A critical evaluation of haul truck tyre performance and management system at Rössing Uranium Mine

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Synopsis

The factors affecting haul truck tyre performance and the effectiveness of the management system at Rössing Uranium Mine were investigated with the aim of increasing tyre performance in terms of running hours until failure. The main objectives were to identify the types of tyre failure, their causes and cost implications, and evaluate the effectiveness of the management system. A site severity survey, weight study, and TKPH studies were conducted to determine the pit conditions, and an analysis of failed tyres carried out. The results showed that tyre performance at the mine has declined from 2009 to date, and the increase in lost value amounted to R5.7 million in 2012 alone. The main cause of tyre failure is loose rocks in the pit. The present management system in the load and haul department is not effective enough due to operational constraints it is facing.

Keywords

tyre failure, cost implications, types of failure, causes of failure, management system, TKPH, haul roads.

Overview

Rössing Uranium Mine is an open pit mining operation on the west coast of Namibia. Currently, there is a global off-road tyre shortage, which has a negative impact on large operations such as Rössing. According to Cutler (2012), it has been estimated that most tyre suppliers have about 25–30% undersupply in the market for the past 3 years. The demand has surpassed supply, as shown in Figure 1, and the tyre shortage crisis has increased tyre prices by as much as 425% since 2009.

Rössing currently has 32 Komatsu Haulpak 730E 2000 HP haul trucks which run on six tyres per truck, thus there are 192 tyres in operation at any given time. The downward trend in tyre life – 7371 hours in 2012 compared to 10 119 hours in 2009 (Figure 2) has a negative impact on operations at Rössing. Optimizing the tyre life is therefore a necessity in order to ensure that the operation does not run out of tyres, as obtaining tyres in the current market is not easy.

According to Simulilo (2012), tyre performance at Rössing over the past two years has been below target, as illustrated in Figure 2. The mine has experienced premature failures in 49% of the tyres, with cut separation being the most common cause. The outcomes of the project will help the mine reduce the number of premature failures and increase the average tyre life.

Rössing is currently under taking a cost-cutting exercise in the wake of poor production and low uranium prices coupled with increasing costs (Aluvilu, 2012). The project has the potential to assist in this, in line with the company's objective, which is to cut costs without retrenching employees. Every additional hour of tyre life is money saved on the procurement of new tyres.

Methodology and objectives

The objectives and methodology of the project are summarized in Table I.

The methodology for the project has been guided by the recommendations of Carter (2007) on areas of awareness for tyre improvement as shown in Table II.

Results and analysis

Performance review

The operation uses two main brands of tyres; namely Michelin and Bridgestone, but does use other brands such as Goodyear and Belshina when the supply of the two main brands is short. The operation is currently running 35 Komatsu 730E 180 t dump trucks, which use tyres sizes of 37.00R57 (Michelin) and 42/90R57 (Bridgestone).

Figure 3 shows the frequency graph for the tyres in terms of the hours run to failure. Ideally the tyre life should fall in the

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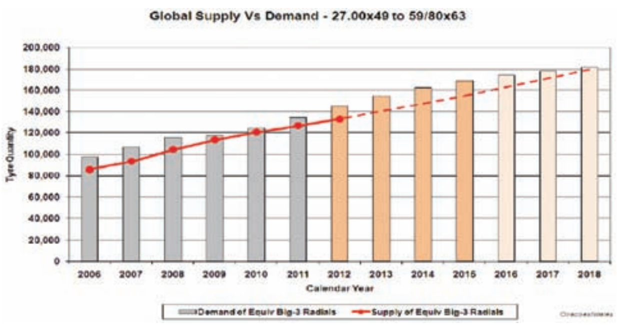

Figure 1—Global tyre supply and demand (Cutler, 2012)

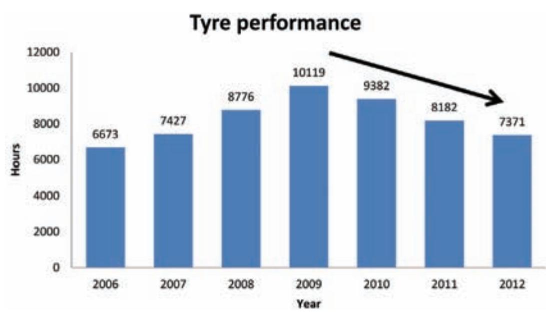

Figure 2—Tyre performance over the past 7 years

Table I

Objectives and methodologies

Objective	Methodology
Conduct a market analysis on tyres.	Literature review
Do a performance review	• Data collection • Data analysis
Determine types of tyre failure at Rössing	• Data collection • Data analysis
Identify and investigate possible causes of tyre failure	• Road severity survey • Loading area investigation • Tipping area severity survey • Weight study • TKPH study • Interviews with the necessary personnel • Observation of general pit conditions
Determine cost implications of tyre failure	• Data collection • Data analysis
Evaluate the effectiveness of the Rössing tyre management system	• Operator questionnaire • Interview with necessary personnel • Data collection and analysis
Identify areas of awareness	Analysis and recommendations

10 000–12 000 hour interval to maximize tyre performance. However, in 2009 only 48% of tyres reached that interval, and only 18.7% and 2.5 % in 2011 and 2012, respectively. In 2011 and 2012 no tyres reached a life of more than 12 000 hours. In 2012 and 2011 most of the failures occurred between 6000 and 10 000 hours. 2009 has been chosen as a baseline year to compare 2011 and 2012 results because it is the best performing year over a 7-year period.

Table II

Areas of awareness for tyre life improvement (Carter, 2007)

Awareness area	Possible actions to Improve awareness area
Driver awareness	• Make operators aware of the supply situation • Solicit input on areas of improvement • Provide incentives for improvements
Haul road design	• Super-elevation in corners (if supers aren't possible, reduce speed) • Identify and remove soft spots in roads • Optimal road crown is 3%
Air pressure maintenance	• Conduct regular pressure checks, with immediate pressure corrections • Daily preferred, weekly necessity • Install new O-rings and hardware when mounting • Inspect/change/repair cracked wheels and components • Inquire with dealer about temperature/ pressure monitoring • Analyse air pressure documents just like any other
Mechanical maintenance	• Check alignment • Check suspension components • Use 'rock knockers' • Rectify problems immediately
Tyre and rim inspection	• Driver walk-around (train drivers what to look for) • Rim inspection for cracks or flange damage • Inspect valve hardware
TKPH management	• Total GVW adherence (no overloading is acceptable) • Adhere to speed limit
Support equipment	• Proper and effective use of graders and rubber-tired dozers • Equipment should be assigned to shovels • Driver radio communication of spills and road damage • Fix problem areas immediately
Analyse scrap tyres	• Analyse history of scrap tires • List types of damage • List vehicles with multiple tire failures • Examine shift performance (individual crews with problems; night vs. day)
Establish performance committee	• Involve cross-section of mine in joint efforts • Plan consistent meeting schedule • Make assignments for change; follow up for corrections
Communicate and report	• Issue consistent, visible reports of efforts • Issue consistent, visible reports of progress • Solicit suggestions.

Types of tyre failure

Figure 4 summarizes the different types of tyre failure experienced at Rössing. Any of these modes of failure can occur at any time in the tyre's lifespan except worn out which usually occurs at the back end of the service life of the tire. The biggest challenge the mine is facing is the fact that there is no system to identify specific areas in the pit where a particular tyre fails, hence the 'hot spots' where most tyre failures occur cannot be identified. This situation has made prioritizing specific areas in the pit for more attention and ascertaining the exact causes of tyre failure a hard task.

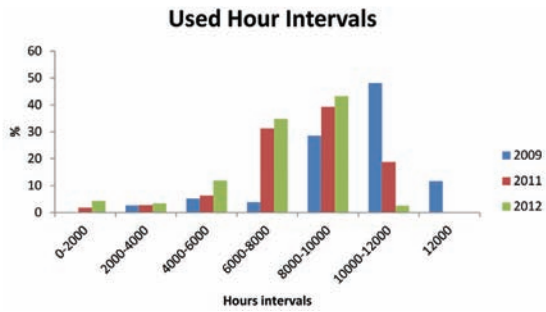

Figure 3—Frequency graph for average tyre hours

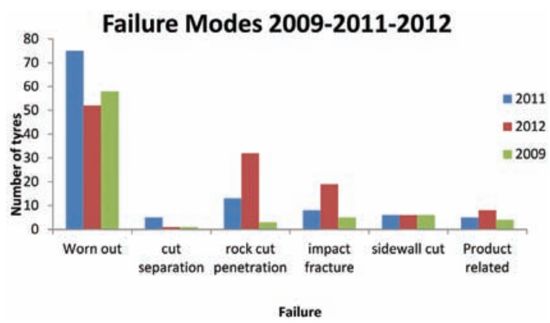

Figure 4—Failure modes

Most of the tyres failed from wear, which is the ideal situation as tyres usually have a lot of hours on them at the time of failure. In 2009 the fleet was a bit smaller than at present, but the fleet was the same for 2011 and 2012, which shows that more tyres were lost in 2012 than in 2011, indicating a drop in tyre performance as the operating truck hours were virtually the same for both years.

Figure 5 shows the average tyre life for each failure mode for 2009, 2011, and 2012. The mine uses the operate-to-failure system whereby a tyre is replaced with a new tyre only once it has failed. This system does not pose any safety hazard as the radial tyres only deflate at failure and do not burst. Worn-out failure mode is the ideal type of tyre failure as it carries more hours and maximizes tyre life more than the other types of tyre failure. Operational failure and product-related failure remain the modes of failure with the lowest average hours across all three years, and much should be done to limit those modes of failure.

Possible causes of failure

Driving over rocks is the general cause of most tyre failures at Rössing. There is no reliable system to locate where the failures take place in the pit, as tyres do not necessary fail immediately on coming into contact with the rock but might fail a few hours or days later. A few areas have been identified as causing specific modes of tyre failure, and the results from the observations and measurements are discussed in detail below.

Tons-kilometres per hour (TKPH)

A tons-kilometres per hour (TKPH) study was done at Rössing Uranium Mine to ascertain whether the mine is using the right tyres for the site conditions. TKPH causes tyre failure through heat separation and increased wear rate. The TKPH study was done only on the Michelin tyre and not the Bridgestone, but it was advised that the results for one brand are significant enough to determine the site conditions.

Results (real site TKPH):

- Front= 706
- Rear= 661.

The tyre in use is a 37.00R57 XDR B4 with a TKPH rating of 848, which means that the tyres on site are the right tyres; therefore the premature tyre failures are not due to the TKPH rating being exceeded. The results of the TKPH study are supported by the results of the weight study, which yielded the loading field data used in calculating the TKPH (TKPH = Average tyre load x Average truck speed).

Road corners

Road corners can be a source of tyre damage but this was not covered in the road severity survey, and an observation exercise was conducted to assess the conditions.

Figure 6 illustrates loose rocks on the shoulder of a berm at a traffic circle and in a turn, which are a source of sidewall cuts. Figure 7 shows partially buried rocks in a turn, which are also a source of sidewall cuts and are not easily visible. The turning radius of the corners is within the mine standards, but the main concern is the loose rocks in the corners as the mine lost six tyres in 2012 due to sidewall cuts. The corners need to be constantly dressed with sand and loose rocks removed, and operators should take care not to cut corners and expose the tyres to rocks.

Loading and tipping areas

Loading and tipping areas are among the areas that have the highest potential to cause tyre damage as they are a source of loose rocks that trucks can drive over. Rössing has two main

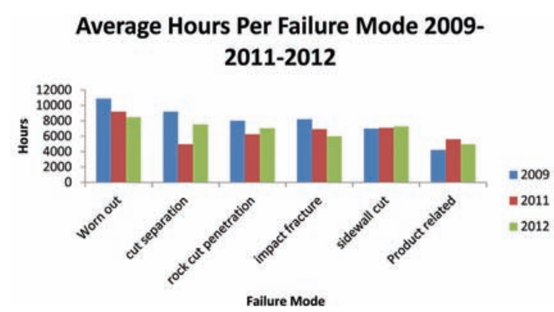

Figure 5—Average hours per failure

Figure 6—An example of loose rocks in a turn, with a truck about to cut a corner

Figure 7—Sidewall cut rocks in a turn

loading areas; namely the stockpiles and the blasted muckpiles in the pit. The two loading areas are serviced by shovels and front-end loaders with auxiliary equipment such as dozers for clean-up.

Figure 8 shows a typical loading area condition at Rössing with loose rocks. Loose rocks are inevitable in the loading area, but should be cleaned up regularly and truck operators should not reverse into a loading area that contains loose rocks. Due to operational constraints, auxiliary clean-up equipment is not always available but effort should be put into keeping the area clean. The shovel operator should also practice a culture of cleaning the area regularly when the clean-up dozers are not available.

Haul roads

A site severity survey was done to determine the pit conditions, including the haul road.

The severity ratings are from 1 to 5, with 5 being the best condition and 1 the worst. Not all the categories are of significance to tyre failure, such as water and road width. The categories of high significance for tyre performance are spillage, gradient, banking, aggregates, undulations, and hammering, which all play a role in how the tyre fails and its wear rate.

Spillage has a rating of 2, which means that around 50% of the haul road on average is covered with spillage and the rock size is in excess of 75 mm, which is large enough to cause tyre failure by modes such as rock cut penetration. Aggregates also have a rating of 2 and pose the same threat to tyres as spillage does. The gradient is rated 2 (about 10% both uphill and downhill), which can cause heat build-up in the tyre leading to failure through heat separation.

Banking and hammering are of less concern as they have ratings of 3, which is good in the current state as tyres are subjected to shock less than 10% of the time and less than 50% of the roads have banking. Undulation is the biggest concern, with a rating of 1 due to the presence of undulations every 3 m. Undulations on the haul road causes payload spillages as well as a slight heat build-up in the tyre. Figure 9 shows an undulating portion of an in-pit haul road, clearly illustrating the severity of the situation.

Figure 10 shows an example of spillage on the in-pit haul road, which also is a major problem as it is a source of loose rocks that cause operational failures such as cut penetration.

Cost Implications

The cost implication of premature tyre failure is based only on the remaining value in the planned tyre life, which constitutes a direct cost incurred. There are other added costs

Figure 8—Loading area with loose rocks

Table III

Overview of in-pit haul road severity survey

Category code	Category	Rating	Comment
CL493	Spillage	2	Spillage over 50% of the haul road, size in excess of 75 mm
CL494	Gradient	2	Gradient over 10% either uphill/downhill
CL495	Banking	3	Less than 50% of roads have banking
CL496	Aggregates	2	Aggregates cover 50% of the width of the haul road (over 25 mm)
CL497	Firmness	3	Sinkage is not in main working areas and is not affecting the tyres
CL498	Water	3	Standing water does not cause damage to the tyres
CL499	Undulations	1	Undulations every 3 m
CL500	Hammering	3	Tyres are subjected to shock damage less than 10% of the time
CL501	Road width	2	Equal to twice the width of a single truck

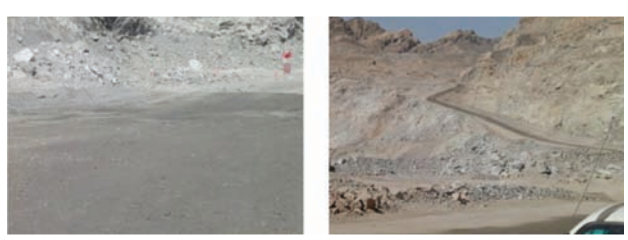

Figure 9—Undulation of in-pit haul roads at Rössing

Figure 10—Example of spillage on the in-pit haul road

incurred on top of the direct cost, such as the labour cost involved in changing tyres more frequently. A single tyre can take up to 8 hours to change, depending on which position it is in. A further indirect cost is the lost production time incurred by tyre changes.

Figure 11 shows the remaining tyre value at failure for each type of tyre failure for 2011 and 2012. The highest cost was incurred due to rock cut penetration, which at R2 million is a 233.3% increase from R807 000 in 2011. Impact fracture is the other type of failure with increased lost tyre value from 2011 to 2012. Value lost due to failure by wear decreased from 2011 to 2012. No tyre value was lost in 2011 due to heat separation, while some value was lost due to heat separation in 2012. The highest costs are incurred through failure of tyres that have run the lowest number of hours which generally happens through premature failure.

The cost per hour is obtained by dividing the value of a new tyre by the life in hours. In 2011 cut separation incurred the highest cost of R47.03 per hour, while failure due to wear had the lowest cost of R15.24 per hour. In 2012 impact fracture had the highest cost per hour with R47.50 per hour, while wear was the lowest with R18.27 per hour. The cost per hour results indicate that cut separation was the most expensive failure mode in 2011, while in 2012 impact fracture was the most expensive.

The high cost per hour of premature failure is due to the low hours on the tyre at time of failure, while tyres that fail due to wear usually have had a long service, hence the low cost per hour. The average cost per hour for 2012 for all the failed tyres, irrespective of the failure mode, is R30.95 per hour, with the operational failures increasing the cost. The average cost is still well above the target cost of R24.00 per hour which is guided by the price of the new tyre and the target lifespan.

Load and haul tyre management system

In the past, when the tyres were performing well, the load and haul management system had a bonus incentive for tyres, which engendered a positive attitude among the operators towards tyre preservation. Management also had more resources when it came to maintaining the roads, as Dust Aside was used more, which kept the haul roads in excellent condition. The load and haul tyre management is not highly effective due to different constraints that the department is facing. According to the superintendent of load and haul at Rössing (Fotolela, 2012) the department is facing constraints such as lack of operators and high production pressure, which leads to tyres getting minimum priority.

Challenges facing the load and haul tyre management include:

- Passive management
- No road maintenance programme
- No specific tyre preservation programme
- Low utilization of auxiliary equipment
- No system to identify point of failure in pit
- No record keeping of road maintenance
- Priority given to production at the expense of tyres.

According to Fotolela (2012) the department is working on addressing the challenges as tyre preservation has been identified as a high-priority area for 2013 in an effort to improve tyre performance.

Conclusion

The mining industry has been facing a tyre shortage for the past 8 years, with a peak in 2008, and suppliers are currently running about 25–30% undersupply in the market for the past 3 years, hence the shortage is not expected to decrease until 2018. The mine experienced an upward trend in tyre life from 2006 to 2009 in terms of average hours per tyre, with 2009 having the highest average tyre life of 10 119 hours, while a downward trend has been evident since then with 7371 hours in 2012. In 2012 operational failure was the major failure category, accounting for 49% of all failures, and had the lowest average hours. The biggest concerns in terms of possible tyre failures are the conditions of the haul roads condition and loading areas, as they are the major sources of loose rocks that cause premature failure. The mine lost R5.7 million due to tyre failure in 2012, which is an increase from R4 million in 2011. The operational failure category made up the bulk of the tyre value lost, accounting for 73% of the total. The maintenance side of the tyre management system is very effective, as tyre maintenance practice, storage, and monitoring are within the Rio Tinto standards. The load and haul side of the tyre management system is not as effective, as no proper road maintenance record is kept, and effective utilization of clean-up dozers is low. This is due partly to the constraints, such as a shortage of operators, that the department is facing.

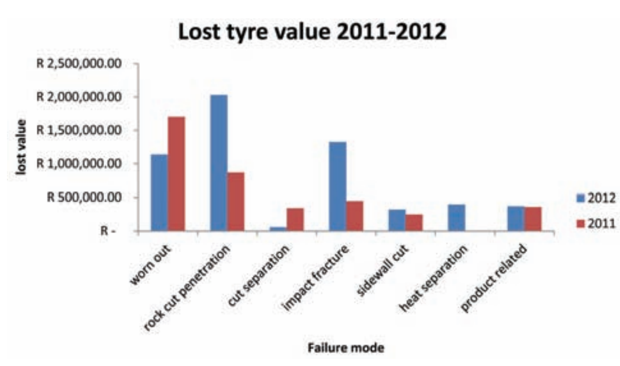

Figure 11—Lost tyre value for 2011–2012

Recommendations

1. A tyre campaign should be adopted to promote collective responsibility and the spillage clean-up policy by all personnel reinstated. The campaign will not involve additional resources and can be very beneficial in terms of worker morale
2. A more aggressive approach should be taken to pit condition maintenance where resources permit and to overcoming the operational constraints that the auxiliary clean-up crews are facing in order to increase their effective utilization. This will be a challenge as the operation is facing an operator shortage, but efforts should be made to work with the available resources
3. A system is needed to identify the exact areas in the pit where tyre failure is common and classify them as 'red zones' that need priority in terms of auxiliary equipment. This will not be an easy system to come up with as most tyre failures do not immediately follow the cause. Aggressive road maintenance can help in this regard
4. The feasibility of re-introducing the tyre incentive programme should be investigated.

References

Aluvilu, P. 2012. Production Engineer, Rössing Uranium Mine. Personal communication.

Carter, R. 2007. Maximizing mining tyre life. Engineering and Mining Journal, (00958948), vol. 208, no. 6. July/August. 58 p.

Cutler, T. 2012. EM tyre supply shortage – How it is affecting us'. AusIMM Technical Meeting, 14 May.

Fotolela, D. 2013. Superintendent: Load & Haul, Rössing Uranium Mine. Personal communication

Sumulilo, F. 2012. Maintenance Engineer, Rössing Uranium Mine. Personal communication. ◆