Marbett Conveyor Components
Engineering Manual

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1 - WHY MARBETT CONVEYOR COMPONENTS ?

Marbett conveyor components give the facility for simple cad design: a conveyor becomes an assembly of basic parts with the drawing being available on cad.

The design of Marbett conveyor components is flexible for the application, presents no protruding sharp edges - preventing injuries to personnel, parts are easy to clean and materials used are the finest quality virgin materials, always certifiable.

Conveyors made with modular conveyor components are easy to modify when production needs some change in plant lay-out, or product being handled.

Functional reliability is proven by years of use by main OEM and stock availability allows the OEM to keep very little stock, which is less likely when they use their own design components.

Rexnord Marbett seeks co-operation with customers to make new products or modify products if the existing do not fit the needs.

2 - FORCES ACTING ON CONVEYORS

2.1 FUNCTIONAL FORCES:

- weight of products
- weight of chains and frame
- A) Pressure of accumulating products
- B) Sudden start or stop
- C) Friction between chain and curve track
- D) Centrifugal forces of products
- E) Side transfer action

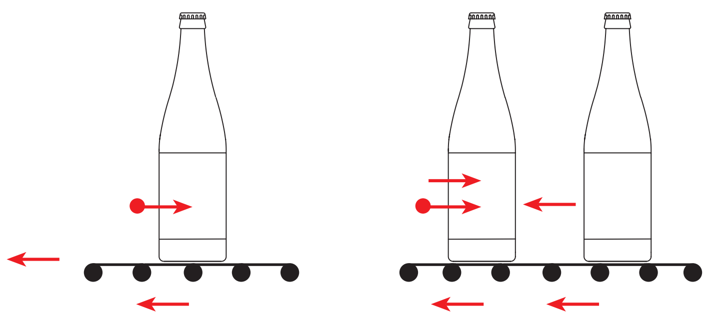
The first two forces are always well known and expressed in Kg/m of conveyor length or N/m of conveyor length. The others need a little more explanation.

A) Pressure of accumulating products

Each product accumulating against an obstacle pushes this obstacle with a force given by its weight multiplied by the coefficient of friction on the chain. Each following product is pushing with the same force against the first so the resulting accumulation force is proportional to the total weight of products upstream.

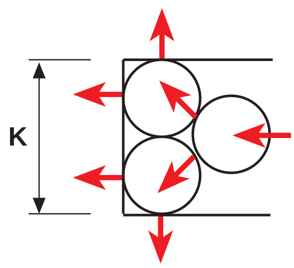
$$Fa = Wa \cdot La \cdot fm$$

where Wa is the weight of accumulating products in Kg/m
La is the length of accumulation in m
fm is the coefficient of friction between chain and product
Fa is the resulting force in Kg ; to have it in Newton simply multiply by 9.81



This force gives a pressure because with round products it acts also on the side guards and gives a force proportional to the number of products in contact with the surface.

$$P = Fa / K$$



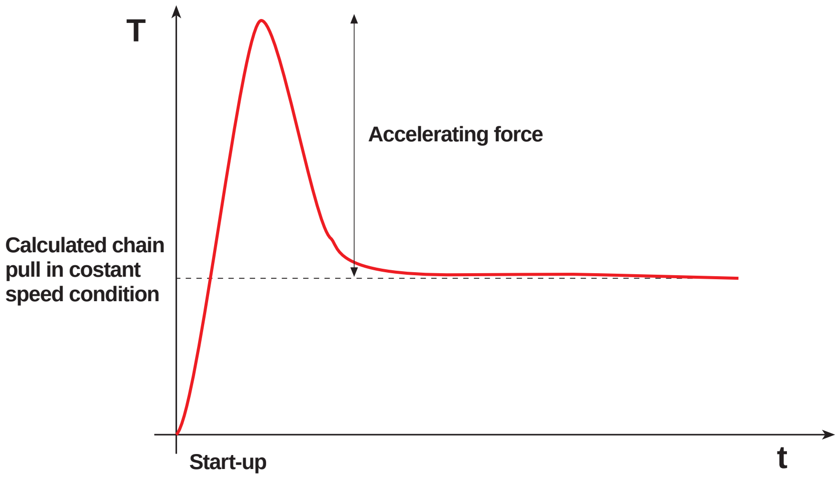
B) Sudden start or stop

When products are accelerated you need to transfer a force from the chain to the products which is proportional to the mass of the products.

$$F = M \cdot a$$

acceleration a is m/s^2
mass M is expressed in kg with a number which is identical to the weight in kg
resulting force F is in Newton

This is an extra force on the chain, on the bearings and on the motor. This force must be added to the pull calculated in constant speed movement taking into consideration the coefficient of friction and in our TableTop® chains engineering manual it is calculated using the PLF (peak load factor) coefficient with a maximum value of 2.



Of course the acceleration you can apply on the product is limited by the coefficient of friction with the following formula:

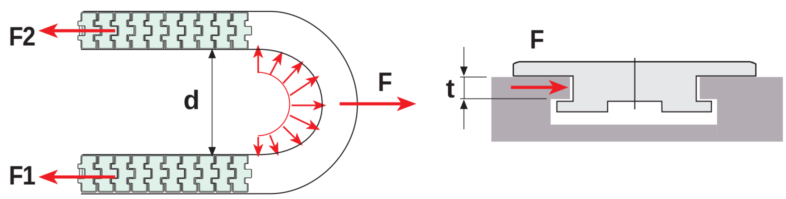
$$a_{max} = F_{max} / M = W \cdot fm / M = M \cdot g \cdot fm / M = g \cdot fm$$

where W is the weight of the product in Newton.
That is why sometimes it is necessary to use HFP (High friction rubber inserts) chains where there is a need to slow the products and reduce their speed considerably.

C) Friction between chain and curve track

In the inside of the curve track the chain applies high pressure as reaction to the change in direction of pull.

$$F = F2 + F1$$
$$P = F / (d \cdot t)$$



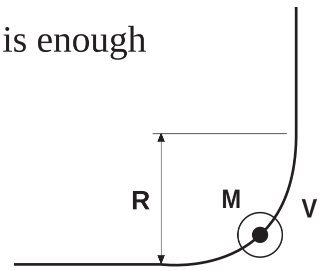
This pressure gives friction and the friction generates heat. Plastic materials used to make the curve track are not good heat conductors and the result is considerable temperature rise. This worsens friction and at high speed melting can occur.

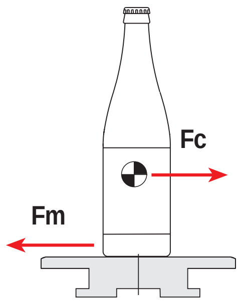
Our TableTop® chain calculation program takes into consideration this effect as PV limit to prevent curve track and chain (if plastic chain) melting, but the force Fc must be taken into consideration in the accurate calculation of the frame.

D) Centrifugal forces of products

At high speed there may be some requirement for pressure from the side guides against the product to keep it in the track when running into an angle.
This is because there must be equilibrium between centrifugal force and force acting between chain and product or product and side guides.
So there may be two cases :

case 1, the friction is enough



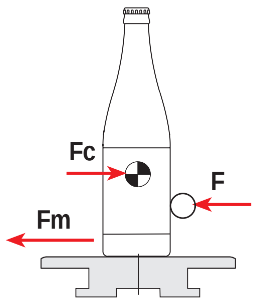


$$Fc = M \cdot v^2 / r < Fm = M \cdot g \cdot fm$$

The product moves on the curve with the chain.

case 2, the friction is not enough

$$Fc = M \cdot v^2 / r > Fm = M \cdot g \cdot fm$$



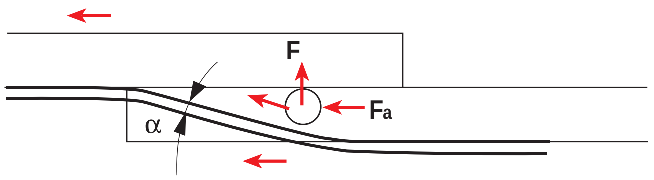
The product needs to be pushed by the side guide with a force F because friction between chain and product is not sufficient to give equilibrium with centrifugal force.

$$Fc = M \cdot v^2 / r = M \cdot g \cdot fm + F$$

$$F = M \cdot v^2 / r - M \cdot g \cdot fm = M \cdot (v^2 / r - g \cdot fm)$$

E) Side transfer action

To make a side transfer the side guide must push the product on the side chain strand.



$$F = Fa \cdot \sin \alpha$$

Where Fa is the accumulation force.

$$Fa = Wa \cdot La \cdot fm$$

so $$F = Wa \cdot La \cdot fm \cdot \sin \alpha$$

If apparently there is no accumulation it is possible to consider La as the transfer length because in that section the products are sliding on the chain to reach the parallel strand.

2.2 EXCEPTIONAL FORCES: Workers walking on conveyors
Sudden vertical acceleration or impacts during positioning on the floor

These two forces are many times the most demanding in dimensioning various frame components.
As general rule:

Weight of one person = 100 kg
Inertia on floor hit = 3 • conveyor weight

3 - CONVEYOR SECTIONS

A conveyor frame is an elongated structure with some wear strips to support the chain and a chain return system based on rollers or serpentine sliding strips. General design follows the principle of modularity with a repetition of the 3.25” (82,5 mm) chain module as many times as required by the product flow. A general formula is:

$$N = Q / (v \cdot W)$$

where: *N = number of strands*
Q = flux of production (kg/min)
v = speed (m/min)
W = weight of products on one meter of strand (kg/m)

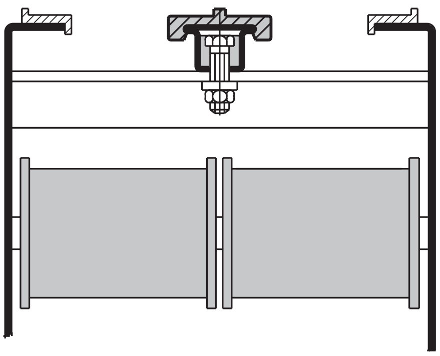
or, with $Q = f \cdot w$

flux of production Q equals frequency of production f (number of products per minute) multiplied weight of one product w, we get the following

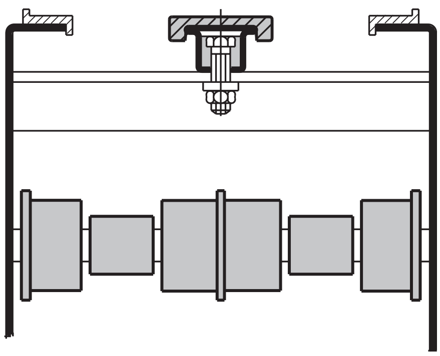
$$N = f \cdot w / (v \cdot W)$$

this means that with constant flux, speed is inversely proportionally to number of strands.

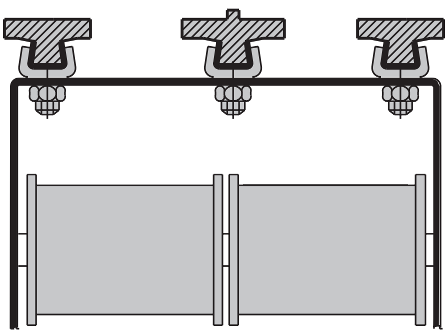
Typical European design



Typical European design small gap (unstable products)

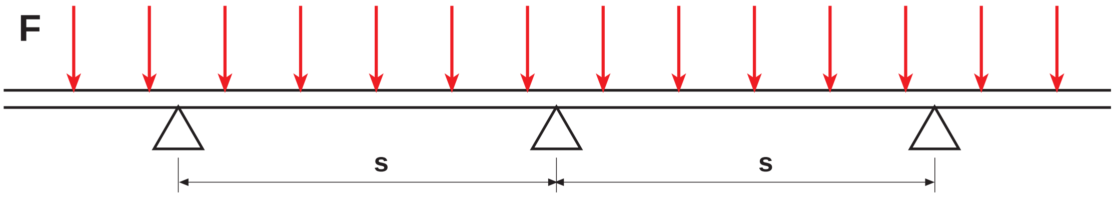


Typical American design (no debris on the return)



4 - WEAR STRIPS AND RETURN SYSTEM

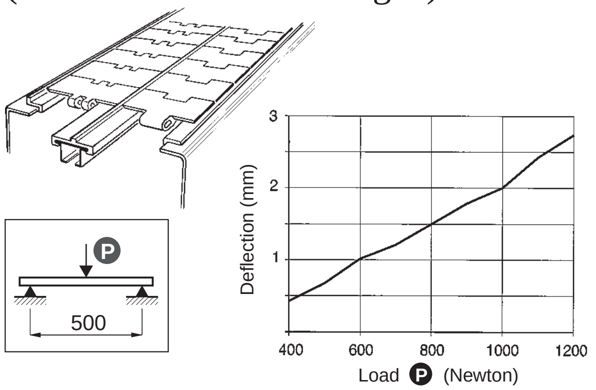
Wear strips and return system must support the chain and everything on the chain. Generally wear strips are supported at fixed distance “s”.

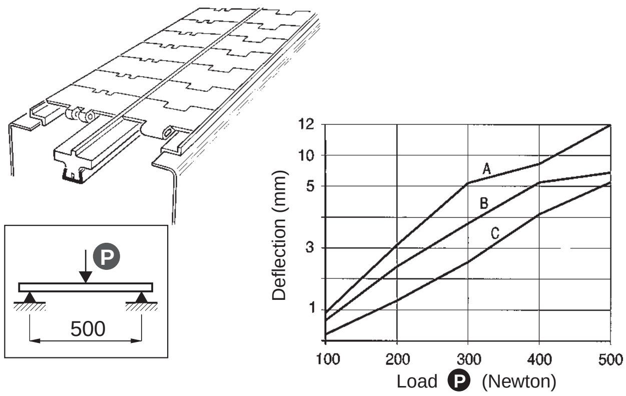


The load on wear strips is distributed on the length

$$F = Wc + W \qquad \textit{(in Newton per meter)}$$

This gives a deflection according to the diagram.
(Rexnord Marbett catalogue)





In this diagram the span (s) is fixed to 500mm, the load is concentrated in the middle and the equivalence between the two loads, distributed and concentrated, is

$$P = F \cdot s / 2$$

To consider a different span it is necessary to know that the relation between span and deflection is cubic:

$$Deflection = constant \cdot P \cdot s^3$$

This means that with double span and same P the deflection is multipled by 8.
In general, an acceptable defection is 2mm on 500mm of span, higher values could give problems to product stability.
If you consider a man walking on the conveyor the load P is 100 kg and an acceptable deflection is 3mm on 500mm.

The return system shall support only the chain. Standard spacing of supports is between 500mm and 700mm or the same value of the wear strips to simplify the design. On wide conveyors with roller return system some care must be given to shaft deflection to avoid roller seizure.

5 - BRACKET AND CLAMP CALCULATION

The Application requires a strength verification only in case of accumulation.

In this case the force on bracket and clamp is given by

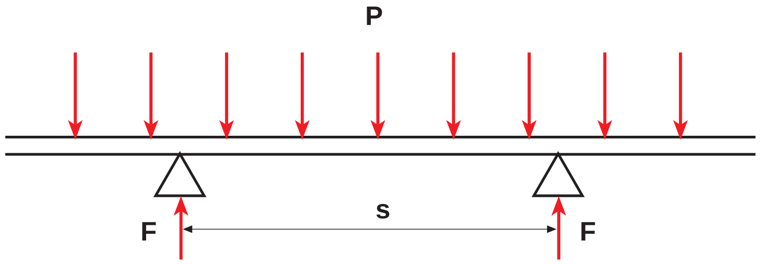
$$F = P \cdot s$$

where P is the accumulation pressure and s is the distance between brackets.

The pressure can be calculated with the computer programme or with the following formula

$$P = W \cdot La \cdot fm$$

where W = *weight of product per unit surface of conveyor in* Kg/m^2
La = *length of accumulation in m*
fm = *friction coefficient between product and chain*



Example :

$W = 200 Kg/m^2$ *(glass bottles on 10 strands of SSC812K325 chain)*
$La = 6\ m$
$fm = 0,2$
$s = 0,5\ m \Rightarrow F = 120\ kg$

6 - SUPPORTING ELEMENTS

To calculate the load on supporting elements, bases and feet, it is necessary to divide the total weight of frames and products in Newton Wt by the number of supports n.

$$F = Wt / n$$

This in the case of uniform distribution of weight and support spacing.

Anyway this force F is considering only static forces and not dynamic forces. Dynamic loading Fd may happen anytime you are moving the structure for assembly or modification.

$$Fd = 2 \bullet F$$

Generally 2 times F is enough to evaluate the dynamic load Fd.

An other kind of load is the weight of workers walking on conveyor frames, so an additional 1000N should be calculated for each support and also each joint. The formula at the end is the following:

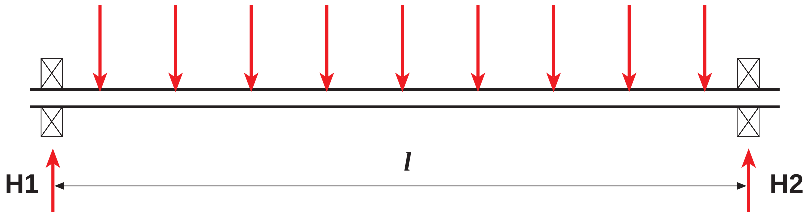
$$Fs = \frac{2 \bullet Wt + 1000}{n} \qquad \text{in Newton}$$

7 - BEARING SUPPORTS CALCULATION

We start with a drive shaft and two supports where we have already calculated the pull tension T on each chain with the TableTop® computer programme. The load on the shaft is Ts and it is distributed along the shaft length l.

$$Ts = n \cdot T$$

where n is the number of strands.

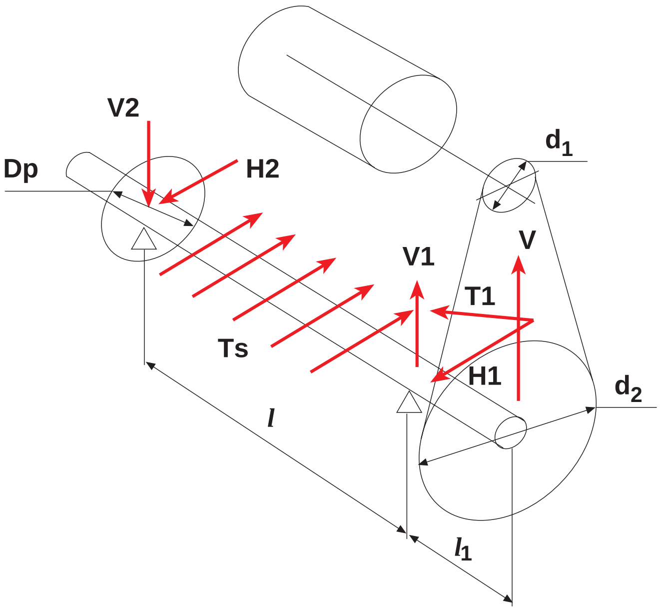


The shaft deflection, bending stress and torsion stress can be calculated with MatTop® computer programme using any MatTop® chain giving the same pull Ts on the same width l.

In the top view shown we have two reactions on the bearings giving equilibrium to the shaft.

$$H1 = H2 = Ts / 2$$

Now we want to consider the action of the drive motor.
The result depends on the position and motion transmission system.
It is interesting to consider the case of the motor placed on top of the conveyor and a transmission chain between motor and drive shaft. The situation is shown in the picture



The drive ratio is given by

$$R = d_1 / d_2$$

and the resulting forces on the drive shaft are vertical and can be calculated using the equation of equilibrium of the momentum around the drive shaft :

$$V = Ts \cdot Dp / d_2$$

with Dp pitch diameter of the sprockets and d_2 pitch diameter of the transmission, and the vertical equilibrium equation :

$$V1 = V + V2$$

$$V2 = V \cdot l_1 / l$$

Thus on the bearing support on the drive side we find the highest load given by the vectorial composition of the two forces H1 and V1 which are making a square angle

$$T1 = \sqrt{H1^2 + V1^2} = \sqrt{(Ts / 2)^2 + Ts^2 \cdot Dp^2 / d_2^2 \cdot (l + l_1)^2 / l^2}$$