Feasibility project for implementation of conveyor belts in an iron ore mine. Study case: Fabrica Mine in Minas Gerais State, Brazil

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Abstract

This article objectifies the implementation of a conveyor belt in an iron ore mine. The mine operational costs of the company Vale S.A. have a tendency to increase in coming years. This increase is related to the rising price of labor, fuel, tires, maintenance costs and large transport distances. Meanwhile, environmental impacts also need to be reduced. The case study of the Fabrica mine operated by VALE in the city of Congonhas, in Minas Gerais State of Brazil, was chosen aiming for a comparative study between the employment of big trucks and the deployment of conveyor belts. The decision for the best alternative would be made by an economic analysis of the incremental cash flow. After the economic evaluation of the project, economic and environmental gains were expected for the alternative of conveyor belt deployment.

Keywords: conveyor belts, incremental cash flow, mining projects economic evaluation.

1. Introduction

Mining operational costs have increased significantly due to increased prices for diesel, large truck tires, equipment maintenance, and manpower.

The competitiveness of the global market for iron ore has demanded efforts from companies to design studies that enable operational cost reductions. The global economic crisis in 2009 produced a decline in sales and, consequently, the price of iron ore for large mining companies also declined, forcing them to halt their operations with high operating costs.

The mining is divided into drilling, blasting, loading and transportation operations, whereby the transportation of iron ore and waste is predominantly carried out by trucks.

The conveyor belt technology is used in various mines around the world, proving to be effective and having a low operating cost. This option applies to the transport of run of mine ore (ROM) for different types of minerals and varied transport distances.

The need to perform mining activities with responsibility and sustainability has increased in recent decades, and business concerns to reduce the impacts on the environment have been important in the development of mining projects.

A case study of Fabrica Mine was conducted searching to elaborate an alternative comparison for ore transport between using trucks and using conveyor belts.

2. Methods

The methodology adopted was that of incremental economic analysis. This was done through an economic evaluation of the difference in cash flow for the two situations studied (Lapponi, 2007). This analysis was necessary whenever there was no increase in production. In the case study, production was maintained and was performed only to compare the transport of ROM done by off-road trucks and conveyor belts.

After obtaining the difference between the cash flows of the alternatives of off-road trucks and conveyor belt, the incremental cash flow was calculated. Subsequently, the discounted cash flow's net present value (NPV) was elaborated.

Positive NPV shows that the replacement of the off-road trucks by a conveyor is economically viable. Otherwise, the best solution is to continue to perform the transport of ROM with off-road trucks.

Advantages and disadvantages between conveyor belt and off-road trucks are shown in Table 1.

Off-Road Truck	Conveyor
Advantages	
1 - Lower investment cost	1 - Long distances
2 - More flexibility	2 - High capacity
3 - Short distances	3 - High availability
4 – No restriction for material size	4 - Low cost of operation and maintenance
	5 - Continuous production
	6 - Easily extendable
	7 - Correct environmentally
Disadvantages	
1 - High operating costs and maintenance	1 - High cost of investment
2 - Large number of equipment for high volumes	2 - Less flexibility
3 - High requirement of employee	3 - Limitation on size of transported material
4 - High maintenance of roads	
7 – Not safe for operator	

Table 1
Comparison between
Conveyor Belt and Off-Road Trucks

The rainy season can be a problem for conveyor or off-road truck transport if the pit is not utilized correctly. It is recommended to mine the top of the pit in this season or above the ground water. The off-road trucks have flexibility to quickly abandon the flooded areas. Under the same conditions, the conveyor needs a good mine plan because time and high costs are involved to relocate this equipment.

There are two main types of layout systems for continuous transport: by belts from within the pit or straps located outside of the pit.

The layout system depends primarily on whether the material is friable or requires crushing before being transported. If the material is friable, it can be removed by excavators and transported directly by belts or trucks to the primary crusher (fixed ex pit or semi-mobile in pit). If the material is not friable, it is detonated, loaded into a primary crusher (mobile), or loaded onto trucks and transported to the primary crushing station (ex pit or semi-mobile in pit).

Most continuous transport systems require a crushing machine that can be classified as mobile or semi-mobile set. Table 1 (Sandvik, 2010) presents a comparison of this classification according to some specific characteristics of the equipment for productivity (t / h), dependence on transport via trucks, type of crusher and costs.

Table 2
Classification of Crushers

	Mobile	Semi Mobile	Fixed
Yield (t/h)	<10,000	<12,000	<12,000
Number of trucks	-	Low	Intermediate
Type of crusher	Jaw	All	All
Crushing operating costs	High	Intermediate	Low

Fixed Crusher

Generally, a fixed crusher is not located inside the pit, but on the edge of the pit or within walking distance. The material is transported by trucks to the crushing plant and then transported by conveyor belt to the processing plant.

Advantages of this system:

• Reduction of transport distance;

• The trucks can temporarily replace the belts if a problem occurs;

• Greater flexibility;

• Easy system implementation;

• Can be adapted to existing operations without geometric changes to the pit.

Disadvantages of this system:

• The system remains fixed in place for several years;

• High costs associated with the relocation of the equipment, if necessary;

• Interference with mine planning.

Semi-mobile Crusher

In this case, the crushing plant is located inside the limits of the pit and has off-road truck accesses as an essential requirement. The semi-mobile crushing plant must be relocated regularly according to the mining plan. The material is transported by conveyor from the crusher to the beneficiation plant.

Advantages of this system:

• Low transportation distance;

• Increase the safety of the mine;

• Reduction of CO_2 emissions;

• The trucks can temporarily replace the conveyor belt in the event of operational problems;

• It is possible to adapt existing operations to some reconfigurations of the pit and make some possible long-term changes.

Disadvantages of this system:

• It needs a period of time for relocation;

• Interference with mine planning because the mining sequence depends on the location of the crusher.

Mobile Crusher

This is a fully mobile system in which the crusher is fed directly by the loading machine, thus eliminating all trucks. After crushing the material, it is transported via conveyor to the processing plant.

Advantages of this system:

• Eliminates the use of trucks;

• Increases the safety of the mine;

• Reduction of CO_2 emissions;

• Low operating cost mine;

• Flexibility to change in accordance with the mine planning.

Disadvantages of this system:

• High initial investment;

• If there is any operational problem, the production is completely dependent on the system.

A conveyor device consists of a horizontally or inclined (upward or downward) profile, curved (concave or convex) or not, or a combination of these profiles designed for the handling of bulk materials. Shipping is done by a continuous belt with reversible movement or not, and it moves on drums, rollers or sliding tables. The equipment is employed in the handling of various types of materials which may be part of an automated complex.

According to Conder and Richardson (2004), there are four main types of belts used in mining for materials transportation:

• conventional belts;

• cable belts;

• tubular belts;

• high strapped slope.

The belts can also be classified according to their mobility in fixed belts, straps, belts and semi-mobile. Webbing straps are mounted on fixed structures and are the most widely used long distance conveyor belts (LDCB's or overlands), and also, in cases of crushing in the pit where the straps will not suffer reallocations. When in the pit, they are connected to the belts of countertops. Electric drives require more skilled and more resistant carpets and their automation is more elaborate because they most often have long lengths. They can operate at higher speeds.

The semi-mobile belts are those called bench belts, and are periodically reallocated in accordance with the mining plan for the fronts and changes in the mining benches. They are designed to be versatile, mobile and easy to be transported and relocated. Mounted on steel structures, this modular machine can be moved easily, optimizing the mining process. The drives are smaller and the carpets are of least resistance and automated.

Thus, this study included three alternatives comparisons for the two cases: the use of off-road trucks and conveyor belts by varying the position of the crushing system:

A. Semi-Mobile Crushing System, outside of the pit with conveyor belts;

B. Semi-Mobile Crushing System, within the pit with conveyor belts;

C. Mobile Crushing System, within the pit with conveyor belts. Table 3 shows the summary of the three alternatives of conveyor belts compared to the current scenario of off-road trucks.

	Number of Crusher	Length of Conveyor (meter)	Reduction of Off-Road Trucks
Alternative A	1	2.560	5
Alternative B	2	4.660	8
Alternative C	3	6.760	9

Table 3
Summary of Alternatives

The capital cost used in the economic analysis is shown in Table 4.

	Conveyor Belt (US$)	Off-road Truck (US$)
Alternative A	55,000,000	12,460,000
Alternative B	56,600,000	19,936,000
Alternative C	90,933,333	53,828,000

Table 4
Capital Cost

The operation cost can be seen in Table 5.

	Conveyor Belt (US$/t)	Off-road Truck (US$/t)
Alternative A	0.68	0.97
Alternative B	0.44	0.97
Alternative C	0.23	0.97

Table 5
Operation Cost

The commitment to the preservation of the environment is a key factor in the sustainability strategy of mining companies. Nowadays, they seek a balance between socio-economic development of the territories where the companies operate, while maintaining the quality of natural resources, biodiversity and life.

CO_2 is the gas that has the greater contribution to global warming. Carbon dioxide currently emitted by burning fossil combustive remains in the atmosphere for a long time (about 100 years). The reduction in the distance and hence the reduction of off-highway trucks allows for the reduction of CO_2 emission.

It is possible to calculate the environmental benefits for reducing CO_2 emissions. According to Bartholomeu (2006), a liter of diesel fuel consumed creates 2.7458 kg of carbon dioxide. The off-road trucks consume an average of 0.25 liters/t. From these data, it was possible to calculate the reduction in CO_2 emissions considering the reduction of the number of off-road trucks, for the three alternatives studied.

3. Results and discussion

The NPV of the three alternatives presented was calculated based on the difference of the discounted cash flow of the conveyor and off-road truck options, considering the assessment of investments, operating costs, depreciation and taxes. Table 6 shows the results obtained by the incremental economic analysis:

	NPV (US$)
Alternative A	-16,980,401
Alternative B	366,498
Alternative C	26,564,712

Table 6
NPV of Alternatives

The Table 7 notices the average reduction in the number of off-road trucks replaced by conveyor belts.

	Average Reduction of Trucks (unit)
Alternative A	3
Alternative B	5
Alternative C	8

Table 7
Reduction of the Number of Trucks

With the lowest number of dump trucks, it was possible to reduce CO_2 emissions as shown in Table 8.

	Reduction of CO_2 Emission (%)
Alternative A	12
Alternative B	19
Alternative C	29

Table 8
Reduction of CO_2 Emission

4. Conclusions

Incremental analysis used in the economic evaluation of alternatives clearly presents the results for the comparative economic flow boxes amongst the alternative ROM transportation with off-road trucks and conveyor belts.

The results of the economic studies conducted show that Alternative C is the most attractive and feasible, mainly because there is a strong trend for increasing fuel, labor and tire costs in Brazil.

Alternative C will reduce CO_2 emissions by approximately 29% and eliminate part of the fleet of off-road trucks used for transporting ROM while increasing the safety of the operating area.

The study showed considerable security and economic gains while lessoning environmental impacts and demonstrated an ability to fight the trend of high operating costs. Cost parameters for operating trucks and conveyor investment must be constantly reevaluated due to their great influence on the results.

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