A belt with a centered and stable trajectory in time, does it exist? … Yes ! provided that…

Mastery of trajectory of belts and mastery of hazards

First part : The prerequisites to ensure that the settings will be final in time.

The conveyor belt conveyor is a "complicated" machine, whose "equation" must be "simplified" and "neutralized" the remaining parameters by controlling the adjustment uncertainties. Our article appeared under the title "Design, New Approach", focuses on simplifying the design of conveyors. It is essential to the understanding of these articles parts 1 & 2.

On the other hand, the best setting, with the tightest fit tolerances, will not work if the influential components are not compliant. These are the prerequisites!

Nobody relies on the good handling of his car on wet roads, if it has smooth tires, despite a perfect adjustment of the geometry of the running gear.

The elements to consider

1) the handling product
2) the belt
3) the pulleys
4) the idlers
5) the accessories (e.g.: skirtboards, scrapers, …)
6) the annexes (e.g.: feeders, dedusting, ...)
7) the frame of conveyor[1]
8) the other equipements[2] (ex. : trippers, bridge of feeders, …)
9) the surrounding area.

Some generalities

All components, listed above, generate or support forces or have coefficients. It suffices that only one of these components has a force, a variable coefficient so that all the other components of the conveyor see the forces, the coefficients, which are assigned to them, to fluctuate.

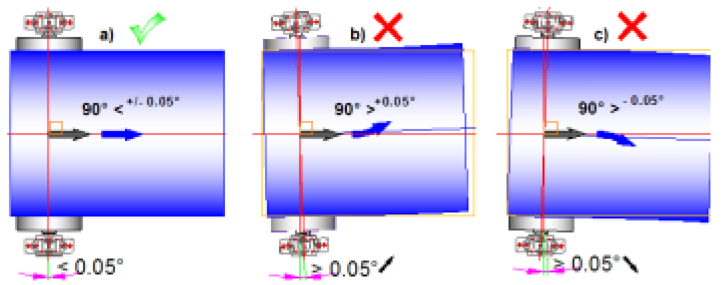

Figure 1. Adjustment tolerance: a) compliant b & c) non-compliant

This variable state of the forces and / or coefficients causes a "precarious and random trajectory" of the belt, if these components generate forces of different directions to the axis of the conveyor, because a frictional contact.

The questions to ask yourself

Geometric position of conveyor components

On the plans, the drums and the rollers are drawn "perpendicular" to the axis of the conveyor; that is to say an absolute value of 90 °.

In fact, on the machine, from what mounting tolerance should we consider that the component is no longer perpendicular to the conveyor axis?

Is the tolerance value on the geometric position of each component constant, regardless of the complexity of the conveyor?

These questions make sense when we know that on most conveyor planes, there is no angular dimension (90 °) or symbol of perpendicularity ⊥ of the pulleys and rollers and there is no general tolerance or specific mounting.

Component shape
the shape of the components, which at first glance seems obvious, also influences the stability of the belt trajectory

- • pulleys, rollers, are '' cylindrical ''.
- • The belt must have symmetry of forces (mirror) with respect to its longitudinal axis.

Should we define manufacturing tolerances of components and tolerances on their future deformation (wear, pollution, fragility, ...) ?

Interface and contact surfaces
What is the influence of the quality of the contact interface between two components (pulley/belt, roller/belt, etc.)
Is it necessary to define acceptability limit criteria for these contact interfaces to guarantee the belt trajectory?
Since the interface of contact between two components can be variable, what are the qualities and the limits of acceptability of the surface of each component, to guarantee the belt trajectory?

Immediate or delayed effect and location of the consequence
The difficulty of understanding the operation of the conveyor is the "moment in time" and the "location" of the consequence!

A variation of state, force, or condition (e.g.: coefficient) has an immediate or delayed effect, even after the disappearance of this variation. Similarly, the location of the consequence can be very far from the generating point of the initial phenomenon.

STUDY OF ELEMENTS TO CONSIDER

This study focuses on factors that may disrupt the path of the belt, excluding considerations of the adjustment of conveyor components.
These factors come from the modification of the state of an element, as source or consequence, as its momentary or permanent deformation, consecutive to:
• an excessive effort,
• a moderate and repeated effort (fatigue phenomenon),
• a contribution or removal of material (clogging by the product, component wear).

Product handled
By nature, the belt handles 0% to 100% of the product flow to be transported, or more. This is the 1st variable to consider.
The product or products conveyed by a conveyor can influence the trajectory of the band at the first day of its commissioning or in time.

This notion of '' in time '', rarely perceived, is a frequent cause of ''tinkering" of the initial settings of the conveyor components, to the point of leading the maintenance service to truffle the conveyor of devices "self-alignment idlers", often not very or not effective and sometimes which aggravate the situation.

This finding means that, from the outset, the builders install self-alignment devices, sometimes at the request of the customers through the specifications.

> This remark underlies the magnitude of the problem and taints the high level of safety normally expected!

Example :
In the case of a product with a large particle size, mixed, initially, homogeneously and then with the blocks concentrated on one belt side, following segregation at the passage of a feeder, it will be possible to note a degradation, to term, the belt side undergoing the impacts generated by the large particle size. This damage of the belt carcass, which is often occult, generate belt creep in time. QED !

***Note**: For all observations concerning asymmetries of tape loading or, more generally, other cases involving the product being handled, refer to the relevant articles below..*

These factors come from the modification of the state of an element, as source or consequence, as its momentary or permanent deformation, consecutive:

- To an excessive effort

- To a large and repeated effort (fatigue phenomenon),,
- to a intake or removal of material (clogging by the product, component wear)).

Belt & splice

The belt may be incompatible with the trough profile of the conveyor supports on which it is mounted. The belt may be too "rigid" in the transverse direction or too "soft". In some cases, for the too stiff version, it is possible to solve the problem by increasing the support spacing or by removing the side rollers of the troughs of one support on two or more. We can also keep the initial spacing between supports but use a lower angle of trough (45 ° to 30 °). Otherwise, change the belt reference.

The belt can have anomalies and / or deformations, having as causes:

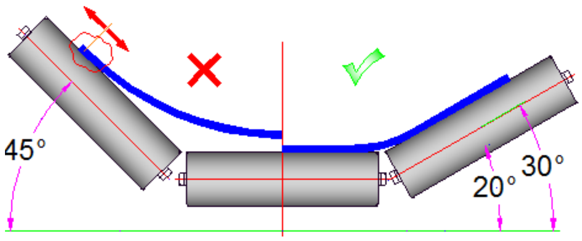

Fig. 2-1 : the belt is too "rigid" / is "adapted"

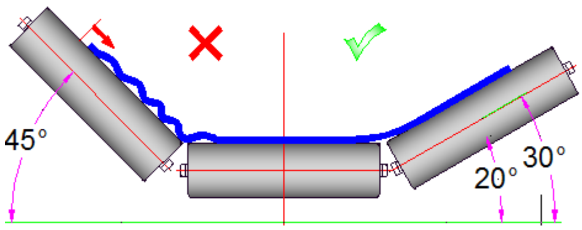

Fig. 2-2 : the belt is too "soft" / is "adapted"

a) Force asymmetries of a new belt:

This asymmetry can come from a problem of manufacture or manipulation. It is easily corrected, from the first hours of operation on the conveyor, provided you have a perfectly compliant conveyor and know the correction method (see part 2 of this article, ... to come).

This asymmetry is characterized by a difference in the length of the warp cables (all or part) between the two ½ plies of the carcass delimited by the longitudinal belt axis. This difference in length is to be reconsidered in "difference of forces", with strong incidences of trajectory, in particular in the concave curves.

To preserve your warranty claims with the belt seller, it is very easy to highlight such an anomaly. For this, it is imperative to have a perfectly adjusted conveyor, with compliant components and idlers, return side, with a minimum pitch of 9 m and more (12, 15 m).

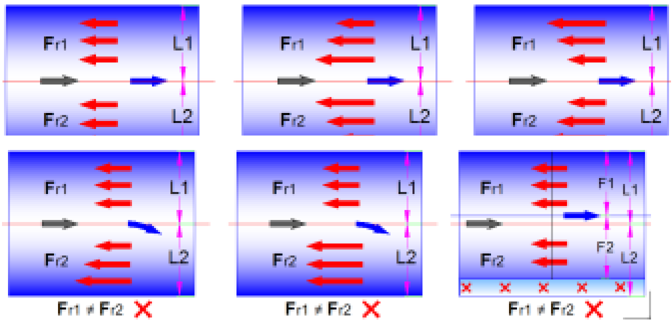

Figure 3.1 : Asymmetrical resistant forces at the conveyor axis

The measurement is with belt of return side in the lower force section, belt to stationary. A simple observation can be made remotely, belt running, safe.If you notice a difference in altitude between the right and left edges of belt, it is that there is a difference in tension between the edges and therefore a difference in cable length. This affirmation applies only to the strict condition that all the pulleys and rollers are perfectly perpendicular to the conveyor axis and parallel to its plane.
This defect can be limited to a belt section.

In this case and under the condition of a perfect and perfectly adjusted conveyor, the axis of symmetry of the forces will coincide with the conveyor axis; on the other hand, **the geometric belt axis** (½ width**) will be offset**.

b) Force asymmetries, belt in operation :

It is to note the same differences of tension in the belt, but originating of excessive stresses during its operation.

It is important to say that this occult carcass damage can occur very quickly in less than a week or after several years, even after 10 years of service.

This damage is mainly due to poor pulley adjustments and the rollers (see Part 2). The anomalies described below are aggravating factors.

c) Other damages affecting the belt :

There are many types of damage. This article only deals with those affecting his trajectory.

d) Doubtful splice :

It is about the quality of its geometry, characterized by a misalignment of two ends to be spliced together.

Such a defect, proven[3], has a limited impact on the belt offset. It is observable a few meters before the splice and on a longer length after its passage. The problem must often be considered as an aggravating factor of a more general degraded situation.

.../...

The sensitive point remains an offset loading of the product on the belt, the passage of the splice under the power supply. This initial offset of the product on the belt becoming the cause of the offset, for the following sections the splice in default.

Pulley

If it is obvious that the pulleys must be perfectly adjusted, that is to say that their geometric position on the conveyor is rigorous under a tight tolerance (e.g.: 90 ° $^{+/- 0.03}$ °), it is equally important to have pulley shape and of surface quality " compliant " with the rules of art.

The importance of this assertion is that the pulleys and assimilated components[4] withstand high forces, when the rollers withstand comparatively lower forces.

Note:
The list of defects, that can affect the pulley ferrule, are:

Concentricity and coaxiality of shaft:
This defect of form can come from a manufacture in rolled sheet, crude, not machined after assembly.

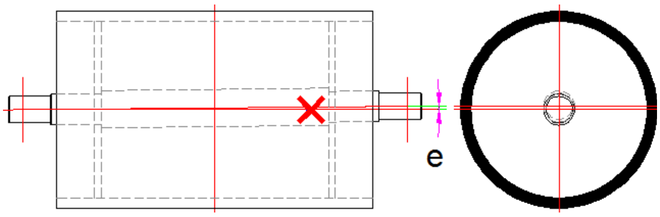

Figure 4 : non-concentric shaft and ferrule

a) Cylindric shape :
All generatrix of ferrule are parallel to the axis of revolution of pulley, with a tight machining tolerance; a too wide tolerance is a defect.

b) Crowned shape :
There is no ISO standard for convex machining of ferrules; the only standard available is NF T47004.

Recurring defects are:

- a machining interpretation error between 1% difference to the diameter of the ferrule edge with the nominal diameter and a 1% slope machining of the frustoconical section of the ferrule.
- The addition of crowned shape between two successive pulleys (ex .: snub or bend pulley).
- Clogging of the middle part of ferrule, often resulting from transverse deformation of the belt carcass (see: transition length, ...).

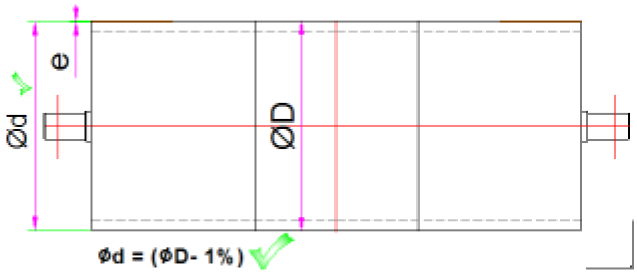

Figure 5.1 : Crowned of pulley compliant

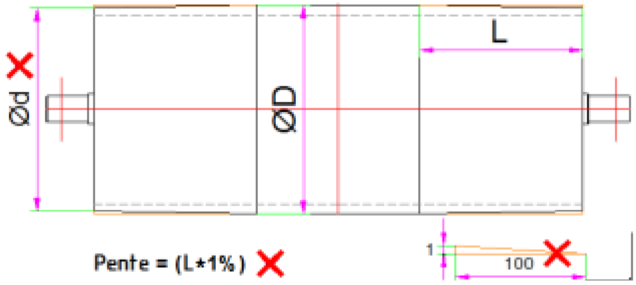

Figure 5.2 : Crowned of pulley non-compliant

c) Concave shape :
Concave ferrule is forbidden!
There is a defect when the ferrule has a concave profile from a depth of the order of 0.5 to 0.1 mm, depending on the surface material of the ferrule (steel, rubber, spikes ceramic, ...). It is this very low value that makes the defect difficult to perceive.

Principle:
If we admit that the convex (curved) profile of the ferrule brings the belt edges towards the middle of the pulley, until finding the equilibrium; for the concave profile the principle is the same but in the opposite direction. Thus, the belt edge is pulled towards the edge of the ferrule and, when the phenomenon is engaged, it only gets worse.

This type of defect originates from :

- Concave machining (extremely rare);
- A "banana" deformation of ferrule, under the belt pressure. In this case, the pulley surface "under load" has a concave profile; conversely, this profile is convex (equivalent to a bulge) for the pulley surface not covered by the belt. This defect is particularly vicious because it can be random depending on the belt tension according to the moment of the observation.

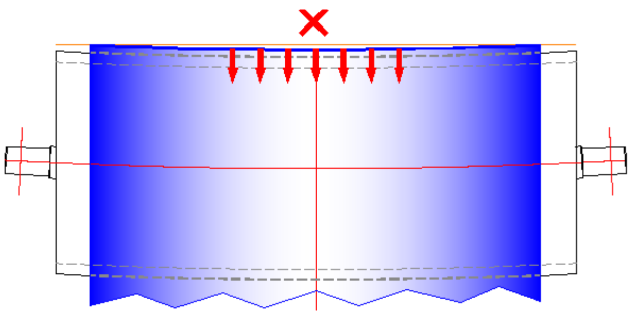

Figure 6.1 : Concave profile by the belt constraint

- The wear of the ferrule, due to permanent instability of the belt, with a sinusoidal amplitude of the offset (see Part 2: guiding the tension pulley, adjusting the rollers).

Figure 6.2 : Concave profile by wear (belt instability)

The most typical case of ferrule wear with a concave profile is available the take-up devices with counterweight, when they are build with 3 pulleys. You can observed offset to a left-hand of belt, on the bend pulley and a right-hand offset on the tension pulley, at the same moment; then the direction of the offsets are reversed with an absolutely regular periodicity to the nearest second, of the cycle '' left - right - left ''.

d) Surface quality :

The pulley ferrule is made of steel (uncoated), with a smooth or grooved rubber coating, of x Shore hardness and thickness x mm, with a corundum amalgam coating, ceramic (Al2O3) with spikes, etc. The ferrule build of rungs (squirrel cage).].

All these surface qualities, in contact with the rolling face of the belt, have a direct influence on the stability of the belt trajectory; this is the theme of this article.

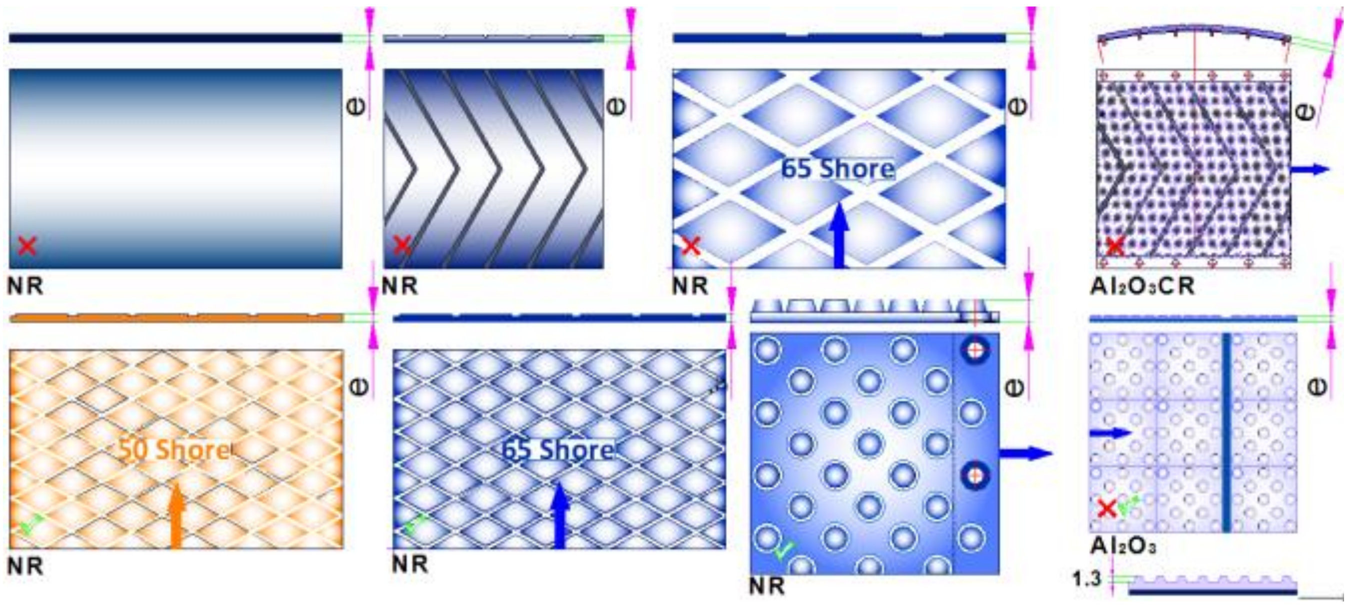

Figure 7 : différentes qualité et matière de revêtement de tambour

Everyone agrees that the coefficient of friction of steel is lower than that of the other materials listed above; beware, the steel rungs of squirrel cages are a special case.

Everyone agrees that covered the drive pulleys with a coating improves their pulling ability. It seems established that a "grooved" coating is more efficient than the same "smooth" quality, since the pollutants at the belt/pulley interface will be contained in the grooves; thus the belt/pulley contact points remain clean.

For all the other conveyor pulleys, for in terms of belt stability, why so often this performance attributed to a grooved coating is forgotten?

Are we sure of the good handling of his car if the tires of the '' non-driving '' wheels are smooth? NO !

In order to guarantee the stability of the belt, from a fine adjustment of all the components of the conveyor, it is imperative that all the pulleys are coated of grooved rubber with small diamonds", so that the smaller pollutant, including a very thin dust layer of a few microns, is pushed into the grooves, leaving the clean contact surfaces with a high coefficient of friction, so as to contain the Interference[5] forces which tend to creep the belt. QED!

The other types of pulley coating will be dealt with in another article.

The idlers of belt
They are essentially the rollers and the soles, the skids, the sliding bars. It is important to remember that a roller jammed on a support is equivalent to a slip pad.

First principle :
• The "belt/roller" contact responds to the laws of direction and forces balance.
• The contact "belt/sliding surface" responds to the law of forces balance only.

Sliding supports have't, properly speaking, of adjustment. The resistant forces they generate in the belt must be "perfectly symmetrical" with respect to the conveyor axis.

The supports, with roller(s), must generate perfectly symmetrical forces parallel or convergent to the axis of the conveyor.

Recurring defects, which influence the trajectory of the belt, are:

Sliding supports

- a difference in coefficient of friction between right and left surfaces. These differences are of the type: wet / dry, polluted / clean, sticky / non-sticky, loads weak / strong, under vacuum of air / with air, ...).
- An altitude difference between each ½ plane to the conveyor axis, which results in a pressure difference of the belt.
- A difference in quality between the right and left supports; here, it is necessary to consider a free roller and a blocked roller present on the same support and in symmetrical position. In fact, the forces resistant to the advance of the belt are clearly different, which implies a belt creep despite a well-adjusted support.

Supports with rollers
Balance of forces :

- a difference in coefficient of friction between right and left surfaces; these differences have an influence only if the support to a "pinch"[6].

These differences are of the type: wet/dry, coated rubber /bare steel

Example:
  - the belt is wet by the rain, return side, on one side, then this water wets by transfer to top rollers on the same side;
  - a series of supports comprises a damping roller on one side and a bare metal roller on the other.

Direction of forces :

- The supports with "pinch" brackets have a mounting direction that involve "converging" forces to the conveyor axis. Conversely, mounting '' upside down '' of the support involves divergent forces to the conveyor axis, which lead to the creep of the belt, often with a sinusoidal trajectory due to other forces acting in the belt.

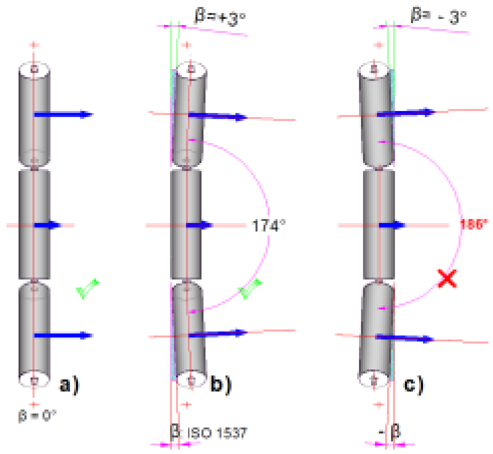

Figure 8 : Trough idlers with 3 rollers
a) without pinch **b)** with pinch **c)** upside down

  - The belts with double running directions impose supports, carrying side, without pinching; any mounting of idlers with pinching is to be forbidden.
  - The generalization of damping rollers over the entire length of conveyor or a long length is to be avoided because of their out of tolerance form quality, if the idlers have a pinch angle.

The accessories
These are essentially skirtboard and rubber seals. The influence of these two accessories on the belt path exists only if they generate an asymmetry of strong forces between the right and left sides of the belt.

Example:

- The rubber seals are in high pressure on one side of belt and on low pressure on the other.
- The product rubs intensely on one side of the skirtboard and rubs weakly or not on the opposite side.

Ancillary equipments

These are essentially feeding chutes, when they do not guarantee, in all circumstances, the proper centering of product.

For many years, there has been a deficit on the proper design of chutes. This subject will be presented in a future article.

The frame of the conveyor

The frame is not directly in contact with the belt and it is not subject to "adjustment" strictly speaking. It is considered to have been erected according to the surveyor's landmarks. Nevertheless, it is taken into account when it allows a variation of the geometric position of the components that it supports, because of an irregular displacement or its deformation.

Example :

- The frame is telescopic and / or variable inclination. The conveyors with this type of device often suffer from a deficit on the guiding and / or articulation elements, whether they are new or used (excessive mechanical play).

- The frame is sensitive to side wind, for the cantilever section (storage conveyor); in fact, the pulley at the end of the arrow moves laterally.

- The head drive pulley is mounted on a cantilever section and there is only one drive unit heavy enough to twist the frame. The head pulley and the idlers are well adjusted and when the belt is put into service, it is centered on the conveyor axis. After some time of operation the belt creep! Here, it is the asymmetrical deformation of the band generated by the twist of frame that generates a voltage difference between the right and left edges of the belt.

- The conveyor is rigidly mounted in a supporting structure that is exposed to the sun. Morning sunlight expands the structure on one side and, in fact, curves the conveyor. During the day, the temperature of the structure becomes homogeneous and the problem disappears.

- The conveyor frame is mounted on a vibrating structure (screen, grinder, etc.). This interference amplifies the slightest adjustment fault. The belt moves with the vibrations and remains stable without vibration.

The ancillary mobile devices

These are, essentially of take-up trolleys, of stocking trolleys, bridges of feeder, for which the quality of the guiding device often suffers from a deficit, whether new or used. The recurrent defects are excessive play between the movable guide element (shoe, shoulder wheel, roller) and the guide rail and a short wheelbase between the guide elements relative to the track (distance between the right rails and left).

The environment

The environment of the conveyor has an influence on the trajectory of the belt, in spite of perfectly adjusted components, when it generates Interference forces, different coefficients between the ½ widths right and left of the belt,

Example:

• The crosswind at the conveyor, which pushes the belt laterally, especially in sensitive sections such as concave curves.

- the rain, pushed by a crosswind, wets the rolling face (underside) on one side of the belt. Quickly, this water will wet the side rolls of the carrier side, on the same side of the conveyor, for dry rollers on the opposite side. In this case, there will be belt creep only if the supports are '' with pinching ''.

- Same above, for dust or any other material that falls asymmetrically on the belt and pollutes only one side of it; for example, a leakage of material from the machines installed above the conveyor; a steam supply (bakery conveyor) on one side of the conveyor, with condensation on the sliding soles only on one side.

Figure 9 : voir en 2ème partie « **les réglages** » !

CONCLUSION

Neglecting the prerequisites, described in this article, results in inefficient of adjustments of components whose subtleties and methods for these adjustments will be described in the next part.

[1] the frames: it is taken into account when it allows a variation of the position of the components which it supports, because of its deformation

[2] the trolleys, bridges of feeders, telescopic elements: they are taken into account when they allow a variation of the position of the components that they support.

[3] established: the experience shows that often, for lack of relevant argument, the splice is called into question to explain the instability of belt trajectory, thus masking a reality of more extensive defects.

[4] Assimilated components: convex curves, consisting of a succession of idlers, are assimilated to an imaginary pulley sector; in fact, it takes the same rules as those of the pulleys.

[5] Interference force: any force, applied to the belt, in a different direction relative to the axis of the conveyor

[6] Pinching: seen from above, it is the angle formed by the axis of the lateral rollers of a support. It is> 180 ° (see ISO 1537 # 4.3.2)

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NB :
Nous attendons vos commentaires sur ce texte qui établit l'état de l'art. .

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