Make the technical concepts coexist with safety requirements on conveyors, it works!

The principles of the "new approach"

Or how best to apply safety standards

Like many inventions, the conveyor belt has evolved according to the events that have raised questions with the users and the builders. Since 1989, European States have been concerned about the safety of machines, through the Machinery Directives (current version: 2006/42/CE).

Today, the big question is to understand why, despite all the efforts in terms of safety, there are still too many accidents on the conveyors with, especially, causes similar to those of the old times. To answer the question, this article focuses on ''understanding standards, proposing solutions and show the added benefits” by means of examples.

UNDERSTAND

Conveyors and safety are two technical domains that interact with a complexity accentuated by several hierarchical levels (hierarchy of Laws). Here is the difficulty.

Hierarchies of texts

The texts that rule machine safety in Europe are the Machine Directives, the EN safety standards of category A (fundamental, general), B (specific and medium aspects) and C (category of machine). The laws of each country complete the legal and regulatory documentation (the Labor Code in France); they must transpose European standards. The peculiarity is that it is the local laws that apply in the case of accidents. The application of the EN, ISO standards has the presumption of conformity value; they must be applied with discernment.

In general, it can be said that the Code Laws give the goal to be achieved and the standards say how to do it.
EN 620, category C, is the "reference" for conveyor safety, but the common mistake is to ignore standards A

This "C" standard applies only to hazards that could have not been previously removed by the application of the higher category A standards (e.g. EN ISO 12100).

The other major pitfall comes from the Machinery Directive 2006/42 / EC, # 1.1.2, 1st paragraph which says "***eliminate or reduce risks ...***". It is this coordinating conjunction "or" that is problematic, so much so that the commented version of the directive (official document) is required to specify

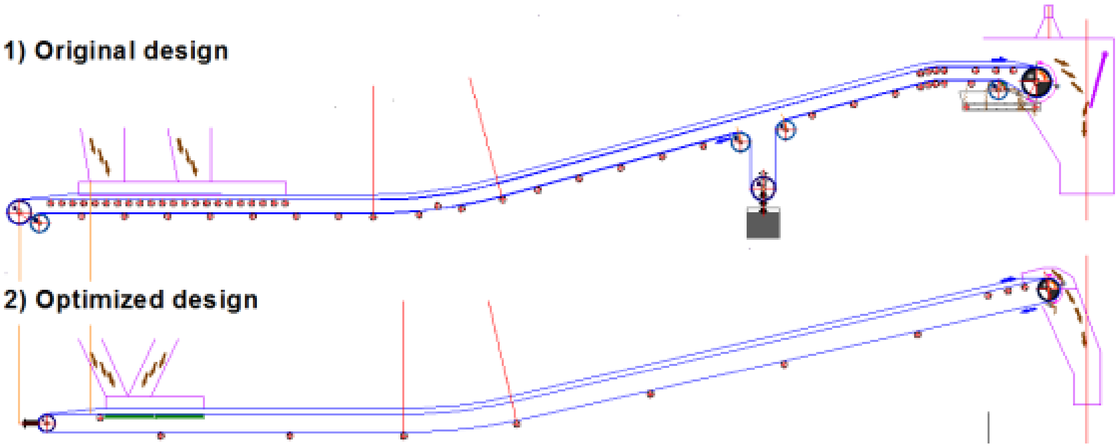

Figure 1: Application of "*New Approach*" to Conveyor Design

1) This conception **does not take into account the 1st principle** of the Directive: it is non-compliant
2) This design **applies the 1st principle** of the Directive: on this point it complies

that there is always this hierarchy of solutions by stipulating that "*eliminating the risk"* prevails over any other provision (**Fig.1**) *"... because they are more effective than protective measures ...*".

The standard EN ISO 12100 version 2010 article 4 paragraph e, logically transcribes the legal text: "- remove the dangerous phenomenon, or reduce the risk ..." with a small subtlety that accentuates the strength of the coordinating conjunction by placing a comma before " or ".

According to experts, it is important to distinguish between the two levels of the term "eliminate (delete)":

1) Eliminate: by deleting the machine, the component exposing at least 1 risk;

2) Eliminate: by replacing the hazardous component with a non-hazardous component (see §178: comments on section 1.1.3 of the directive).

IN CONCLUSION

At this reading level of the directive, there is no longer any ambiguity about the hierarchy of safety solutions:

1) eliminate the risk by:

a) deleting the machine;

b) deleting the component;

c) replacement of the hazardous component with a non-hazardous component;

2) the risk must be protected (EN 620).

a) By a nip guard device before the nip point;

b) By an added device fixed guard around the risk area

c) By a completely enclosing.

These statements are further reinforced by the "NOTE 1" and "NOTE 2" at the end of Article 4 and Article 6 of EN ISO 12100.

In fact, EN 620 only applies for the remaining risks; that is, those that could not be removed. QED!

This conclusion is my interpretation of the texts and it is the one that the Courts retain.

PROPOSING SOLUTIONS

In concrete terms, the design that best meets these requirements consists of:

1a. Delete the machine

As an example, ultra-radical, of the prescription "delete":

- 100% of the conveyors called Speed-up feed conveyors (**Fig.2**) are unsuitable for their purpose because they do not perform their 1st function. A simple observation of the angle of the drop parabola of the product at the moment of its contact with the plane of the downstream belt demonstrates the systematic underperformance of this type of machine.

Since this type of conveyor exposes at least at one risk, it must be eliminated from the equipment.

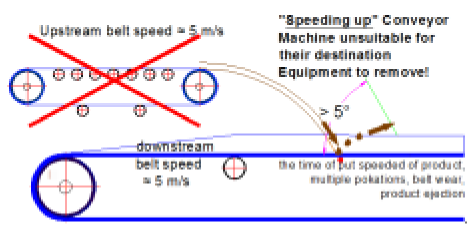

Figure 2: Delete the speed-up feed conveyors

- A certain percentage of reversible and/or shuttle type conveyors can be eliminated in favour of simple rotating corridor type. It is wise to ask the question on a case-by-case basis.

- 100% of the conveyors called "pick up crumbs" (**Fig.3**) installed under the head section of certain conveyors and which are exposed to several risks; this isn't justified if ISO 5048 standard 5.3.3 is correctly applied (see below: 75 to 80% of the return idlers).

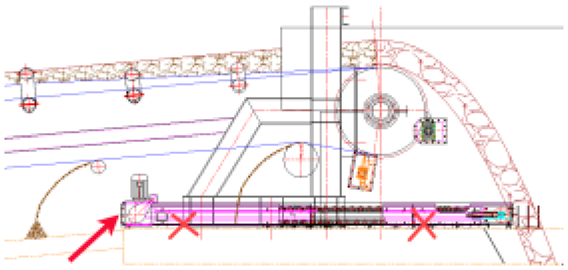

Figure 3: Delete the « pick up crumbs » conveyor !

Since this type of auxiliary machine has at least 1 risk, it must be eliminated from the equipment.

1b) <u>**Delete the components**</u>

- 100% of snub pulleys associated with a drive pulley (**Fig.4**), which allows a belt winding arc / drive pulley less than or equal to 200°, has no justification, proved by calculation.

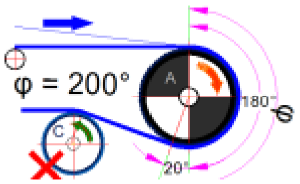

Figure 4: Delete the snub pulley in head

Since this snub pulley is exposed to at least one risk, it must be removed from the conveyor.

<u>NOTA</u>: The above argument is often true with a belt/pulley winding arc greater than 200°; it must be calculated.

- 100% snub pulley, associated with a free tail pulley (**Fig.5**), has no technical justification.

Historically, these snub pulleys were intended to reduce the vertical space between top belt and return belt thanks to a large diameter tail pulley thanks to cotton belt carcass. This design has continued under the pretext of a better stability of belt trajectory in this section. This assertion is questionable, if the relative geometric position between these two pulleys is out of tolerance (very frequent case). The problem is revealed when the belt reaches a significant asymmetric deformation of its carcass. Thus, few establish the causality with the snub pulley and this anomaly is compensated for by the addition of various self-training idlers with limited efficiency, but with extra risks.

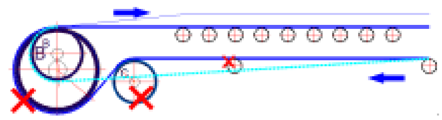

Figure 5: Delete the snub pulley in tail

Since this snub pulley has at least 1 risk, it must be removed from the conveyor and, if necessary, the tail pulley changed to a diameter in accordance with ISO 3684.

- 100% of belt pre-tensioning systems of take-up type (**Fig.6**) with variable in running, by means of a counterweight, for conveyors with a horizontal or ascending profile, handling cold products (≈ 20°C) , on a distance between center to center up to 1100 m, an elevation of about 30 m, isn't proven by calculation.

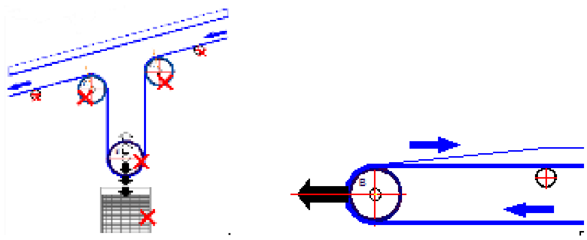

Figure 6: Delete of GTU system in favor of a simple screw/nut system

Since this GTU system is exposed to at least one risk, it must be eliminated from the conveyor in favor of a simple "invariable" take-up system (screw/nuts model**) applied to a tail pulley**.

<u>Example</u>

During a theoretical and practical training, 7 pulleys out of 9 were deleted from a conveyor of 425 m of length (**Fig.7**), a reduction of 78% of the number of pulleys! Before intervention, the customer suffered many malfunctions with of upkeep costs and a costly maintenance; but after simplification, reliability and safety have reached a very high level with added durability over time.

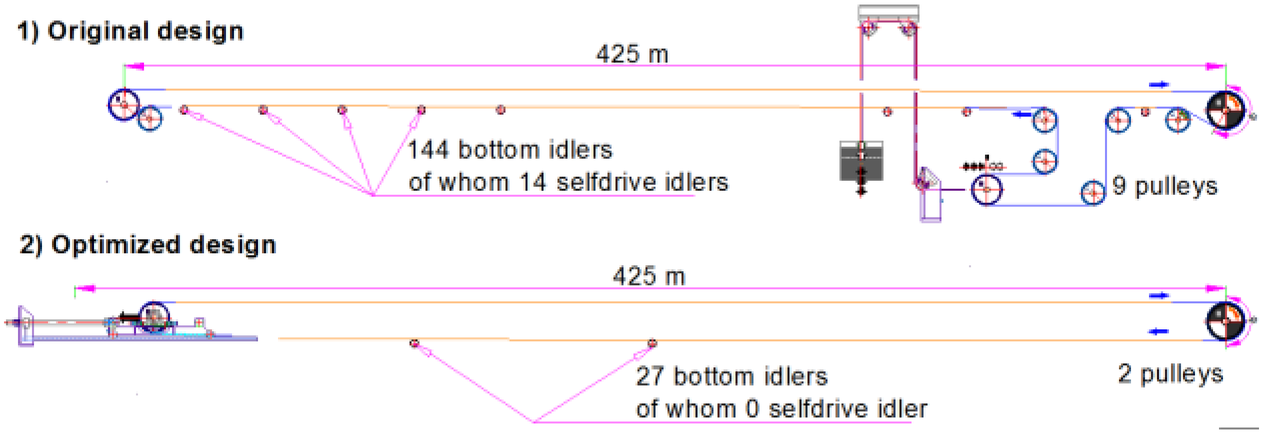

Figure 7: Application of "*New Approach*" to Conveyor Design

1) This conception **does not take into account the 1st principle** of the Directive: it is non-compliant
2) This design **applies the 1st principle** of the Directive: on this point it complies

- 75 to 80% of return idlers are in excess, which is demonstrated on the base of calculation in support of ISO 5048 section 5.3.3 (v 1989).

Here, a text explanation is required!
This article, 5.3.3, defines the minimum and maximum deflection of the belt, at any point on the conveyor (under the feed, carrying side in tail, in head, return side ditto), in all circumstances (starting-up, working, braking, empty, under load). This is the prescription that must be applied. For top idlers, 'observe a pitch of between 1.0 m to 1.5 m and 2.5 to 3.0 m, for bottom idlers', comes from the examples written in the 1973 version of the standard. This was revised in 1989 (**Fig.9**).

Very many conveyors are now running with a pitch distance of 12 to 15 m between return idlers, even ≈ 30 m for conveyors up to about 30 m of length (= zero return idler) (**Fig.8**), even 36 m on a conveyor of 5 km length, for the return section, which is a "stretched belt strand", between the head pulley and the drive pulley 215 m away.

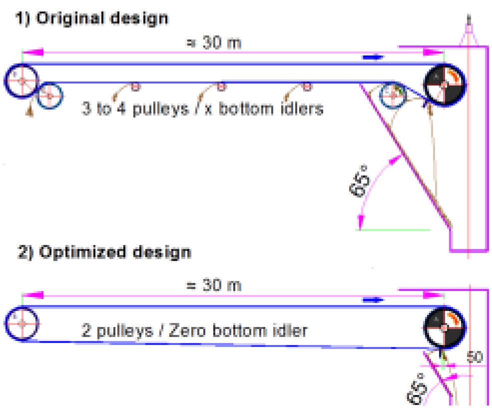

Figure 8: 1) non-compliant 2) compliant

The long pitch design between idlers is even more the case when the return belt is a stretched strand; that is to say with a drive pulley in tail. The above example of 36 m becomes obvious.

Figure 9: 3 m : non-compliant ; 12m : compliant

- 100% of trough idlers in convex-curve section, top side, are in excess, when it comes to the section before the head of the conveyor (**Fig.10**), insofar as these two last sections can be combined into a single rectilinear section. This typical design, with a convex curve, was due to a fall parabola of product, to the unloading pulley, considered as shorter. The fall parabola calculations show that this argument is unfounded.

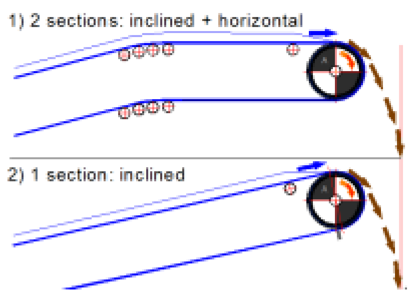

Figure 10: 1) non-compliant ; 2) compliant

Since this convex curve system exposes as many risks as there are rollers, it must be removed from the conveyor in favor of a single rectilinear section.

- 100% of the idlers of convex curves on the return side, are in excess and should be replaced by 1 category C pulley, for a reduction of the number of risks and the obligations for easy maintenance.

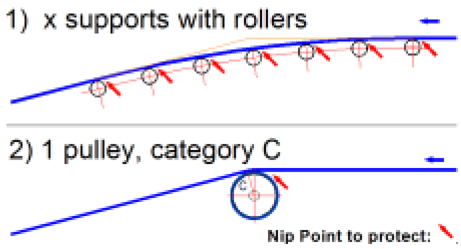

Figure 11: 1) non-compliante 2) compliant

- 50 to 100% idlers of concave curves on the return side (**Fig.12**) are in excessive number from the simple fact that the belt is in sustentation by its tension forces, in this section. A simple observation of this section shows that the belt does not touch or very weakly contact on the idlers of this section. A pitch between rolls of 18 to 24 m is often possible, with many advantages to the key.

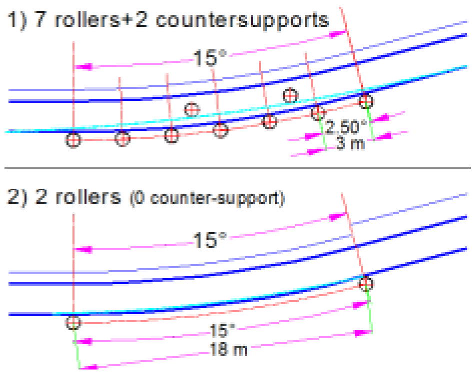

Figure 12: 1) non-compliante 2) compliant

- 98 to 100% idlers of the top side are in excess! Here, it's a case of conveyors with a tripper (**Fig.13**), for the section between the last point of belt contact on top idler, to the beginning of the concave curve which precedes the tripper, and the drive pulley, if the section following the carriage is always empty.

If we consider a length of 80 m, for this section, with a pitch of 1.20 m between idlers, this represents the removal of about 64-66 supports and as many risks as there are rollers removed (trough 3 rolls = 192-198 rolls)... The best, in the case of a project, is already to shorten the conveyor for the section beyond the tripper end-location.

- Often, 100% of the idlers of the feed bridges, top side, are in excess. Indeed, a simple study can demonstrate that it is easy to remove the "feed bridge" and all the risks associated with it (snapping, shock, ...) and for better conditions for the conveyor components, including the conveyor belt.

- Some percentage of idlers, carrier side, could be considered in excess.
  E.g.: In the case where the belt has an arrow less than 1% of the pitch and a low filling coefficient. The solutions are:
  a) Increase the pitch between idlers until a belt deflection greater than 1% or more of the pitch is obtained.
  b) Decrease the belt speed and thus increase the filling coefficient (about 85% of ISO) which will increase the belt deflection.
  c) As the case may be, good design is a combination of both.

Starting from a pitch correctly calculated between supports, carrier side, in tail section, for example 1.25 m, it is certain that this pitch can increase as one approaches the head pulley; this assertion is even more the case when the conveyor is steeply inclined, with a significant difference in height between the tail and the head.

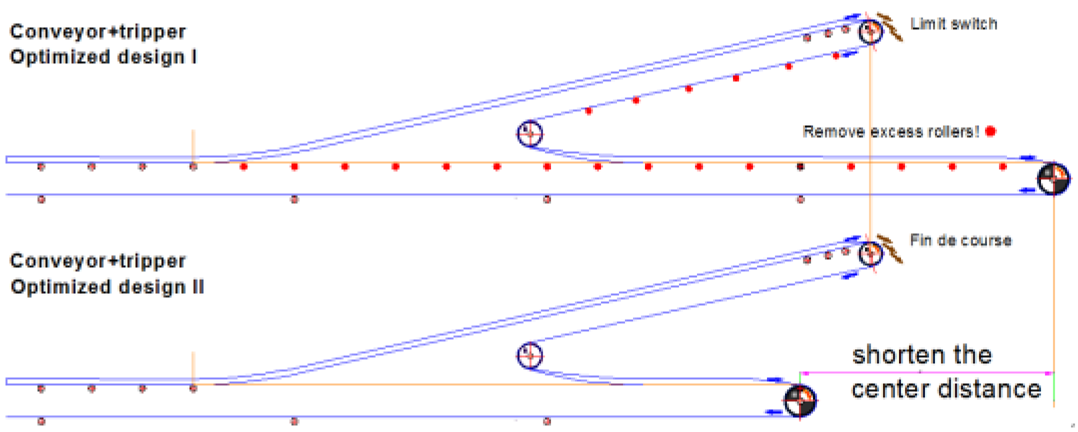

Figure 13: Remove excess rollers!

As an example, the pitch can easily go up to 6.0 m (**Fig.14**). A variable pitch, as recommended above, is easier to apply with clam-operated fixing brackets.

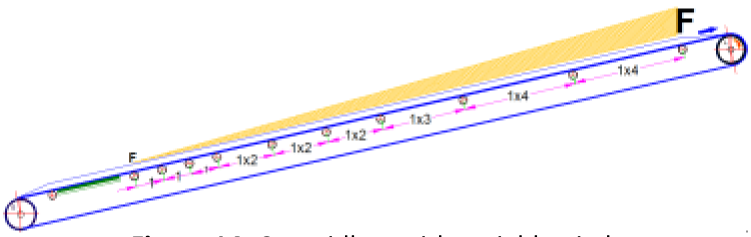

Figure 14: Carry idlers with variable pitch

1c. Replace the components

- 100% of the rollers, especially under the feed section (**Fig.15**), which can be replaced by sliding sole, sliding pads, sliding bars, must be replaced subject to feasibility (speed, load, products, etc.).

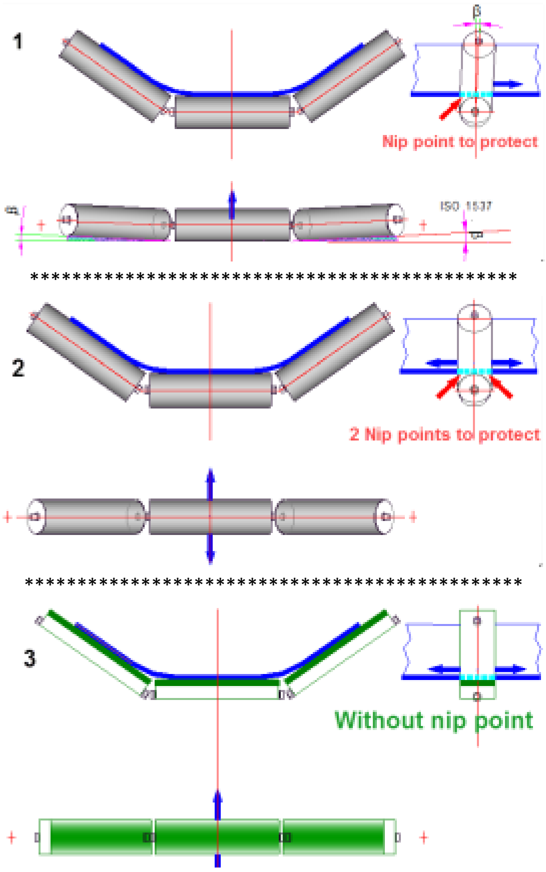

Figure 15: Supports with rollers & sliding-surface

1) Belt with 1 way, on rollers
2) Belt with 2 ways, on rollers
3) Belt with 1 or 2 ways, on sliding-surface

- A high percentage of rotation detectors are not compliant; adding a protective hood to them is contrary to the safety requirements, since there are models that are not exposed to the risk of cut-off and snapping. For conveyors with high industrial risk, the belt is monitored by ultrasonic sensor; more efficient equipment and without risk.

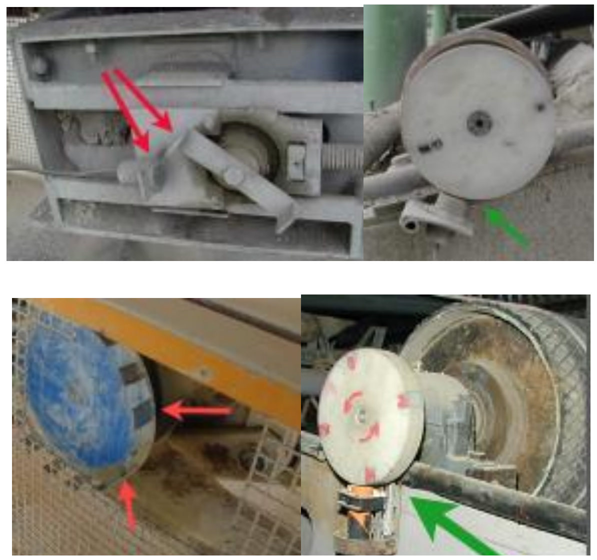

Figure 16: rotation detectors non-compliant/compliant

2a/b/c Protection front of the risk

For risks that could not be eliminated by the deletion of the machine and of components, **it is necessary, now and only now, to apply the requirements of EN 620** and all the safety standards mentioned in this standard.

For information, a few French experts, members of CEN TC148 WG1, in charge of the EN 620 standard, argue that "nip guards" (**Fig.17**) must be defined as the 1st level of safety devices. For example, they allow for the cleaning of the conveyor without risk with the machine running, without disassembly of the protectors.

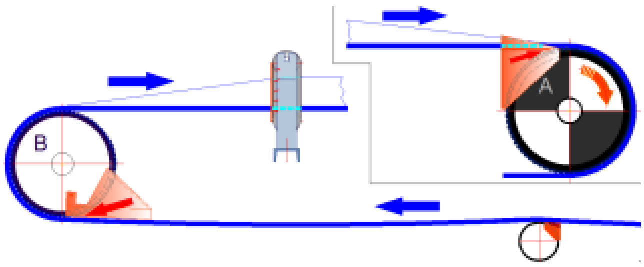

Figure 17: 4 examples of « *nip guard* »

Other types of protectors apply in order of priority, in the case of it being impossible to incorporate nip guard models; these are the fixed-guard (**Fig.18**), then the surrounding grills (completely enclosing) (**Fig.19**). These models are often disassembled for various reasons; in this case the area at risk is no longer protected and, in fact, this is the source of many accidents.

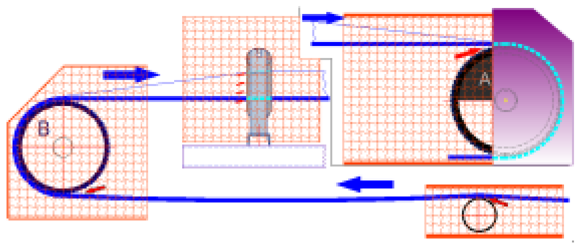

Figure 18: 4 examples of « *fixe guard* »

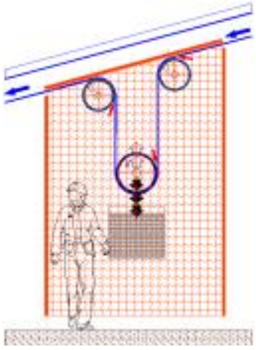

Figure 19: example of protector « *surrounding grills* »

ADDED BENEFITS

This chapter shows some of the advantages gained by the deletion of machines and components, described above.

After deletion of conveyor for speed-up feed conveyor:
The conveyor upstream will be adapted to allow a "mass" feed, with at 90 ° orientation with respect to the downstream conveyor (belt to protect). Thus, the speed of the product is considerably reduced. Damage to the belt is eliminated (punching, wear), product ejections (rebound phenomenon) are eliminated as well as cleaning costs, the risk of falling due to cluttered grounds; etc.

After deletion of the "pick-up crumbs" conveyors:
The risks related to their maintenance, often expensive, the disorders related to their presence, at the level of the hopper of the conveyor it serves, are removed.

After deletion of snub pulley at the head:
Its removal eliminates the disorders related to the underlying scraper, because of the clogging of this pulley by splattering material after the scraper. This clogging causes a significant loss of efficiency of the scraper. The presence of the snub pulley implies a reduced slope of the hopper face under this pulley, which leads to the clogging of the hopper. The removal of this pulley increases the slope of the chute face and reduces the risk of clogging. Dirt on the floor immediately behind the hopper and all along the conveyor, as well as the related risks (falls, slipping, cleaning interventions).

After the deletion of snub pulley in tail:
Its removal eliminates "hidden" damage to the carcass of the belt. This type of damage represents a significant cost with the constant need for adjustment of the swerved belt, the addition of training idlers and, consequently, the addition of new risks, and the premature replacement of the belt. This deletion reduces the accumulation of products on the ground at this section, which in turn greatly reduces the frequent need for cleaning and the risks associated with subsequent interventions.

After deletion of counterweight tension (GTU):
This concerns all models, mainly those installed return side and having 1 or 2 bend pulleys, in favor of a simple screw system to tail pulley. This deletion eliminates "hidden" damage of the carcass of the belt (misalignment of the pulleys), which represents a significant cost between the incessant adjustment actions of a swerved belt, the addition of training idlers and, consequently, the addition of new risks, and the premature replacement of the belt. This deletion eliminates accumulations of products on the ground in this area, eliminating the cleaning needs and associated risks.

The proof by example!
Since 2002, a cement plant has successfully operated an overland conveyor of 1,100 m in length, with a rise of 28 m and an output of 700 t/h, with a polyester-carcass belt of 800 mm width, operating at a speed of 1.7 m/s, whose take-up is "invariable under operation" (cable tractive device) and has a useful stroke of only 4.50 m for belt tension length.
So we recommend for any conveyor project, of modest size, a configuration with an ultrasimple belt-tension system (screw / nut or the like), as the first safety requirement.

With this conclusive experience, another cement plant has applied this rationale over the course of a few years, with this simple design introduced for all its conveyors, starting with those which disrupted the production because of recurring disorders with the counterweight (GTU).

Return-side idlers:
The increased idler pitch, in a ratio of 1 to 4 or 5, that is to say an original pitch 3m and a new pitch of 12 to 15 m, or more, makes it possible to obtain a greater stability of belt trajectory. The first benefit is in terms of safety. This design eliminates the adjustment interventions; this means so many risks removed.

The cleanliness of the rollers is easily achieved because of the increase in the belt-on-rollers pressure. Care should be taken to coat the roller with a smooth rubber, of 35 Shore, according to the plasticity of the product being handled. In fact, the so-called "anti-sticky rubber disc" rollers are disappearing from the world of conveyors; because these components are very often the cause of swerved belt and with its destruction, that is to say many interventions and additional costs. With the disappearance of these rollers, the risks which are related to them also disappear.

Note: the return rollers are often loaded to between 5 and 20% of their admissible load! Increasing their load to 100% of their capacity will not reduce their longevity, on the contrary. The "long" pitch between the supports eliminates the axial forces (force due to the swerved belt) applied by the belt to the rollers. These axial forces are the first cause of the destruction of the rollers! Again more gains!

Zero return idler:
A design reserved for short conveyors, up to ≈ 30 m length.
A design with zero return idlers eliminates any risk of trapping, roller drop and dirt on the ground. A clean floor eliminates the risk of falling, people slipping and the risks associated with cleaning interventions. Maintenance and stock costs are removed as well as the belt-damage that was due to the rollers in the old design.

SOURCES

All these applications have been widely demonstrated since 1986. All our calculation models, developed in our C3® and Traject® software, are based on the laws of physics, mechanics, and standards and have been enriched by our appraisals applied in 42 countries of the world.

Marc des Rieux, Expert
marc.desrieux@c3-expert.com
www.c3-expert.com

NB
This text which establishes the state of the art
Your remarks and comments are welcome to change practices to the benefit of all

Cet article a été publié / This article was published in :
Infovrac 206/Janv-Fév/page 44/ https://fr.calameo.com/read/00500337104c2f7a790a0
Mines & Carrières 243/Janv2017/page 47
Dry Cargo International 211/March2018/page 80 /
http://www.drycargomag.com/ThreeDmags/Magazine-Editions/March-2018-Issue/files/1.html