Investigation into off-the-road tire performance at Aruwakkalu Quarry

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Abstract: The performance of heavy mobile equipment used in the mining industry is often restricted by the capabilities of their tires. These off-the-road tires experience highly variable and complex working conditions in comparison to other commercially used tires. As a result, expenditures on tires occupy a reasonable portion of the total mining cost and off-the-road tires are prone to complex failure modes, which the studies have been limited. Lack of quantitative analysis on the performance characteristics of these tires hinders the overall productivity in mining industry, specially in local context. The paper presents a study on off-the-road tire performance conducted at two selected mine sites in Sri Lanka. Site specific operational and environmental conditions encountered by the off-the-roads tires were taken into account, to determine the modes of failure and optimum tire performance through best practices.

Keywords: Off the road tires, Tread wear rate, Tire failure modes, Mining industry

1. Introduction

Off-the-road tires play a vital role by facilitating the loading and hauling operations, in mining industry. Optimum functionality and appropriate maintenance of these tires are critical as they involve with heavy capital investments. Additionally, idling of heavy machinery during tire replacements, account for serious operational losses. It is a difficult task to maintain records on tires as the working conditions proven to be complex in mining operations. Also the lack of knowledge on tire management practices has restricted the availability of such information.

The mining industry in Sri Lanka also experience above circumstances and lack of information deprives the investigation into the effective use of tires in mining industry. Appropriate research and development with sharing knowledge and information is compulsory to implement tire management practices that would reduce the costs involved.

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Investigation into tire failure modes with respect to the working conditions and establishing possible relationships would improve the understanding on how to improve the off-the-road tire life. Additionally, it will help to identify cost reduction methods as well as to implement necessary steps to maximize the tire life.

2. Literature Review

The main factors that affect the tire life have been categorized as truck interaction, road interaction, maintenance interaction and environment interaction (Zhou *et al.* 2008). Additionally, a combination of high speed, long distances & loading over the recommended capacity can generate excessive heat on the tires and reduces their lifespan dramatically. Ton Kilometre per Hour (TKPH) value is a measurement that indicates the degree of influence by such combinations (Carter, 1998). Preventive measures such as, proper monitoring and maintenance are proven to be critical in improving tire performances. Ensuring the quality of haul roads by proper drainage and regular scraping is also considered to create less tire wear (Grayson & Wilson 1997).

3. Methodology

3.1 General approach

The main focus of this study was to assess the factors influencing on the performance of off-the-road tires in the context of Sri Lankan mining industry. Aruwakkalu limestone quarry site with varying operational conditions were chosen to examine the site specific acronyms and data collection.

3.2 Site selection

The largest open pit mine in Sri Lanka, Aruwakkaru limestone quarry of Holcim Lanka Ltd utilizes off-the-road tires for heavy mobile equipment such as dump trucks and loaders. It also consumes a considerable amount of tires for the mining operations according to the records. Hence, an investigation into the tire life and their performance at Aruwakkalu mines provided most suitable conditions to conduct this study.

3.3 Data collection

Information on the tire usage was collected at the Aruwakkalu site over a time period of 7 months starting from July 2013. The data was recorded in tabular format with details on serial no, wheel position, initial tread depth, fitment hours, current hours and truck type. Additionally, engaged date, removal date and load counts were noted as appropriately.

Table 1: Machines and tire details

Machine type	Tire Manufacturer	Tire size
Dump Truck	TRIANGLE	18.00R33
Wheel Loader	TRIANGLE	35/65R33

Information on off-the-road tire records by the Holcim Lanka Ltd.,

was also incorporated where necessary to improve the data availability.

3.4 Tire Wheel Position Acronyms

The following figures represent the acronyms used to denote the tire positions on dump-trucks. Tire positions on the wheel loader was considered as left-front (LF), right-front (RF), left-rear (LR) and right-rear (RR)

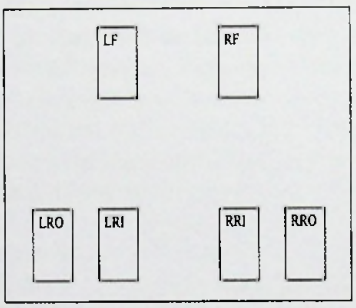
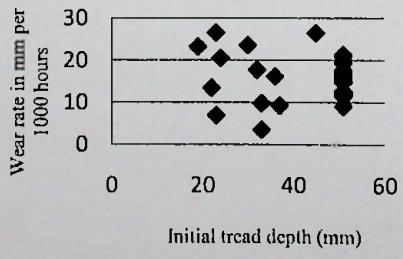


Figure 1: Tire positions acronyms used for 6-wheel dump trucks. (LF-left front, RF-right front, LRO-left rear outside, LRI-left rear inside, RRI-right rear inside and RRO-right rear outside)

4.0 Results

4.1 Influence of initial tread depth in tread wear



Correlation between initial tread depth and tread wear rate obtained as -0.109

Table 2: Dump truck Tire wears rates with respect to wheel positions

Tire position	Wear rate (mm per 1000hrs)
Front (LF & RF)	16.48
Rear outside	14.33
Rear inside	13.77

4.2 Average tire life calculations

Average tire life based on the tread wear rate was calculated by the following equation and results are given in table 2.

Tire life = (Total hours covered × original tread depth) / worn tread amount

Table 3: Average tire life of dump truck and loader tires

Machine	Life based on tread wear	Life as a combination of tread wear and scrapped tire life
HD 325 dump truck	3458 hours	3217 hours
WA 600 Wheel loader	10461 hours	7098 hours

When calculating life by combination of tread wear and scrapped tire life, the original hours covered by scrapped tires were assigned as their life instead of the tread wear predicted life.

4.3 Ton-Kilometer-per-hour (TKPH) value for dump truck tires

Ton-kilometrer-per-hour values were calculated using the following equation, and results are given in table 4

Operating TKPH = (Average tire load in tons) x (average speed in miles per hour)

Table 4: Ton-Kilometers-per-hour (TKPH) value for dump truck tires

Tire position	Operating TKPH value
front tires	207.9
rear tires	176.03

5.0 Discussion

The tire performance was analyzed mainly based on the tread wear rates, as the tire wear rate is independent from the initial tread depth. A correlation value of -0.109 was obtained through the graph for initial tread depth and tread wear rate. However, the results do not display a clear relationship between initial tread depth and respective tire wear rate values.

Based on the tire wear rates, the front tires of the machines wear out at a brisk rate compare to rear tires. A slight variation in wear rate can be also observed between rear outside & rear inside tires, where the rear inside tires have the lowest wear rate.

The TKPH values of the front tires generally exceed the manufacturers TKPH ratings for the particular tire size and type. However, the TKPH values of the rear tires reside within the limiting value. The operating TKPH should always need to be less than the manufacturers TKPH rating to prevent excess heat generation. Hence, the results suggest that front tires get overheated during the operation. Excessive heat generated on the front tires could be influential to make them wear out quicker than the rear.

The above results may have been subjected to the factors such as; steepness of the haul roads, surface condition of the haul roads, tire inflation and overloading, which could not accounted in this study. However, based on the available results, a tire rotation sequence has been proposed to minimize the uneven wear of off-the-road tires at the Aruwakkalu quarry. The proposed rotation sequence is as follows.

1 F→RI; RI→F; RO stay the same

2 F→RI; RI→RO; RO →F

3 F→RI; RI→F; RO stay the same

Where, F-front tires, RI-rear inside and RO-rear outside.

6.0 Conclusions

The study recommends using dump truck tires with higher TKPH limiting value for the Aruwakkaru site. Use of the proposed rotation sequence will lead towards the optimum use of the off-the-road

tires and minimize the operational costs under the prevailing conditions.

Additionally, best tire management practices such as maintaining records, frequent inflation checks and cleaning of haul roads and loading and unloading premises may also improve the tire life.

Acknowledgements

Authors are thankful to Dr. AMKB Abeysinghe, Dr. HMR Premasiri and Eng. PVA Hemalal (Department of Earth Resources Eng.), Mr. W Wedage, Mr. G Silva, Mr. D. Rajapakshe, Mr. P. Kumarage (Aruwakkalu Quarry, Holcim Lanaka Ltd)

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