A Techno-economic study of pumping Vs conveying for the long distance transport of mineral sand ores

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Abstract

This project aims to investigate the financial and technical aspects of conventional & multi-stage pumping systems as well as overland conveying systems. Capital and operating costs for the three systems were obtained from information extracted from external and internal sources. This enabled an NPC to be conducted over a fifteen year period at a require rate of return of 12.5%. For throughputs in the order of 600tph conventional pumping proved to be the most financially viable method over 10km. At throughputs over 1000tph, overland conveying became the favoured method due to the escalating power costs associated with both pumping methods. Conducting a sensitivity analysis on the key variables showed that further investigation into maintenance costs for overland conveyors would be needed, as this variable can affect the NPC considerably.

1.0 Introduction

The purpose of this project is to perform a techno-economic comparative study between the use of conveyors and slurry pumps for the transportation of mineral sand ore from the mining pit to the concentrator. This paper will analyse three methods in particular over a 10km distance so that a recommendation on the best method of long distance transport can be made. The three methods are conventional pumping, multi-stage pumping and overland conveying. In conducting the analysis consideration was given to financial as well as technical aspects associated with each method of transport.

2.0 Background

A green-fields analysis as compared to a real model will be conducted. The analysis was conducted on an as new basis over a straight line for a range of distances and throughputs (in tonnes per hour). An average elevation change was determined by acquiring elevation data for the distance from the mining pit to the concentrator for a number of Iluka's mine sites in WA. The area of analysis for pumping (as seen in figure 1) will commence at the end of the trommel hopper, and conclude before the cyclone feed hopper. The process water and tails pumps will also be included in the pumping analysis. For conveying the area of analysis will commence at the end of the Jacques screen hopper and will conclude at the before entering the trommel as shown in figure 2.

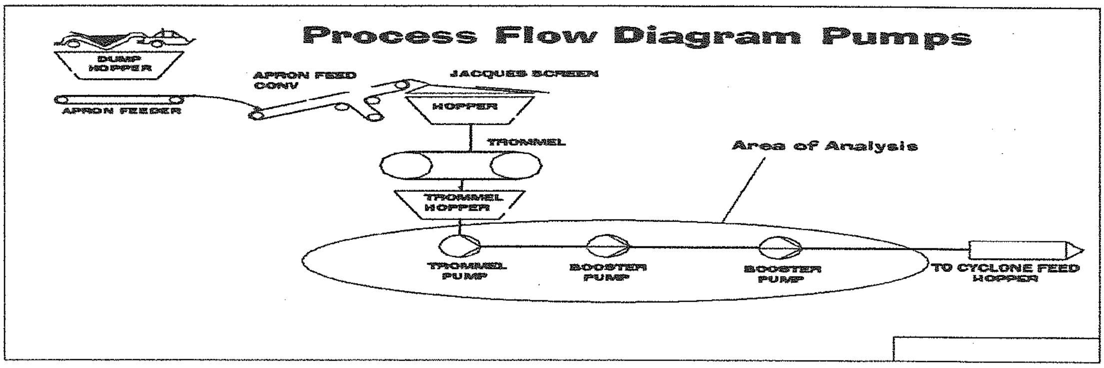

Figure 1. Conventional and Multi-stage Pumping Process Flow Diagram

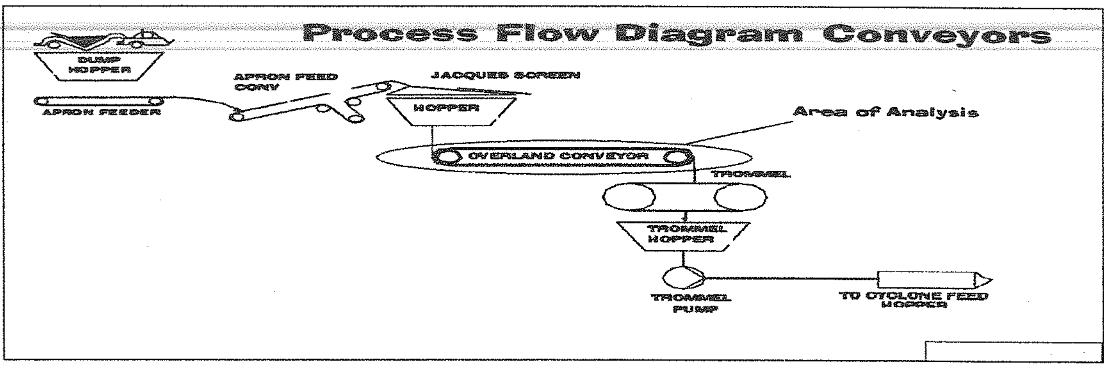

Figure 2. Conveyor Process Flow Diagram

2.1 Conventional pumping

Conventional pumping is the most common method of transporting mineral sands at Iluka Resources. Conventional pumping can be described as slurry pumping whereby booster pumps are located along the pipeline several hundred metres apart. The distance between pumps is determined by pressure requirements, as a pump requires a certain inlet pressure to operate effectively. The number of pumps on a given line will be determined by the friction losses through the pipe and the terrain the pipeline travels (Halkjaer, 2004).

2.2 Overland conveying

Iluka Resource's currently employs small scale belt conveyors to transport mineral sand ores. Large overland conveyors are typically belt conveyors and are one of the most versatile and widely used methods of transporting material over long distances. The belt conveyor is essentially an endless belt on which the solids are transported. The belt is friction driven at one end and is carried on an idling drum at the other end (Hudson, 1949).

2.3 Multi-stage pumping

Multi-stage pumping is similar to conventional pumping however all pumps are arranged in series at the one pumping station instead of several hundred metres apart. Each lot of pumps arranged in series is referred to as a train and the train is generally located at the start of the pipeline (Warman, 1994). It is not uncommon to have several trains along one pipeline. The major advantage of multi-stage pumping is the saving on electrical costs however the higher pressures produced can increase operating costs significantly.

3.0 Methods and Techniques

To complete this project extensive information was required from various internal and external sources. Obtaining information externally involved specifying the exact requirements and submitting them to the supplier. Constant communication was needed to ensure correct quotes were obtained. In obtaining information internally, various personnel in charge of specific areas had to be contacted, usually by telephone or email. In the numerous site visits, information was obtained by interviewing numerous key employees.

Some information had to be obtained from other companies such as SKM Consulting. Conveyor information in particular was sought from SKM. The calculations needed to get capital estimates on the various parts for an overland conveyor were obtained from a computer program (BeltStat) at SKM. The total conveyor capital costs were determined by obtaining pricing for the various conveyor parts.

4.0 Results

4.1 Capital Costs

The capital costs associated with the three systems are illustrated in figure 3. It can be observed that overland conveyors have a considerably larger capital outlay than the pumping systems. Overland conveyors are very large continuous structures and require a great deal of steel and expensive belts so the initial outlay is substantial. Both pumping systems have a similar initial capital outlay. Multi-stage pumping has a slightly lower capital outlay due to the saving on electrical costs as cabling is not required over the entire distance and a control centre is not needed for every booster pump.

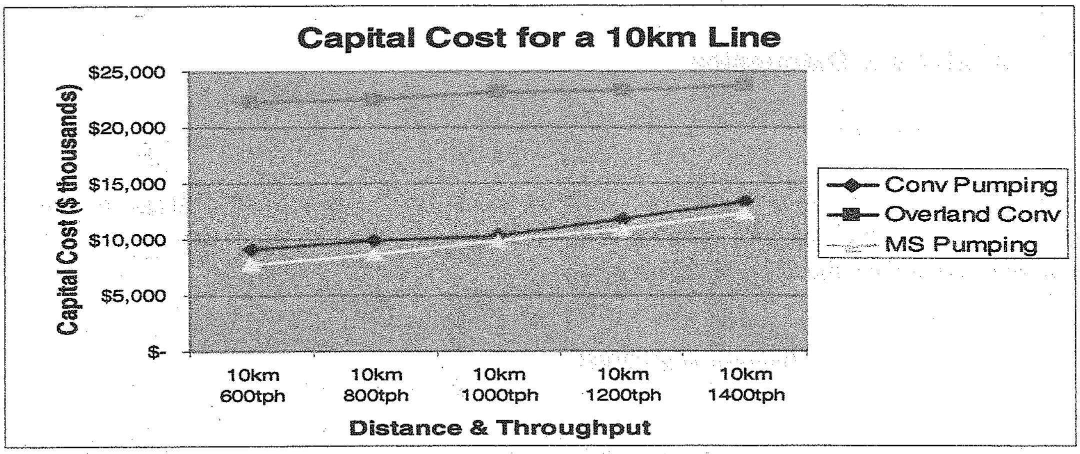

Figure3. Capital Costs for all three systems

4.2 Operating Costs

The operating costs can be determined by summing the annual power, maintenance and insurance costs for the three systems. As can be seen in figure 4 the operating costs show very different results to the capital costs. Overland conveying has the least annual expenditure on operation while multi-stage pumping has the greatest annual expenditure. Multi-stage and conventional pumping systems have many pumps along a 10km line, therefore the power consumption is much larger than an overland conveyor which typically has one large motor that drives the belt. The annual operating costs for multi-stage pumping are greater than conventional pumping because of the higher pressure produced in the multi-stage systems. High-pressure introduces the need for steel piping which results in greater friction losses and hence more pumps. There is also the need for gland water pumps to effectively seal the slurry pumps at high pressures. The gland water pumps add to the power consumption and are also maintenance intensive. Insurance costs have minimal impact as they only account for 0.1% of the initial capital cost each year.

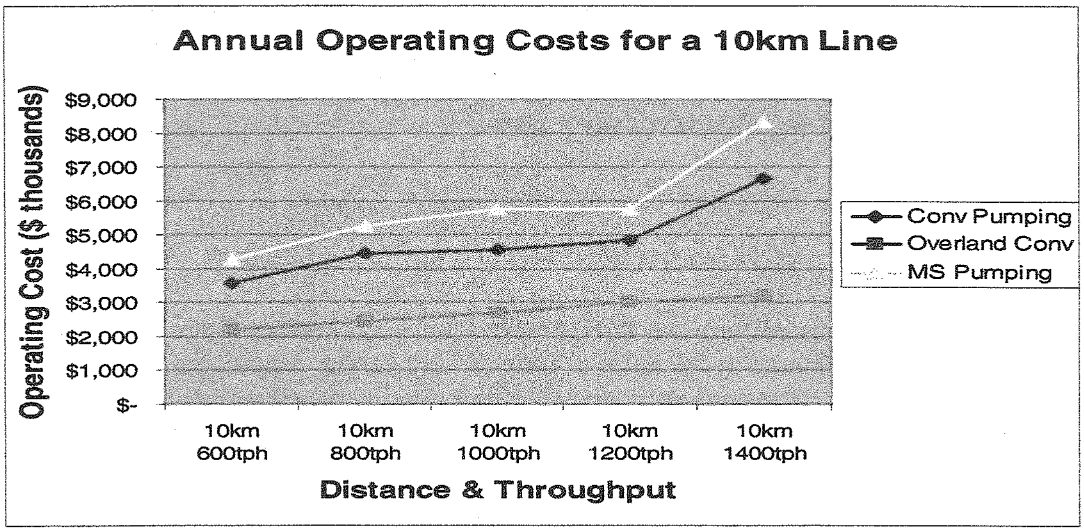

Figure 4. Annual operating costs for all three systems.

5.0 Analysis & Discussion

5.1 NPC Analysis

The net present value of a project is found by discounting the project's future net cash flows at the required rate of return and subtracting from the resulting present value the initial cash outlay on the project. Therefore:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0 \text{ (Peirson et al, 2003)}$$

In this project there is no revenue as it isn't possible to determine the increase in worth of the feed from the beginning of the overland conveyor to the end of the overland conveyor as this would be zero as the ore is only moving from one location to another. The same reasoning can be used for conventional and multistage pumping systems. Therefore the net present value will be referred to as net present costs (NPC) for this project.

As can be seen in figure 5 the NPC for the 10km line shows mixed results. It is clear that conventional pumping has the least costs at 600tph but becomes more expensive as the throughput increases. Overland conveying becomes the favoured transport method as the throughput increases above 1000tph. Even though the initial capital costs are very large for overland conveyors, the annual operating costs are relatively low. Multi-stage and conventional pumping however have a smaller capital outlay, but have very large annual operating costs making them a less desired transport method as throughput increases.

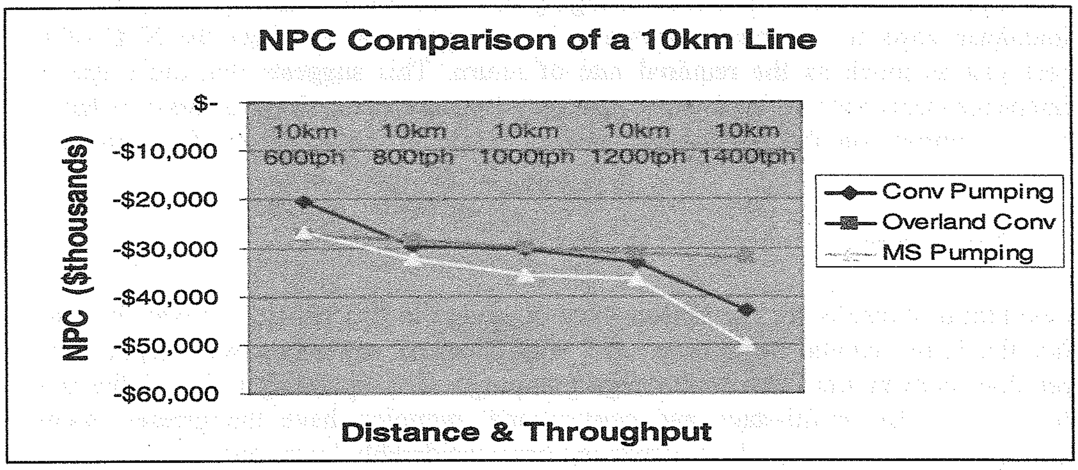

Figure 5. NPC Comparison of all the three systems

5.2 Sensitivity Analysis

Sensitivity analysis involves assessing the effect of changes or errors in the key variables on the net present value or in this project the net present cost (NPC). For example Iluka management may want to determine the effect a 20% positive or negative change in the required rate of return has on the net present cost. If the net present cost is sensitive to changes in particular variables, the estimates of these variables may need to be examined more thoroughly (Peirson et al, 2003).

As it is unnecessary to investigate the impact of all variables on the NPC, the key variables which have been chosen include:

- Required rate of return
- Maintenance cost
- Power cost

The following table ranks the variables which are most sensitive to changes from their expected value. The analysis looks at the range of the NPC taking into account a 20% positive and negative change from their expected value.

	Required rate of return	Maintenance cost	Power cost
Conventional pumping	1	3	2
Overland conveying	1	2	3
Multi-stage pumping	1	3	2

Figure 6. Sensitivity analysis variables

As we can see in figure 6 changes in the required rate of return has the greatest effect on the NPC of a project for all three systems. The required rate of return is determined by the Iluka financial hierarchy and is deemed to be suitable for Iluka projects during the current financial period. Therefore changing this variable is unlikely to occur. The maintenance costs for overland conveying has the potential to affect the NPC of the project just as much as the required rate of return. This suggests that more data on maintenance costs for overland conveyors may be needed, as slight errors can have a significant impact on the profitability or cost minimization of an overland conveyor project.

6.0 Conclusion

The preliminary results for the project were presented in this paper. As was discussed earlier the initial capital costs associated with overland conveying were significantly larger than conventional and multi-stage pumping. The operating costs of the three systems show that multi-stage and conventional pumping have the greatest annual operating costs, whereas overland conveying has considerably lower operating costs. The NPC analysis conducted over a 15 year period showed mixed results. For the 10km line conventional pumping seems to be the most cost effective method of transport at the lower throughputs while overland conveying is favourable at throughputs greater than 1000tph. It is recommended via the sensitivity analysis that maintenance costs for overland conveyors should be investigated further as Iluka does not have large overland conveyors and this cost was based purely on estimation.

7.0 References

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