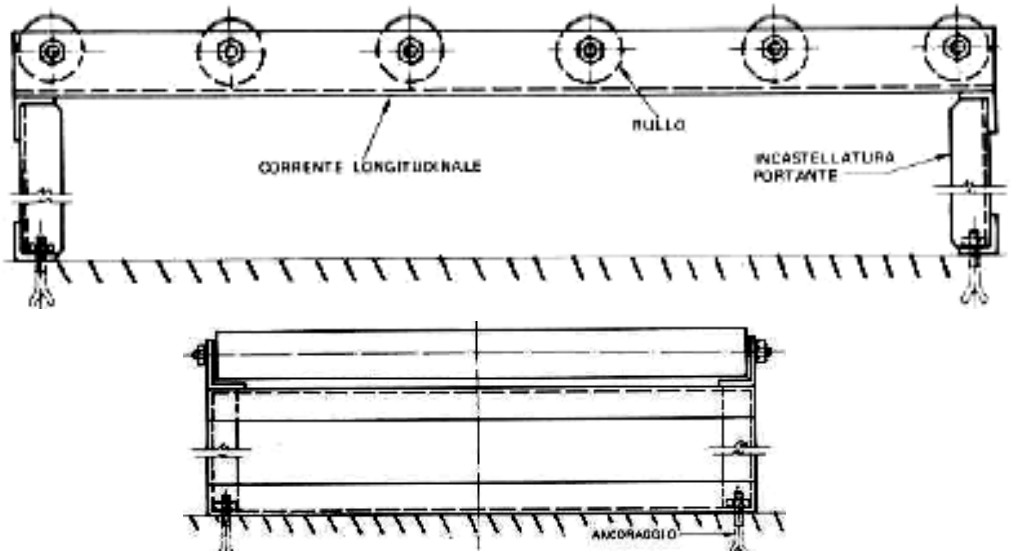
The supporting structure is often made with vertical metal profiles (gantry) which support two longitudinal currents to C or L on which are mounted the rollers.

Rollers conveyors coateg with PVC

Roller at watertight

Roller conveyors

The supporting structure is often made with vertical metal profiles (gantry) which support two longitudinal currents to C or L on which are mounted the rollers.

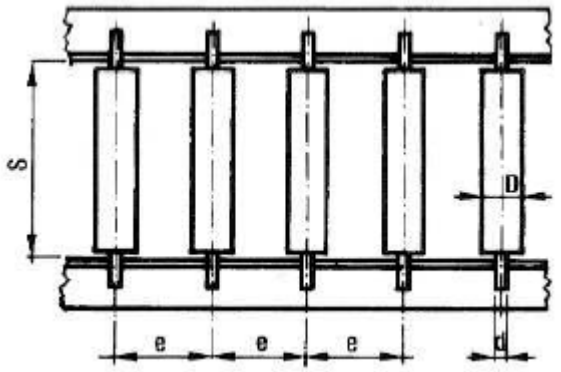


Structures supporting of the roller conveyors with floor anchoring

Roller conveyors

Often the structures are made to elements of equal length (3¸6 m), which are then coupled by bolting.

The dimensional characteristics are the following main:



Diameer of rolles D (mm)	Diameter of trees d (mm)	Lenght of the rollers L (mm)
20 – 30	5 – 6 – 7 – 8 – 10	200 – 250 – 315 400 – 500 – 630 800 – 1000 – 1150
40	8 – 10 – 12 – 14 – 15	
50 – 60	10 – 12 – 14 – 15	
76 – 89	15 – 20 – 25	
102 – 108	20 – 25 – 30	
133 – 159	20 – 25 – 30 – 40	
Lenght between the currents: S = lenght of beat of the roller + 2 mm – minimum pitch e = D + 2 mm		

Roller conveyors

The length of the useful table S (mm), if B is the width (mm) of the neck perpendicular to the direction of travel, in the case of entirely rectilinear sections can be assumed to be:

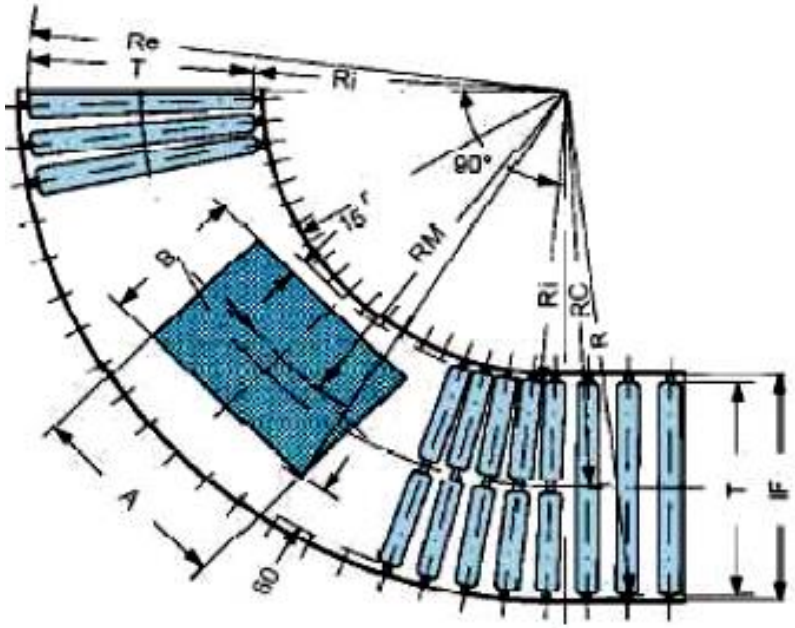
$$S_{\min} = B + 50$$

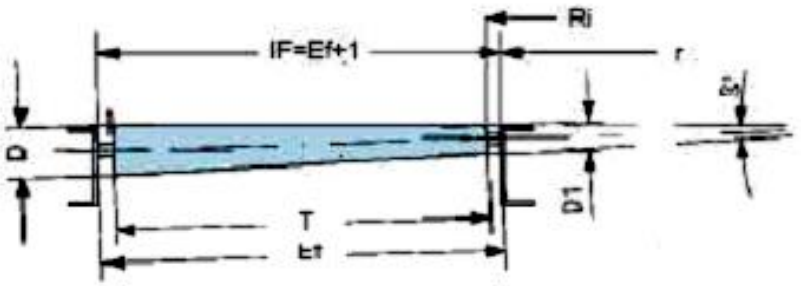
In the case of mixed traits, indicated with R_i the inner radius of the curve (mm), it can adopt the report:

$$S = \sqrt{(R_i + 15 + B)^2 + \left(\frac{L}{2}\right)^2} + 60 - R_i$$

The previous report applies to curves formed by cylindrical rollers, tapered or double in axis.

Roller conveyors





where:

A = length of the neck

B = width of the neck

T = length of the roller

R_i = inner radius of the roller

R_M = average radius of travel of the neck that is:

$$R_M = R_i + 15 + \frac{B}{2}$$

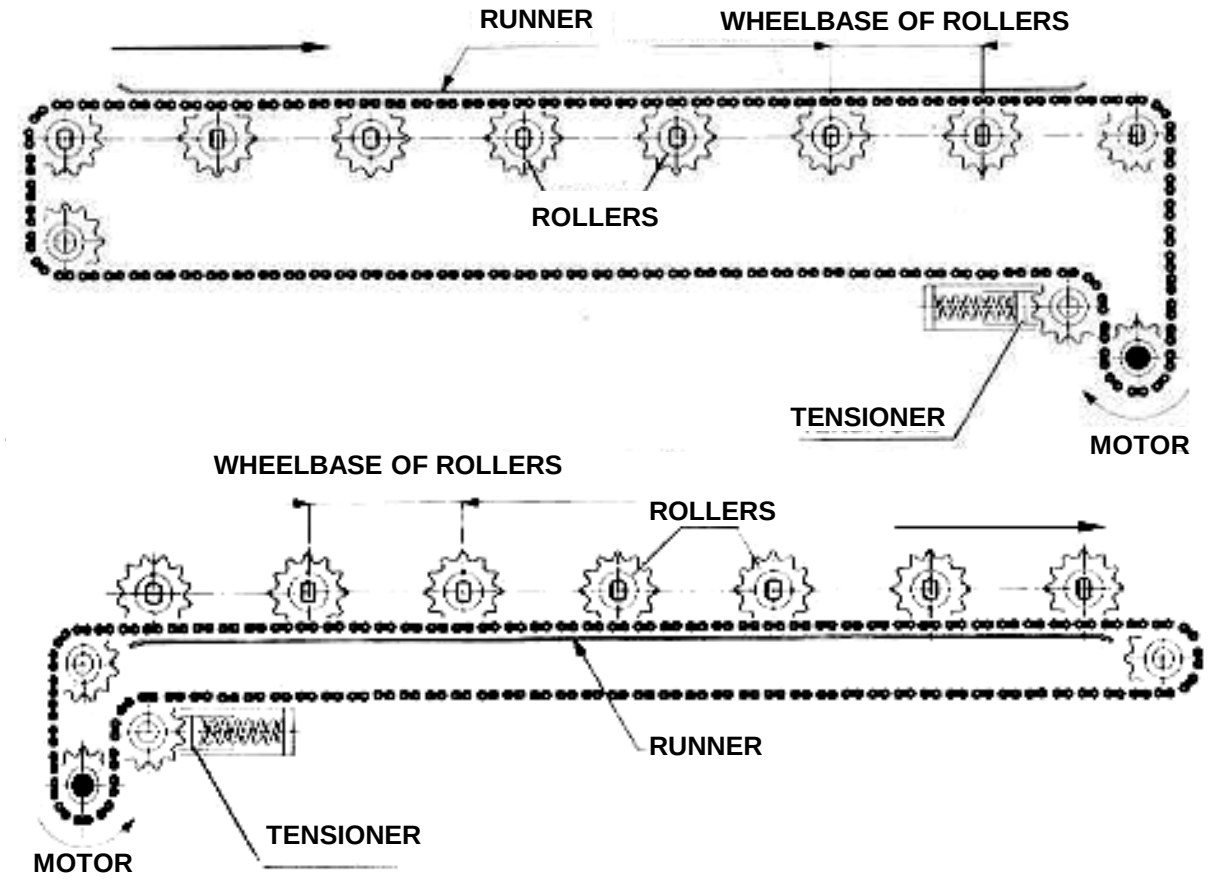
Roller conveyors

In the case of horizontal conveyors, the advancement of the material takes place:
- at push;
- by means of motorized rollers.

There are several possible solutions for the motorization.

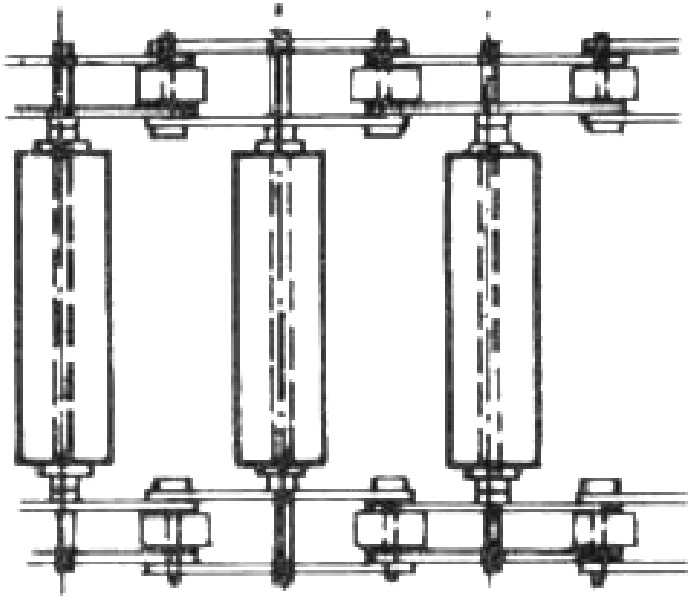
We have the motorized chains that can control the rotation of the rollers or the advancement of the rollers. In the second case because the rollers can turn in neutral, if the UdC transported encounters an obstacle, you can accumulate to create of the convenient accumulations**.**

Roller conveyors



Rollers driven by chain through crown or simple pinion (tangential chain)

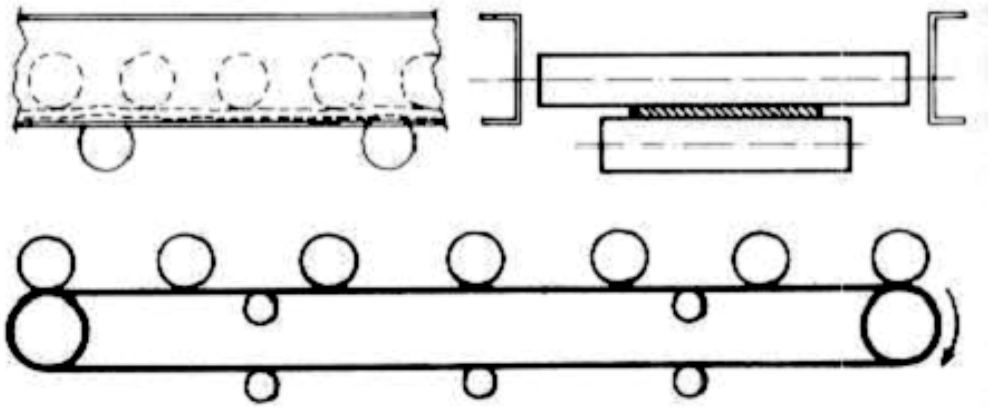
Roller conveyors



Roller conveyor with chains hauling continuous on both sides

Roller conveyors

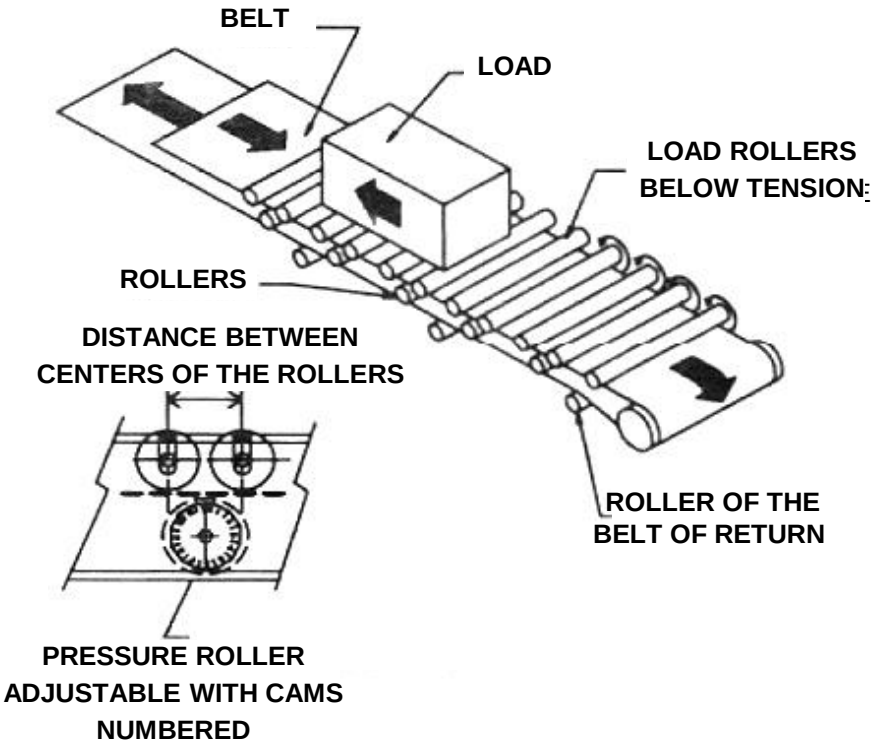
It can do slide a tape against the lower generating line of the rollers. The conditions of rolling of the rollers are secured by rollers, spaced in a suitable manner, which press the tape in motion against the support rollers. It is necessary that these necks are equipped with surface of supporting smooth and stiff.

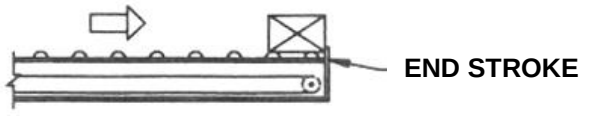


Roller conveyor driven by tape or by a flat belt with rollers pressing the underlying

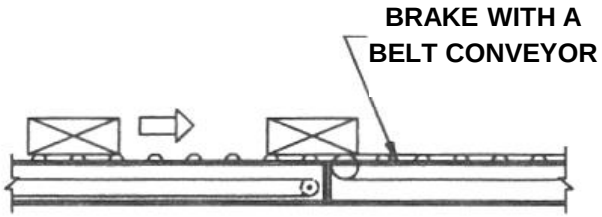
Roller conveyors

The control devices allow to apply different pressures to the tape in order to exploit the conveyor for accumulation of UdC. It is possible to build systems that slow roller conveyor sections the progressive accumulation of the UdC.





MODE I (NO ISSUE)



MODE II (ISSUE OF THE BRAKE BAND)

Roller conveyors

Belt conveyor to accumulation

Roller conveyors

Other solutions are possible.

In the case of rollers conveyor in sloping and idle rollers you can take advantage of the gravity to the advancement of necks. A slope of 3 to 6% is usually sufficient.

You must take into account:

- weight of necks;
- type of material in contact with the rollers;
- regularity of the support surface.

In practice, it may take the following values of slope:

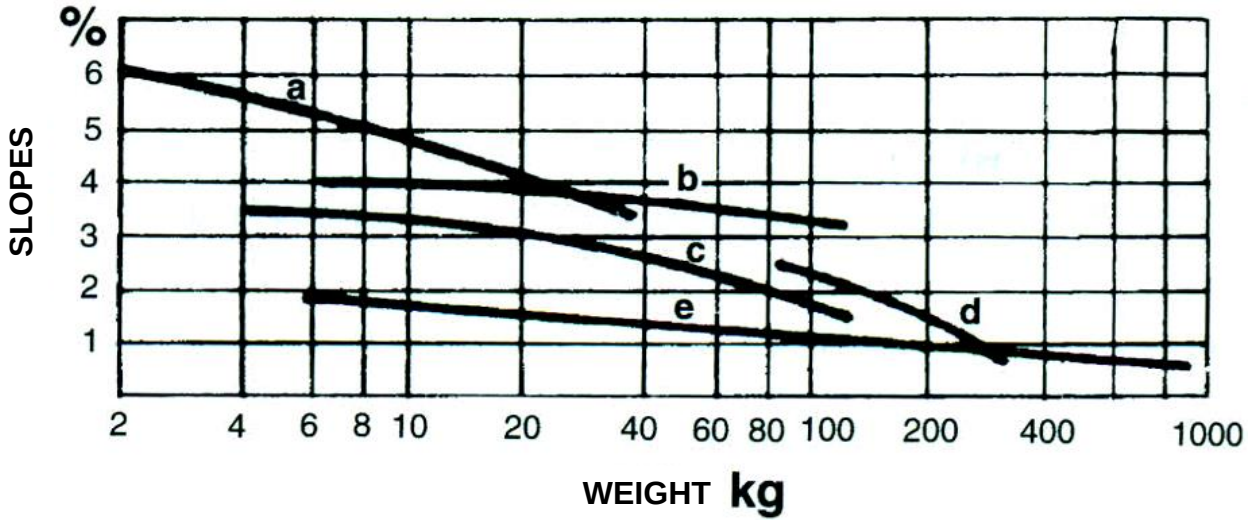
- 8,5%, with the supporting surface of the load on the rollers in cardboard;
- 4,5%, with the supporting surface of the load on the rollers in wood;
- 2,5%, with the supporting surface of the load on the rollers in metal.

Roller conveyors

Conveyors in sloping with rollers "idle"

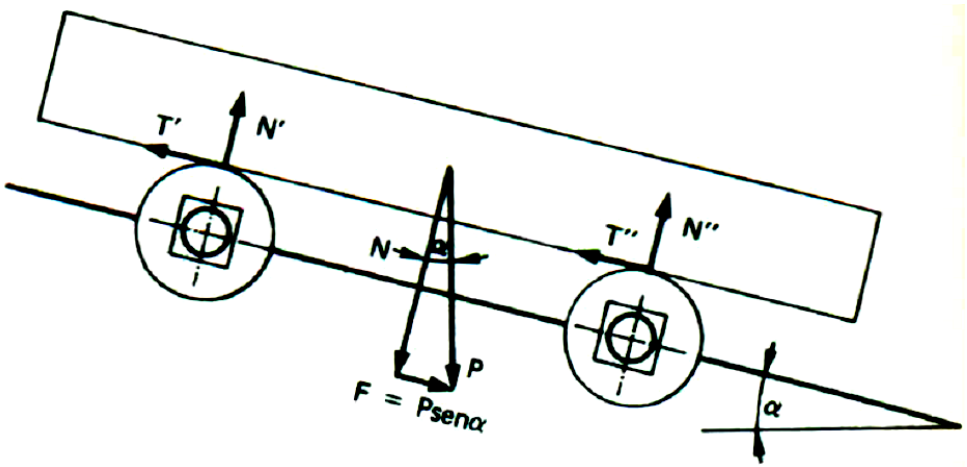
Roller conveyors

The graph below allows to determine the minimum slope of the conveyor roller mounted on ball bearings depending on the weight and type of materials handled (a: cardboard boxes, b: packing cages, c: wooden boxes, d: drums , and: brackets of foundry).



Roller conveyors

The motion of the necks to flat faces on the idle rollers of a conveyor by gravity in the absence of slippage is:



It can write:

$$T < \mu' \cdot N$$

where:

$T = T' + T''$

μ' = parameter of friction between the necks and rollers

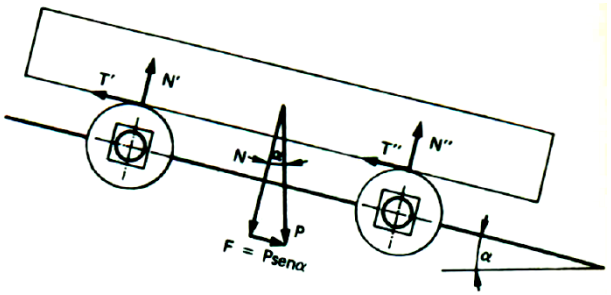
$N = N' + N'' = P \cos\alpha$

P = weight of a single neck

Roller conveyors

The dynamic equilibrium of an object that rests on two rollers, inclined of the angle α on the horizontal, can be expressed by the relation:

$$F - T = \frac{P}{g} \cdot a$$



where:

T = resultant of the two friction forces:

$$T = N \cdot \left(\frac{\mu}{R} + \frac{f \cdot r}{R} \right)$$

μ = parameter of rolling friction

f = coefficient of friction in the pins

R = radius of the rollers

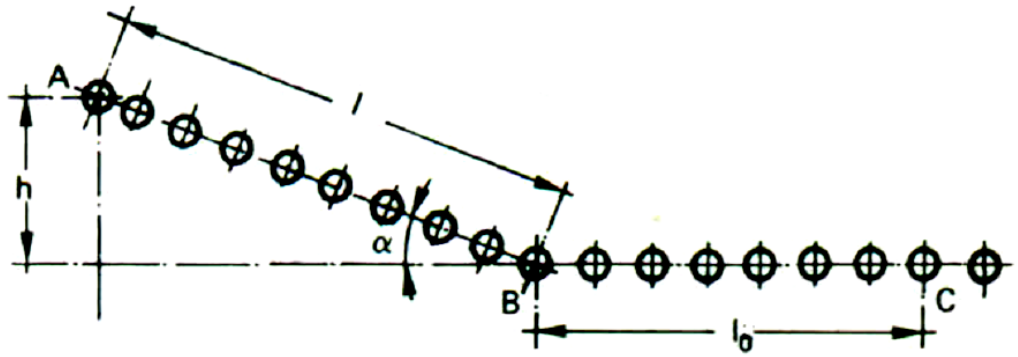
r = radius of the pins

Roller conveyors

The motion of the neck is uniformly varied with acceleration:

$$a = g \cdot \left(sen\alpha - \frac{\mu + f \cdot r}{R} \cos\alpha \right) \approx g \cdot (tg\alpha - k)$$

Notes the speeds v_A e v_B, what are the relative speeds at points A and B



it can write the equality of the kinetic energies:

$$\frac{1}{2} \cdot m \cdot v_B^2 = \frac{1}{2} \cdot m \cdot v_A^2 + m \cdot a \cdot l$$

where can get the v_B:

$$v_B = \sqrt{v_A^2 + 2 \cdot a \cdot l} = \sqrt{v_A^2 + 2 \cdot g \cdot (tg\alpha - k) \cdot l} = \sqrt{v_A^2 + 2 \cdot g \cdot \left(\frac{h}{l} - k \right) \cdot l}$$

Roller conveyors

The length l_o of the tract of the horizontal roller conveyor, necessary to cancel the speed v_B reached by the neck B, is achieved by imposing:

$$\frac{1}{2}\cdot m\cdot v_B^2 - m\cdot g\cdot\left(\frac{\mu + f\cdot r}{R}\right)\cdot l_o = 0$$

which gives:

$$l_o = \frac{v_B^2}{2\cdot g\cdot k} = \frac{v_B^2}{2\cdot g\cdot\left(\frac{\mu + f\cdot r}{R}\right)}$$

As for the rollers, instead, it takes building on the bearings, the choice of which depends on the maximum weight that they must bear: this assumes that you can evaluate in advance how many rollers it distributes the load to be transported.

It must also take into account the deformation of the tree which causes an additional moment applied on the bearing. Chosen the bearings define the diameters of the shaft and roller, it is important to specify the thickness of the roller.

Wheel conveyors

The **idle wheels conveyors** allows at neck in transit on the line of to be moved while maintaining its position relative to the axis of the line itself and are employed in the case where the loads to be handled are lightweight and have a flat bottom.

It mainly consists of a frame in bent sheet steel of high thickness, and by trees of union of the frame on which are mounted of the idle wheels, or printed in light alloy, mounted on ball bearings.

They are transport systems ideal for the end of the line semi-automatic packaging and are installed in environments where the operating space is reduced. They are suitable for the transport or the accumulation of boxes with flat base (wheels) or for plastic containers (rollers to three sectors).

Wheel conveyors

The diameter of the wheels or rollers is around 50 mm; more than one wheel is keyed on the same tree, and the distance between the trees is approximately 80-100 mm.

The advantages are due to the lightweight, low cost compared to other conveyors and minimal friction resistance.

Can also be motorized and can be extensible.

Wheel conveyors

Extendable roller conveyor

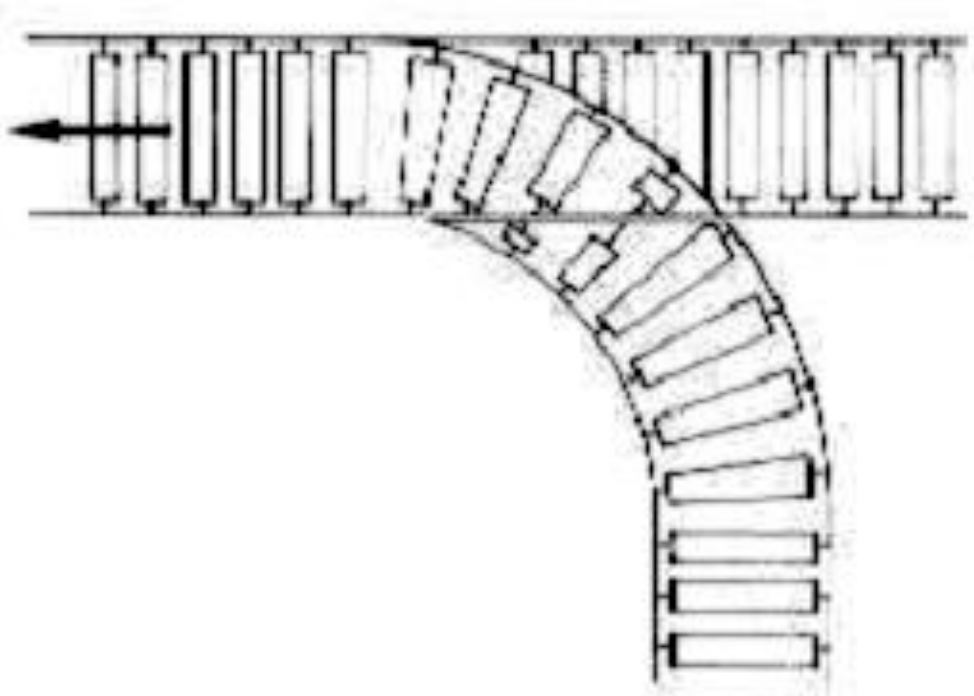
Gravity roller conveyor

Wheel conveyors

Other basic elements for the realization of systems of rollers or wheels conveyors, driven or idle, are the sections of deviation that include curved (tapered roller) and switches that enable the material not to do non rectilinear paths, or to divert the loads from one or more roller conveyors or more carriers of the same type.

Wheel conveyors

It is therefore possible to have connections of two roller conveyors by means of curve inserted between them.



Wheel conveyors

It is also possible to have the different levels appropriate between the conveyors the rollers of feed and reception in order to download of necks light.