ANALYSIS OF THE FAILURE TYPES OF IDLERS USED IN BELT CONVEYORS

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ABSTRACT

Belt conveyors have better performance in several aspects in transporting granular materials over medium distances such as: low use of labor and energy, less harmful to the environment, provides a continuous flow of material between operations, more economical and safer, greater reliability and versatility, and virtually unlimited capacity compared to other modes of transport such as trucks or rail. As a result, it is the most used system in bulk transportation (materials in large quantities in raw state) and in the present study ore transportation is used more specifically. Carrying out the characterization and hierarchy of the materials of the idlers of belt conveyors is relevant because they represent the second highest maintenance cost of this means of transport, since the belt is the highest cost representing 30% to 70% of the maintenance cost. The analysis of data on the life of 97778 idler rollers made available by the maintenance department of the mining company Vale made it possible to identify the main causes that lead to the replacement of impact idler rollers (receive material loading), carrying idler rollers (move the belt during the journey) and return idler rollers (support the belt for its return without load), which are: noise, wear and idler seizure for load and impact idler rollers, among which in carrying idler rollers noise is more important (74,5% of replacement) than in impact idler rollers (46,0% of replacement). This replacement reason is caused by the excess load that causes the bearing to be damaged and, thus, promotes the generation of noise that is a parameter for the replacement. In return idlers, the amount of replacement due to wear is approximately three times greater than due to noise (62,0% and 20,6% of replacement respectively). This is due to the fact that these idlers do not receive a direct load from the transported material, being more relevant the abrasive wear mechanism resulting from the contact between the idler and the belt and the ore adhered to its surface. The knowledge of these replacement reasons allows to understand the specific operating conditions of the idler, and based on that, carry out an experimental planning that is more adequate to the reality of belt conveyor idlers, being able to better identify the main life determination tests to be carried out according to the type of idler studied.

Keywords: *Belt conveyor idlers, idler replacement reasons, mining, ore transportation.*

INTRODUCTION

Belt conveyors perform better in several aspects in transporting granular materials over medium distances such as: low use of labor and energy, less harmful to the environment, provides a continuous flow of material between operations, more economical and safer, greater reliability and versatility, and virtually unlimited capacity compared to other modes of transport such as trucks or rail. As a result, it is the most used system in bulk transport (materials in large quantities in raw state), and in the present study, it is used in the transport of iron ore more specifically[2].". Figure 1 schematically shows a belt conveyor.

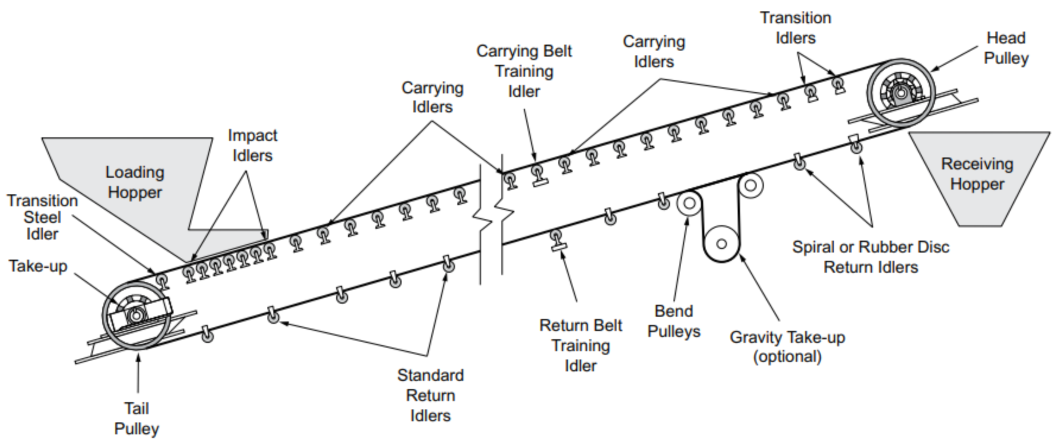

Figure 1: Schematic representation of a belt conveyor[5].

Observed in Figure 1, in the loading region (loading hopper), the ore is poured onto the belt, which is supported by impact idlers. This is the zone where the greatest loads exist in the system due to the falling height of the transported material. As a result, it is necessary to use rollers that are not rigid, as this can seriously damage the conveyor belt[2]. So the roller coating is made of rubber, which is a viscoelastic material, to reduce the loads. After loading the ore onto the belt, it is moved by carrying idlers, whose function is to support the belt with the ore. Carrying idler rollers operate at the same speed as impact idler rollers, with high load but no impact and in an environment with less suspended contaminants from ore loading. At the end of the process, the ore is unloaded and the belt returns in contact with the return idlers, which only serve to guarantee belt tensioning. These idlers are subjected to light loads, but they come in contact with the part of the belt that transports the ore and, therefore, have more contact with the ore[1, 2]. Therefore abrasive wear is more significant on these rollers in relation to the other rollers. The load distribution due to material transportation on the carrying roller and impact roller, considering a homogeneous ore flow, can be observed in Figure 2. Also can be seen that the inner bearings have more loads but the outer bearings have more contact with the weather (rain, wind and sunlight).

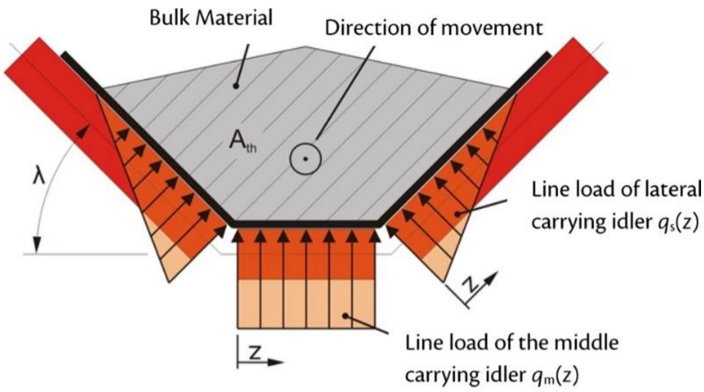

Figure 2: Load distribution on a belt over a triple idler with a homogeneous ore flow [3].

Understanding the reasons that led to the replacement of these rollers is of great importance, as they are fundamental components of belt conveyors. Because they represent the second highest maintenance cost of this means of transport, since the belt is the highest cost representing 30% to 70% of the maintenance cost[4].
As a result, using data provided by the mining company VALE on reasons for changing 97778 idler rollers: 7866 impact rollers, 68419 load rollers and 21493 return rollers, it is possible to understand, through the so-called defects by VALE, how the failures are occurring and what are the main reasons that led to the change of each type of roller.
Therefore, the objective of the present work is to analyze the data of the roller replacement history, in order to help future works to carry out the characterization and hierarchy of the rollers, considering all three types of rollers, focusing on their main reasons of replacement.

METHODOLOGICAL PROCEDURE

In order to analyze VALE's data, it is necessary to understand that the defects presented by VALE are actually reasons that led to the replacement of the rollers. Therefore, the maintenance department monitors the rollers, measuring vibration, temperature and others, by predictive maintenance and, with this, evaluates whether the change will be made and when it will be done.
VALE provided a report in the Microsoft Excel with 97778 idler rollers replacement reasons. After analyzing report, it was observed eight replacement reasons:

- Noise: The vibration frequency of the roller is measured, if abnormal, its temperature is measured to verify the criticality of the problem and when the replacement should be carried out;
- Worn: The coating is worn in a way that makes the roller uneven in relation to others in the same position;
- Seizure: The roller is locked, usually due to bearing failure;
- Broken: The bearing or roller is broken in a way that may or may not damage the belt;
- Missing: The roller is missing from the easel;
- High temperature: Temperature greater than 55°C on the roll without abnormal noise;
- Standardization: Replacement of the roll so that only identical rolls remain on the easel;
- Damaged easel: Breakage or damaged of the easel.

Using the same software, the data has been filtered by each type of idler roller with the dynamic tables help to perform the analysis. Then, it was counted the replacement amount of defects (replacement reasons), position and both (replacement reasons for each positon on the idler), using the count function in “values” and putting each parameter in “lines”. After that, in another sheet, the graphs were made for a better visualization, beyond the formatted table of replacement reasons for each positon on the idler, which was made with color scale (red > yellow > green) from conditional formatting.

RESULTS AND DISCUSSION

As shown in Figure 2.a, it is seen that the three main reasons for changing impact rollers are: noise, wear and seizure (in that order), representing 88,43% of all changes. For carrying rollers (see Figure 2.b), the three main reasons are the same as for impact rollers, in addition to presenting the same hierarchy, which represent 90,12% of all replacements. However, in the return rollers, the same hierarchy of replacement reasons does not occur, even with the same two main reasons, in which wear is now the main reason, followed by noise and standardization, representing 91,04% of all replacements.

The replacement reason due to noise is the main one for impact rollers (46,03%) and carrying rollers (74,46%), being more relevant for carrying rollers. An assumption for this is the excess load that causes the bearing to be damaged and thus promotes the generation of noise, which is a parameter for the replacement.
In return rollers, the number of replacements due to wear is approximately three times greater than due to noise (61,97% and 20,60% respectively). This probably happens due to the fact that these rollers do not receive a direct load from the transported material, being more relevant the abrasive wear mechanism resulting from the contact between the roller and the belt with ore adhered to its surface.

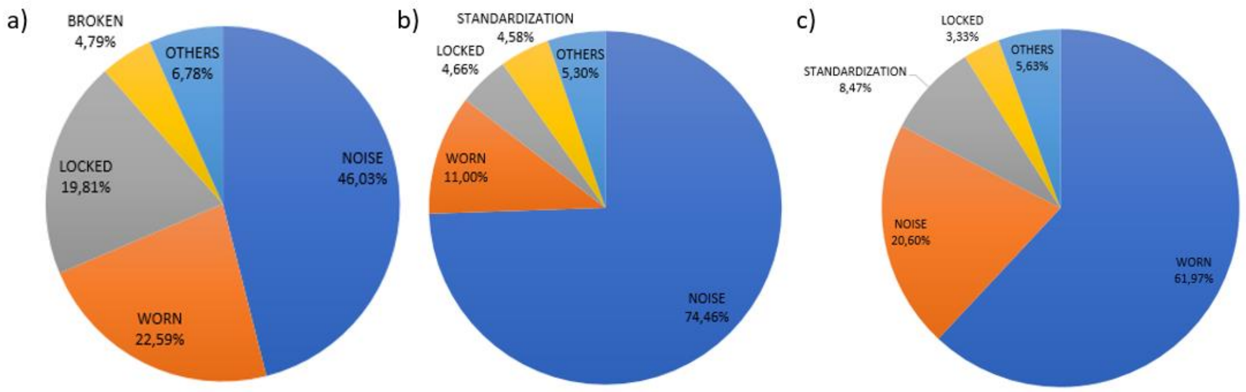

Figure 2: Replacement reasons percentage of a) impact, b) carrying and c) return idler rollers.

For a deeper understanding, it is necessary to detail the reasons for substitution linked to each position. The impact and carrying idlers are triple for the data collected, but the return idlers are not like that, they can be flat or double, so this analysis is not done. Figure 3 shows examples of the types of idlers for a better understanding of the positions of the rollers on the idler.

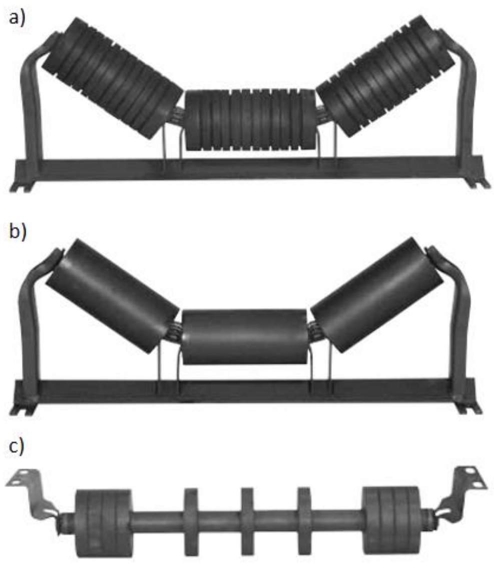

Figure 3. Examples of a) impact, b) carrying and c) return idlers[5].

Table 1 shows the amount of each impact roller replacement reason and the position on the idler, in addition to performing a hierarchy through a color gradient (red > yellow > green). It is observed that for all positions the main reason is noise and only for three cases of roll replacement the positions were not recorded (shown in the "Unfilled" column). It is clear that the side rollers (left and right roller) have exactly the same hierarchy, as well as close values for the seizure and wear replacement reasons.

For the central roller this does not occur, with wear being the reason with the second greatest impact instead of seizure (less than half of the cases). An assumption for this event is that the bearings of the side rollers are in direct contact with the weather (rain, wind and sunlight), causing the grease to lose its lubricity, which favors seizure failures. As the central roller is better protected from such weather, in particular rain, for these the main field removal criterion is wear.

Another type of reason for replacement that has a high discrepancy of incidence between the positions of the rollers is the high temperature, which in the central roller has more than double in relation to the others. It is speculated that this occurs from bearing loading. For the central rollers, both bearings are highly loaded and have a high frictional moment and, consequently, a higher temperature. As for the side rollers, the inner bearing is heavily loaded, but the outer bearing is not. As a result, the outer bearing is unlikely to fail due to high temperature.

Table 1: Replacement reasons quantity and the roller position for impact idlers.

Replacement Reasons	Central	Right	Left	Unfilled
NOISE	1095	1247	1279	0
WORN	605	562	607	3
SEIZURE	277	599	682	0
BROKEN	152	109	116	0
HIGH TEMPERATURE	86	38	32	0
MISSING	74	110	123	0
STANDARDIZATION	29	20	18	0
DAMAGED EASEL	0	1	2	0
Total	**2318**	**2686**	**2859**	**3**

The same analysis is done for the carrying rolls as seen in Table 2. Noise and wear are the main reasons for all rollers and there are seventeen rollers that were not recorded (in the "Unfilled" column). The lateral rollers have the same hierarchy and differs in the central roller, the same observed in the analysis of the impact rollers.

Similar to impact rollers, central rollers have higher amounts for wear and smaller amounts for seizure, possibly for the same reason as impact rollers, in which, due to being in contact with the weather, the external bearing of the side rollers lose their lubricity. There are also more high temperature replacements on the center rollers, caused by the higher loads on the bearings compared to the side rollers.

Table 1: Replacement reasons quantity and the roller position for carrying idlers.

Replacement Reasons	Central	Right	Left	Unfilled
NOISE	19613	15766	15557	12
WORN	3044	2310	2168	3
SEIZURE	340	1392	1456	1
STANDARDIZATION	1080	999	1055	0
BROKEN	965	751	600	1
HIGH TEMPERATURE	363	186	192	0
MISSING	65	248	248	0
UNFILLED	2	1	1	0

Total	25472	21653	21277	17

CONCLUSIONS

The three main reasons for replacing carrying and impact rollers are, respectively: noise, wear and seizure, representing approximately 90% of the reasons for both, where noise has greater relevance for carrying rollers. While the three main reasons for replacing return rollers are respectively: wear, noise and standardization, also representing approximately 90% of the reasons.

The high incidence of noise in the impact and carrying rollers can be due to the high loads, compared to the return rollers, damaging the bearings and causing noise. On the other hand, the return rollers present higher occurrences for wear, as they are in direct contact with the surface of the belt that was in contact with the ore, which has abrasive material adhered to it.

The rollers in the lateral positions of the idler, both impact rollers and carrying rollers, have a similar hierarchy in change parameters and differ from the rollers in the central position of the idler. The central rollers have larger amounts for wear and smaller amounts for seizure, in relation to the side rollers. The external bearings of the side rollers are in direct contact with the weather (rain, wind and sunlight), causing the grease to lose its lubricity, causing a higher incidence of failures due to the seizure of these rollers. In addition, the central rollers are experiencing greater loads, thus causing a greater amount of high temperature replacements than on the side rollers.

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REFERENCES

1. ABNT (Associação Brasileira de Normas Técnicas). NBR 6678: Transportadores contínuos: Transportadores de correias: Roletes: Projeto, seleção e padronização. Rio de Janeiro, 2017.
2. CEMA. Belt Conveyors for Bulk Materials. 2. ed. USA: Conveyor Equipment Manufacturers Association, 2007.
3. HÖTTE, St. et al. THE WAY TO THE DIN 22123 – INDENTATION ROLLING RESISTANCE OF CONVEYOR BELTS. 2020. Disponível em: https://news.bulk-online.com/bulk-solids-handling-archive/the-way-to-the-din-22123-indentation-rolling-resistance-of-conveyor-belts.html. Acesso em: 03 maio 2022.
4. MOLNAR, W.; VARGA, M.; BRAUN, P.; ADAM, K.; BADISCH, E. Correlation of rubber based conveyor belt properties and abrasive wear rates under 2- and 3-body conditions. Wear, v. 320, n. 1, p. 1–6, 2014. Disponível em: https://doi.org/10.1016/j.wear.2014.08.007.
5. REXNORD. Rex conveyor idlers. 2014. Disponível em: http://www.rexnord.com/ContentItems/TechLibrary/Documents/6002_Rex-Conveyor-Idlers_Catalog-pdf.