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Comparative study of costs of belts and trucks for the transportation of mineral in surface mining [Estudio comparativo de costos de fajas y camiones para el transporte de mineral en minera superficial]

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Resumen

Este estudio se enfoca en realizar una descripción detallada de los costos unitarios asociados del traslado de minerales en operaciones mineras La hipótesis planteada sugiere que, al realizar una evaluación económica, las fajas transportadoras exhiben un valor presente más bajo en comparación con el uso de camiones. La investigación se caracteriza por ser aplicada, no experimental y descriptiva. La conclusión extraída señala que, al contrastar estas dos opciones mediante un análisis económico, la faja transportadora tiene un valor presente reducido de 119 millones de dólares, lo que representa una ventaja frente a los camiones que registran un valor presente de 164 millones de dólares, reflejando una diferencia del 39% indicando que la faja transportadora se posiciona como la opción más beneficiosa para su construcción. Para llevar a cabo este proyecto, serían necesarios contar con 13 camiones también una apiladora igual que un cargador frontal y la trituradora de material. En contraste, una opción a utilizar camiones requeriría una cantidad de 22 unidades, con una demanda de un 50% en términos de valor presente en comparación con el enfoque de la faja transportadora.

Palabras clave: Faja, camiones, costos, valor presente, trituradoras.

Abstract

This study focuses on making a detailed description of the unit costs associated with the transportation of minerals in mining operations. The hypothesis proposed suggests that, when carrying out an economic evaluation, conveyor belts exhibit a lower present value compared to the use of trucks. The research is characterized by being applied, non-experimental and descriptive. The conclusion drawn indicates that, when contrasting these two options through an economic analysis, the conveyor belt has a reduced present value of 119 million dollars, which represents an advantage over trucks that have a present value of 164 million dollars. reflecting a difference of 39% indicating that the conveyor belt is positioned as the most beneficial option for its construction. To carry out this project, it would be necessary to have 13 trucks, as well as a stacker, a front loader and a material crusher. In contrast, an option to use trucks would require a quantity of 22 units, with a demand of 50% in present value terms compared to the conveyor belt approach.

Keywords: Belt, trucks, costs, present value, crushers.

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1. Introduction

In the current bibliographical investigation, its main objective is to make a detailed description of the unit costs associated with the transfer of minerals in open pit mining operations, focusing specifically on the comparison between the use of conveyor belts and trucks. (Raimundo, 2021) argues that to effectively address this evaluation, specific objectives have been outlined that will guide the development of the study. Firstly, it is intended to determine the technical design characteristics of the conveyor belts, understanding in detail their specifications and requirements for efficient performance in the mining context. (Borges, 2010) In a complementary manner, a similar analysis will be carried out for trucks, identifying the key technical characteristics that impact their design for the hauling of minerals in mining operations. (Rios, 1995) Subsequently, a comparison will be made of the costs associated with each transportation system, considering crucial factors such as fuel consumption, maintenance expenses, labor involved and possible operational stoppages. This analysis will allow obtaining a complete vision of the economic aspects linked to each method of transportation. Finally, (Guzman, 2003) based on the results obtained, the most appropriate transportation option will be proposed, taking into account technical, economic and environmental criteria. This proposal will be based on a comprehensive analysis that reflects the particularities and specific needs of the operation. open pit mining in question. By achieving these objectives, the aim is to provide the mining company with an informed and detailed vision that facilitates strategic decision-making regarding the choice of the most efficient and profitable transportation system to optimize its operations (Nieves, 1988).

2. Materials and Methods

2.1 Materials

This process is enhanced by reviewing the mine's operational reports, followed by the application of simulation methods and mathematical tools in the corresponding analysis.
Data will be collected through daily reporting, timing and GPS to measure times, distances and speeds on transportation equipment. The analysis and processing phase will use spreadsheets, allowing for efficient interpretation of the information collected.

2.2 Procedure

To carry out this investigation, field tests and specifications of equipment such as the CAT-793D truck and the type B conveyor belt with a width of 2400 mm were carried out, in order to obtain data and compile information on costs and time. that are used in the mine. When the total information is collected, the pertinent calculations will be made in order to analyze the unit costs of both belts and trucks. These collected and synthesized data were processed on the desktop and subsequently compared with other research done by other authors. According to (López, 1997) With the data already collected, a comparison of results will be carried out that will allow establishing the most appropriate costs for this plan.

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Figure 1 CAT-793D Truck

Figure 2 Belt T 3/8 – 5/32 EP 800/4 type B x 95”

2.3 Population and sample

Population: The entire fleet of trucks dedicated to hauling ore in mine operations is carried out using conveyor belts that make up the population under study.

Sample: The most relevant choice of the sample in the mineral transportation process in the Cajamarca region occurred specifically in the hauling activity using trucks and in the transfer of mineral through conveyor belts.

For the implementation of the Belt (T), the use of 13 trucks must be used, while for the truck alternative, 22 pieces of equipment are required. The specifications of the Belt (T) and its lengths, the belt is type B, its type of casing is 95” it has a band resistance (N/mm) EP EP (polyester - polyamide) its number of layers is 4 The upper coverage is 3/8” its lower coverage is 5/32” and its lengths have an inclined section that is A - B CT=100 m and its final CT 90 m and a Length of 258.20 m slope 7% and its horizontal sections B - C, initial CT of 90 m, final CT 90 m and a length of 289.70 with a 0% slope, in section C - D, the initial CT is 90 m, and its final CT is 90 m and its length is 1596.50 and a slope of 0%, D - E, initial CT 90 m, final CT 90 m and its length is 548.30 and a slope of 0%. The specifications of the truck model CAT-793D, Cat 3516B HD engine has a net speed of 1750 rpm net power 1743 kW has a payload of 232 T rated gross weight of 383848 Kg and has a box weight of 30700 kg and a displacement of 78 L.

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3. Results

3.1. Costs for operation, investment and maintenance

In this review, we will closely analyze and compare the costs associated with the implementation and operation of belt and truck systems (Guzman, 2003). This assessment will provide detailed insight for companies and projects seeking to optimize resources and make informed decisions based on the costs of each transportation method.

Conveyor belt: for the belt system, obtaining components such as the protection, structure and safety system are included (Roulunds, 2024).

Annual costs cover recurring expenses such as energy, fuel and operating personnel. Finally, (Ccori, 2019) shows the maintenance costs that include preventive, corrective activities and other essential elements.

Main investment: The value for each meter of the belt will be $21,770,000, this incorporates essential elements such as rollers, drive system, pulleys, hoppers, tensioning car, safety systems, counterweight and support structures, among others (C.E.M.A, 1996).

Annual costs: Covers lubricants, machinery maintenance, fuel, labor and welding materials (Goodrich, 2015)

Table 1 Conveyor belt costs

Belts Costs	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*TOTAL*
Investment	*$22,889,000.0*										*$22,889,000.0*
Labor force	*$1,123,000.0*	*$1,123,000.0*	*$1,123,000.0*	*$1,123,000.0*	*$1,123,000.0*	*$1,123,000.0*	*$1,123,000.0*	*$1,123,000.0*	*$1,123,000.0*	*$1,123,000.0*	*$11,230,000.0*
Input	*$25,000.0*	*$25,000.0*	*$25,000.0*	*$25,000.0*	*$25,000.0*	*$25,000.0*	*$25,000.0*	*$25,000.0*	*$25,000.0*	*$25,000.0*	*$250,000.0*
Mant (P)	*$6,087.2*	*$6,087.2*	*$6,087.2*	*$6,087.2*	*$6,087.2*	*$6,087.2*	*$6,087.2*	*$6,087.2*	*$6,087.2*	*$6,087.2*	*$60,872.0*
Mant (C)	*$193,416.2*	*$329,416.2*	*$193,416.2*	*$356,916.2*	*$193,416.2*	*$329,416.2*	*$193,416.2*	*$356,916.2*	*$193,416.2*	*$329,416.2*	*$2,669,161.8*
Devaluation	*$2,266,111.0*	*$2,266,111.0*	*$2,266,111.0*	*$2,266,111.0*	*$2,266,111.0*	*$2,266,111.0*	*$2,266,111.0*	*$2,266,111.0*	*$2,266,111.0*	*$2,266,111.0*	*$22,661,110.0*
SUB - TOTAL (USS)	*$26,502,614.4*	*$3,090,782.0*	*$3,226,782.0*	*$3,063,282.0*	*$3,226,782.0*	*$3,090,782.0*	*$3,226,782.0*	*$3,063,282.0*	*$3,226,782.0*	*$3,090,782.0*	*$59,760,143.8*

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Truck transportation: This expense covers the maintenance of machinery and involves expenses for fuel, labor, oils, filters, coolants and rubber tires. This covers maintenance activities such as welding, welding supplies, electrical materials and their elements.

Table 2 Truck costs

Truck	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	TOTAL
Investment	$116,820,000.00										$116,820,000.00
Labor force	$2,816,000.00	$2,816,000.00	$2,816,000.00	$2,816,000.00	$2,816,000.00	$2,816,000.00	$2,816,000.00	$2,816,000.00	$2,816,000.00	$2,816,000.00	$28,160,000.00
Input	$581,066.86	$581,066.86	$581,066.86	$581,066.86	$581,066.86	$581,066.86	$581,066.86	$581,066.86	$581,066.86	$581,066.86	$5,810,668.60
Mant (P)	$7,258,010.10	$7,258,010.10	$7,258,010.10	$7,258,010.10	$7,258,010.10	$7,258,010.10	$7,258,010.10	$7,258,010.10	$7,258,010.10	$7,258,010.10	$72,580,101.00
Mant (C)	$5,048,158.94	$13,848,158.94	$13,848,158.94	$13,848,158.94	$13,848,158.94	$27,036,520.94	$13,848,158.94	$13,848,158.94	$13,848,158.94	$13,848,158.94	$142,869,951.40
Devaluation	$11,682,000.00	$11,682,000.00	$11,682,000.00	$11,682,000.00	$11,682,000.00	$11,682,000.00	$11,682,000.00	$11,682,000.00	$11,682,000.00	$11,682,000.00	$116,820,000.00
SUB - TOTAL $	$120,841,235.90	$12,841,235.90	$12,841,235.90	$12,841,235.90	$12,841,235.90	$12,841,235.90	$12,841,235.90	$12,841,235.90	$12,841,235.90	$12,841,235.90	$366,240,721.00

Table 1 and Table 2 present the detailed cost calculations for acquisition, annual, maintenance and depreciation on the previous pages. Depreciation is calculated by dividing the acquisition inputs by a certain period of 10 years, and an additional 20% is added for unforeseen events.
The equipment is purchased only in the first year, followed by maintenance and component replacement. The first year includes depreciation expenses, fuel, labor, and equipment acquisition. In subsequent years, these elements, except procurement, are considered and component-related inputs are added. These results include a present value with its initials VP and an equivalent annual cost with its initials CAE.

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A detailed summary of the total costs associated with the acquisition of trucks and conveyors is presented in Table 3. This comprehensive analysis covers various aspects, from the initial investment to annual and maintenance costs. Thus facilitating a more accurate understanding to support informed decisions in industrial and logistics projects.

Table 3 Total acquisition cost

hauling structure	US$
Belt (T)	$22,880,111
Stacker	$356,200
Truck	$67,431,180
Front loader	$2,800,920
Crusher	$11,333,014
Total	$104,801,425

3.2. Difference between belts and trucks

Table 4 exhaustively details the Differential Flow and its Present Value (PV), these were developed and calculated during the process of analyzing the expenses for the different options considered in this research. These values were very essential and important to express the flow of financial variation over the years, providing us with very important data and information in order to be able to make good and correct and appropriate strategic decisions in the context of the options already previously evaluated and analyzed. (Zuleidi, 2014).

Table 4. Difference in the VP of trucks and belts

Time (in years)	Difference in the VP
2015	$14.830.569,00
2016	$8.227.141,00
2017	$7.267.141,00
2018	$6.851.641,00
2019	$7.327.141,00
2020	$12.145.980,00
2021	$7.363.141,00
2022	$6.815.641,00
2023	$7.610.499,00
2024	$7.227.141,00
Total	$70.180.121,00

The preparation of Table 5 was developed with the purpose of making the comparison and seeing the difference between the VP and the objective of identifying the reserve that has been achieved in the financing of the hauling machinery. This reserve can have the initiative of up to 50% going towards the restoration of the place in question and charitable activities for the future.

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Table 5. VP of the belt and accessories

Machinery	V.P
Belt T	$-14. 615.569
Truck	$-88.227.516
Front loader	$-7.256.142
Stacker	$-1.851.641
TOTAL	$-111.950

The table presents negative figures, since the data collection considers initial costs, expenses and maintenance per year. The result obtained from the initial costs, expenses and devaluation, the interest rate will be 15%. While trucks have the highest present value, the tape shows the lowest present value in this analysis. (Mercado, 2008) It should be noted that the integral Present Value of the belts and their equipment is being evaluated, generating a total Present Value $ -111 M.

Figure 3 shows that the trucks have a higher Present Value; it is important to note that this equipment undergoes more important maintenance, which causes an increase in its costs and consequently in its Present Value.

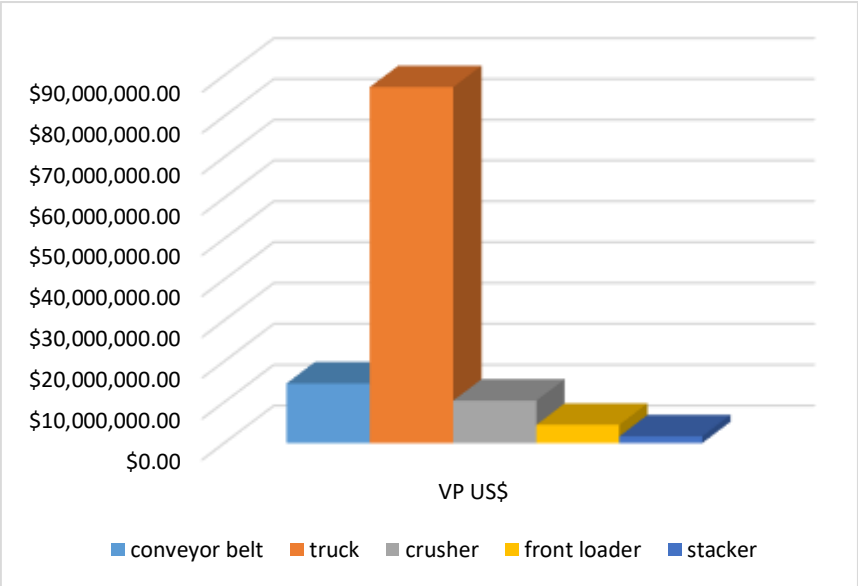

Figure 3. VP – belt accessories

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Table 6 Alternative VPs

Transport system	VP (U$$)
Truck	$ -164.247.516,10
Belt T	$ -117.255.842,72

It shows the Present Value of two alternatives, and by analyzing the comparison of these values, it is concluded that the Present Value of the truck option is greater than that of the conveyor belt. Figure 4 shows that truck alternatives have higher acquisition costs, annual costs, and costs associated with maintenance. Which amounts to US$ -46 million or 39%. This suggests that it is more advantageous to invest in the conveyor belt alternative rather than purchasing new trucks.

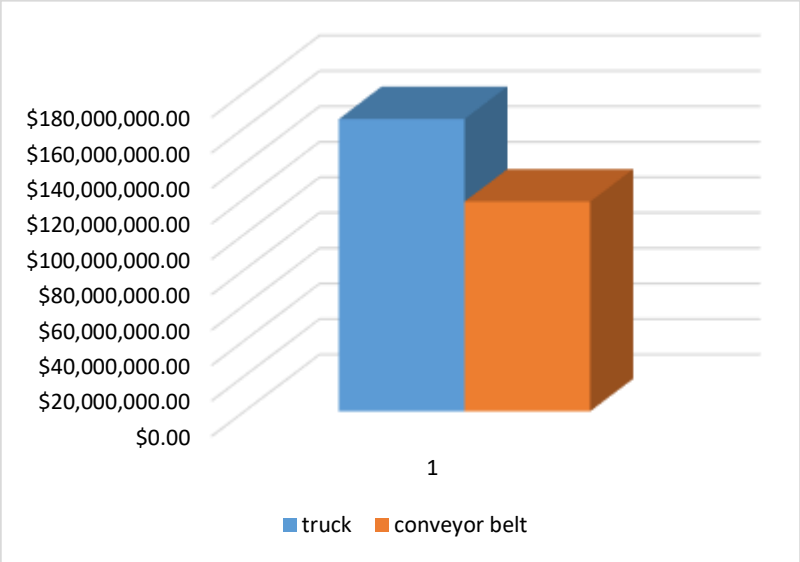

Figure 4. Alternative VPs

Table 7 Trucks vs VP Belts

Transport sistem	VP (U$$)
Conveyor belt	$-34.615.807,23
Truck	$-24.598.998,74

The truck is considered the equipment with the highest Present Value. This fact is due to the fact that trucks have a high maintenance cost, this increases their total cost and therefore also the PV. The difference of -9 million dollars, which represents 39% of the investment, clearly highlights the important difference between the two alternatives examined. The use of the Equivalent Annual Cost becomes important because it provides a concrete measure of the financial impact of each option. The marked financial difference indicates that the option with negative value shows better performance in terms of differences in annual costs (Roulunds, 2024). This robust financial

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analysis allows for a deeper understanding of the economic implications of each alternative evaluated.

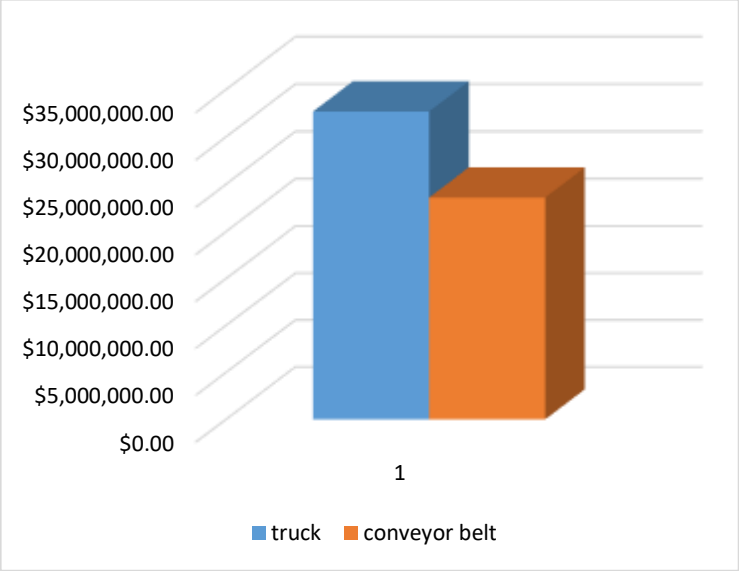

Figure 5. Belt vs trucks VP

4. Conclusions

• The final volume of waste to be transported by conveyor belt during the next seven (7) years is 179,412 million cubic meters.
• The necessary diameter of the conveyor belt will be 5,023.75 meters, from level 100 to level 90.
• For the width, 2.4 meters was considered, which is ideal for the volume that would pass through the belt.
• The power required for each section is: A-B: 3,744.50 kW; BC: 480.30 kW; C-D: 2,064.20 kW; D-E: 809.30 kW.
• The tension necessary to keep the belt taut without creating waves or breaks is: A-B: 578.12 N/mm; B-C: 74.21 N/mm; CD: 319.31 N/mm; D-E: 125.13 N/mm.
• Operations with (FT) require 13 trucks, crushers, front loaders and stackers, while the truck alternative requires 22 pieces of equipment.
• According to the Economic Study, conveyor belts have a Present Value (PV) of less than US$ 119 million, which gives them a 39% advantage over trucks, whose PV is US$ million 164 snowflakes. The Equivalent Annual Cost (CAE) also had a difference of 39%, this would show us that the best option will be (FT). Additionally, the Present Value of Differential Flow is 50% lower than that of trucks, supporting the return on investment in conveyor belts.

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