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ABSTRACT

ASSESSMENT OF THE MAIN TRANSPORT SYSTEMS IN THE ROȘIA POIENI QUARRY

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The purpose of this research is to evaluate the functionality of the two main transport systems in the Roșia Poieni quarry. The first system involves high-capacity truck transport. The second system is continuous with roller belt conveyors. Essentially, the work highlights two aspects.

The first aspect involves the appreciation, estimation, and evaluation of the functionality of the Komatsu 785 high-capacity dump trucks used to transport ore to the crusher and tailings to the dump. The evaluation is based on the analysis of the dump truck failures.

Equally, the research evaluates the operational reliability based on major failures that occurred in the operation of the continuous transport system with roller belt conveyors. The importance of the topic is demonstrated above all by the global demand for copper, exemplified by the electric car industry and photovoltaic systems for green energy production.

The database that allows the evaluation of the Komatsu HD 785 dump truck is made up of reports drawn up regarding its functionality. The reports highlight, by year, the main preventive, but especially corrective maintenance activities. By default, the main defects are highlighted as well as how to solve them.

The analysis of the reports drawn up for the period 2015-2022 allowed the highlighting of the main defects and how to remedy them, for variants 5 and 7 of the HD 785 dump truck. Mainly, the stresses that lead to the appearance of defects, especially through wear, come from:

− the dead weight of the dump truck and the load, which reaches up to 166 tons;

− the configuration of the roads in constant transformation, characterized by large slopes, extreme turning radii, the condition of the road surface;

− atmospheric conditions, cold, heat, dust, humidity, water accumulations especially at the base of the quarry.

The analysis of these technical data leads to a series of very important information that allows the evaluation of the overall functionality of the Komatsu HD 785 dump truck.

1. Most interventions occur in the mechanical installation elements: the cylinders and rods of the steering system; the rear-front suspensions (telescopes); the rear axle tie rods; the oscillating arms that attach the front wheels to the chassis; the rear wheel attachment brackets.

The mentioned connecting subassemblies are considered wear elements, but at the same time also protection and safety elements. They are the ones that fall first, protecting the upstream force execution elements, which are much more complex and expensive. In addition, they incorporate a cheaper execution technology. Diagnosis, accessibility, disassembly, reassembly is relatively easy, requiring tools, devices, universal lifting installations. Viewed from this point of view, downtimes are much reduced, but the qualification of the human operator must also be taken into account.

The analysis of the database shows that there were about 80 interventions on the force subassemblies installation systems, over a period of eight years, for the seven Komatsu 785 dump trucks, variants 5 and 7. It results that, on average, 10 interventions were carried out/year, a value that is absolutely satisfactory.

2. The Komatsu SAA12V140E-7 diesel engine is a reliable piece of equipment. On the K2 dump truck, the engine was replaced after 29,383 hours of operation, although the company indicates the RK overhaul after 18,000 hours. It is noted that the overhaul is performed in the specialized workshops of the manufacturing company. In the quarry workshop, the defective engine is replaced with a new or overhauled engine.

3. It is worth noting the relatively large number of interventions on the braking system consisting of the service brake, parking brake and retarder system. The situation is explained by extreme traffic conditions, high tonnage, high transport slopes.

4. The analysis also shows that the frequency of major defects in the Komatsu 785 dump truck is very low. They fall well below the prescriptions in the dump truck user manual. Minor defects occur either due to manufacturing defects of some parts or due to improper operation. In 90% of cases, the defects are gradual, progressive, wear-and-tear. They lead to the slow

deterioration of parameters as a result of component wear. Defects are anticipated by previous observations.

As a final conclusion, the Komatsu HD 785 dump truck is a reliable piece of equipment that meets the current requirements for road transport in the quarry. The ore is transported from the crusher to the preparation plant warehouse by a continuous transport system consisting of five roller belt conveyors. For identification, the conveyors are coded B1, B2, B3, B4 and B5S. This main ore transport system is known in company practice as the belt relay.

Conveyors B1, …, B4 are stationary and ensure the transport of ore horizontally and on inclined planes to the B5S conveyor, also stationary. This conveyor ensures the collection and deposit of ore in the preparation plant warehouse. Based on the daily reports on the date of corrective maintenance interventions, in conjunction with the actual operating times of each conveyor on each work shift, the actual operating times until the conveyor belt failure are determined for each conveyor, recognized as the time between failures. For each conveyor, an ascendingly ordered statistical series consisting of the effective operating times until the failure of the belt and vulcanizations results.

Based on the statistical series of times until failure, using the estimators indicated in the specialized literature, the empirical function or distribution of the distribution of belt and vulcanization defects is determined, also known as the empirical failure function, or experimental failure function.

The criteria used for adopting the distributions are the dispersion and the difference between the empirical and theoretical distributions. Those distributions for which the dispersion and the difference have the lowest values are adopted. The dispersion represents a measure of the centering of the values with respect to the average value (median), which is considered to be the value closest to the real value.

B1 conveyor

The reliability of the B1 conveyor is assimilated by the reliability of the EP 250/5 (EP 1250) textile insert belt. Reliability indicators can be evaluated, equally, using the normal or three-parameter Weibull distributions. The service life of the EP 250/5 textile insert belt is about 5836 hours, expressed in effective operating hours, under quarry operating conditions.

Operating conditions are defined by operation in an open atmosphere, under the open sky, over a short horizontal transport distance, about 100 m, with medium-value technological forces, the presence of an abrasive environment, and favorable conditions for preventive and corrective maintenance. The B1 conveyor is considered a reliable equipment characterized by an average time between failures of 5836 hours.

B2 conveyor

The reliability of the B2 conveyor is assessed by assimilating the reliability of the conveyor belt subsystem consisting of the serial elements of the belt conveyor and vulcanizations. The operating conditions of the conveyor belt are defined by the operation underground, with upward transport on a 12° inclined plane, a transport distance of 970 m, with high technological forces, the massive presence of the abrasive environment in a limited space with natural ventilation, improper conditions of preventive and corrective maintenance.

The reliability of the STM 3150 steel cord belt conveyor is evaluated with the three-parameter Weibull distribution. The average operating time of the belt conveyor is 17906 hours, expressed in effective operating hours, under quarry operating conditions.

Conveyor belt hot vulcanizations are evaluated equally with the normal and three-parameter Weibull distributions. The presence of the normal distribution in the evaluation of vulcanizations is explained by the large number of data available, but also by the long duration of product operation monitoring.

The average operating time until a vulcanization is re-done or fully performed is 886 hours. It is worth noting the higher share of re-doing the vulcanization coatings with much shorter execution time, with direct influences on the availability of the conveyor. The very large gap between the reliability functions of the belt conveyor and the related vulcanizations indicates that the reliability of the conveyor belt subsystem is assimilated by the reliability of the vulcanizations. Under these conditions, the reliability of the B2 conveyor is quantified by the reliability of the vulcanizations and is characterized by the MTBF indicator of 886 hours.

In the entire belt relay, the B2 conveyor is the element with the lowest reliability. The large number of vulcanizations that need to be performed indicates the need to analyze the technology of their implementation.

B3 conveyor

The reliability assessment of the B3 conveyor follows the algorithm presented for the B2 conveyor. Structurally, the conveyors are identical, it is equipped with the same type of belt, what differs is the shorter transport length and the higher transport inclination, with direct implications on the demand on the conveyor belt.

The operating conditions are defined by underground operation, upward transport on a 15˚ inclined plane, a transport distance of 860 m, with high technological forces, the massive presence of the abrasive environment, improper conditions of preventive and corrective maintenance. The reliability of the STM 3150 belt conveyor is evaluated with the three-parameter Weibull distribution.

The belt conveyor is a reliable product characterized by an average mean time between failure, MTBF, of approximately 18520 hours. The value is comparable to that shown for the belt conveyor of the B2 conveyor.

The hot vulcanizations related to the conveyor belt are evaluated equally with the normal and three-parameter Weibull distributions. The average operating time until a vulcanization is restored or fully performed, MTBF, is 1137 hours. The value is comparable to that shown for the B2 conveyor. The difference can be explained by the different operating conditions of the two conveyor belts.

The very large gap between the reliability functions of the belt and the related vulcanizations indicates that the reliability of the conveyor belt subsystem is assimilated by the reliability of the vulcanizations. Under these conditions, the reliability of the B3 conveyor is characterized by the MTBF indicator of 1137 hours.

B4 conveyor

The reliability assessment of the B4 conveyor follows the algorithm presented for the B2 and B3 conveyors. The conveyor construction is identical, being equipped with the same type of belt conveyor. The operating conditions are defined by underground operation, upward transport on a 9˚ inclined plane, a transport distance of 520 m, with high technological forces, the massive presence of abrasive media, and improper preventive and corrective maintenance conditions.

The reliability of the ST 3150 belt conveyor is evaluated with the three-parameter Weibull distribution. The belt conveyor is a reliable product characterized by an average mean time between use and failure, MTBF, of 19373 hours. The value is comparable to that of the B2 and B3 conveyors. Conveyor belt hot vulcanizations are evaluated equally with normal and three-parameter Weibull distributions. The mean time between re-vulcanization or full completion, MTBF, is 1774 hours.

The very large gap between the reliability functions of the belt and the related vulcanizations indicates that the reliability of the conveyor belt subsystem is assimilated by the reliability of the vulcanizations. Under these conditions, the reliability of the B4 conveyor is assimilated by the reliability of the vulcanizations and is characterized by the MTBF indicator of 1774 hours.

B5S conveyor

The reliability of the B5S conveyor is assimilated by the reliability of the belt conveyor with textile inserts EP 250/5. Reliability indicators are evaluated with the three-parameter Weibull distribution. The B5S conveyor is a reliable equipment characterized by an MTBF of 1737 hours. It is worth noting the relatively low value of the belt conveyor's service life, compared to the B1 conveyor, which is the same type of belt with five textile inserts.

As a general conclusion, the three-parameter Weibull distribution is used to describe the functionality of the five conveyors. The use of this distribution law allows obtaining synthetic relations for calculating reliability indicators. The fundamental problem in assessing the reliability of the belt relay is to establish the analytical expression of its reliability.

From the point of view of reliability, the belt relay is considered as a complex system consisting of five subsystems connected in series, namely the conveyors B1, B2, B3, B4 and B5S. The reliability of the belt relay is the product of the reliabilities of the five conveyors.

The reliability of the belt relay is evaluated by an exponential function whose coefficients and exponents are obtained from specific Weibull distribution parameters specific to each conveyor.

The reliability function shows that the probability that the belt relay will not fail due to the conveyor belts after 400 hours of operation is 85%, under the conditions of applying the planned preventive maintenance system. The probability density function of defects, as well as the failure intensity function, indicate values of the order of 10-4 def/h, which confirms the high level of reliability. The system is characterized by an average time between failures MTBF of 731 hours.

A complete assessment of the functionality of the belt relay can be made based on its availability. Availability is determined based on the operational reliability indicators, determined in this paper, and the maintainability indicators, which quantify maintenance actions.