Technical Report

CASE STUDY

ON

NIMINGARRA HAULAGE

THE EFFECT OF GOOD HAULROAD CONDITION

UPON

HAULTRUCK PRODUCTIVITY & TYRE WORKLOAD

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1 INTRODUCTION

In October 1985 Goldsworthy Mining Limited, which operated the Goldsworthy[1] and Shay Gap iron ore mines in the Pilbara region of Western Australia, undertook a pilot ore haulage program (20,000 tonnes) over a 45 kilometre cycle from the Nimingarra pit to the Shay Gap crusher using Wabco[2] 120 ton (110 tonne) haultrucks[3].

Two years later, in November 1987, routine production commenced from Nimingarra. The ore was again hauled to the Shay Gap crusher – however this time over a shorter, realigned haulroad (32 kilometre cycle) that eliminated most of the dips and curves of the road used in 1985[4].

These hauls are among the longest ever undertaken using rear dump haultrucks of 100 tonne or greater capacity.

This case study examines the effect of the improved haulroad condition upon haultruck productivity and tyre workload.

2 SUMMARY OF FINDINGS

Improving the condition of a haulroad can result in a substantial improvement in haultruck productivity (by 10% for this particular case study); it can also reduce tyre workload considerably (estimated by as much as 15% in this case) – thereby reducing the incidence of low-life tyre heat failures for minesites that are operating haultruck tyres close to their workload limit.

3 WORKSHIFT AVERAGE SPEED

Workshift average speed is defined as the distance travelled by a haultruck during a mine shift, divided by the shift time. For example, if a haultruck covers a total of 120 kilometres in an eight-hour shift[5], then its workshift average speed is 15 kilometres per hour (120km / 8hr).

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[1] Goldsworthy was the first large iron ore mine built in the Pilbara region of Western Australia. It opened in 1965 ahead of Hamersley Iron's (now Rio Tinto) Tom Price mine in 1966, and BHP's (now BHP Billiton) Newman/Whaleback mine in 1968.

[2] Wabco (Westinghouse Air-Brake Company) was the predecessor to Dresser which was subsequently acquired by Komatsu. The current range of Komatsu electric drive haultrucks is based on the original Wabco 120 Haulpak.

[3] An even longer pilot haul (62 kilometres round trip) was conducted in November 1985 with the Wabco 120's from Kennedy Gap to the Shay Gap crusher.

[4] In August 1988 a crusher was commissioned at Nimingarra, reducing the maximum ore haul at Nimingarra to a 15 kilometre round trip.

[5] Prior to the advent of fly-in fly-out (FIFO) mining operations, which initiated the move to two x 12 hour shifts per day, most mines operated on a three x 8 hour shift basis.

3.1 Tyre workload (TKPH)

Workshift average speed is one of the two determinants of tyre workload or TKPH; the other is tyre average load[6]. Generally, workshift average speed increases as haul cycle distance increases; this is because, on a longer haul, a truck spends more time travelling relative to its periods at rest while being loaded and while dumping its load.

For example (refer Table 1 in the Addendum):

Scenario 1 – Short haul:
The workshift average speed for a haultruck operating on a 4 kilometre cycle might be 12 kilometres per hour.

Scenario 2 – Long haul:
If that haultruck was operating on an 8 kilometre cycle then its workshift average speed would typically be considerably higher – in the order of 16 kilometres per hour.

3.2 Haultruck productivity

Let us assume for the above two haulage cycle distances (4 kilometres at an average 12 kilometres per hour for Scenario 1, and 8 kilometres at an average 16 kilometres per hour for Scenario 2) that haultruck average payload is 100 tonnes.

Scenario 1 – Short haul:
For the 4 kilometre haul cycle, the productivity of each haultruck is 2,400 tonnes during an 8 hour shift (12kph x 8hr / 4km x 100t).

Scenario 2 – Long haul:
For the 8 kilometre haul cycle, productivity drops by 33% to 1,600 tonnes per truck per shift (16kph x 8hr / 8km x 100t).

Although Scenario 2 workshift average speed was higher by one-third, this has been more than offset by a doubling of haulage distance causing an overall reduction in truck productivity.

3.3 Combined effect

We can conclude that higher workshift average speed is typically associated with longer haul distance – with a resultant increase in tyre workload (operational TKPH) and a reduction in haultruck productivity.

[6] Tonne Kilometre Per Hour (TKPH) is a measure of tyre workload capability; it is calculated as the product of tyre average load (tonne) over a haul cycle and haultruck workshift average speed (kph).

4 NIMINGARRA HAUL

The 1985 pilot haulage at Nimingarra was on a relatively poorly formed road that followed the contours of the terrain – rising, dipping and curving – between the Nimingarra pit and the Shay Gap crusher.

The road was extensively reworked prior to the commencement of full production haulage in 1987. Cut and fill was undertaken to straighten the road and to eliminate many instances of rises and dips. This realignment of the road shortened its length from 22.5 to 16 kilometres (a reduction of 29%).

4.1 Workshift average speed & productivity

As we have seen in section 3, shorter haul distance generally results in reduced workshift average speed which:

a) partially offsets the truck productivity increase associated with the shorter haul cycle, and
b) reduces tyre workload (operational TKPH).

However, what occurred at Nimingarra was quite different – and unexpected.

The highest workshift average speed recorded for the haultrucks operating from Nimingarra in 1985 had been 22.5 kilometres per hour (four complete haulage cycles over an eight hour shift). The average shift speed noted during the first month of operation, in November 1987, on the realigned and shortened haulroad was 24.0 kilometres per hour (six complete haulage cycles over an eight hour shift).

Contrary to expectations, the shorter haul cycle resulted in higher workshift average speed providing much higher productivity than had been budgeted.

While the 29% reduction in haul distance had been expected to result in a 3% drop in workshift average speed – from 22.5 to 21.8 kilometres per hour (refer Table 2), it in fact increased by 6% to 24.0 kilometres per hour (refer Table 3). Workshift average speed on the new shortened, realigned road was 10% higher than anticipated – with an equivalent 10% increase in actual haultruck productivity compared with what had been budgeted.

4.2 Workshift average speed & tyre workload

While the higher than expected workshift average speed on the improved Nimingarra haulroad produced an equally unexpected windfall in productivity, it immediately set off alarm bells in relation to tyre workload.

The longest haul in the Shay Gap mine proper at the time (November 1987) was from Sunset 7 pit to the crusher with a workshift average speed

of 20.6 kilometres per hour. A heat study conducted in March 1987 had shown that tyre temperatures on this haul were approaching maximum allowable levels. So a workshift average speed of 24.0 kilometres per hour on the new Nimingarra haul had the potential to create a spate of expensive (in terms of tyre usage cost and tyre related haultruck downtime), low-life tyre heat separation failures.

Otraco immediately recommended that measures be implemented to minimise the risk of tyre heat damage. These included:

a) tyre pressure and temperature monitoring[7] at the end of each haul cycle, with maximum allowable limits set for inflation pressure and temperature build-up, and
b) swapping trucks between Nimingarra and the shorter Shay Gap hauls as required.

While high tyre air chamber temperatures and inflation pressure build-ups were recorded over the duration of Nimingarra haulage from November 1987 (viz. regular chamber temperatures of 90 degrees Celsius and as much as 100°C, and pressure build-ups of 30psi and occasionally considerably higher), the incidence of heat related tyre failures was exceptionally low.

Based on theoretical TKPH calculations, the operational TKPH, at a workshift average speed of 24.0 kilometres per hour, exceeded the tyre manufacturers' TKPH ratings by between 10-15%. The tyres used on this haul should have been suffering an exceedingly high incidence of low-life heat separation damage. However they were not – even when trucks were on occasion left operating on the long Nimingarra haul rather than being swapped to shorter Shay Gap hauls.

This highlights a major shortcoming of the TKPH system of calculating tyre workload in that it does not take into account haulroad condition.

5 CONCLUSIONS

The lesson of Nimingarra haulage is that improved haulroad condition can lead to a substantial increase in a haultruck's productivity while simultaneously reducing considerably the workload of its tyres.

There are four main elements to making haulroads more productive and tyre friendly. They are:

1. Reducing haul distance and unnecessary gradients, through:
    - Horizontal curve minimisation

[7] Otraco used **Monitire**, a TPMS (Temperature Pressure Monitoring System) that it developed jointly with Topy in the early 1980s, to monitor tyre chamber pressure and temperature on Nimingarra haulage from October 1985.

- Vertical curve minimisation

2. Reducing rolling resistance and tyre/truck stress, through:
    - Pothole and undulation elimination
    - Road sub-base material selection and compaction
    - Road surface material selection and smoothing

3. Reducing tyre/truck lateral stress, through:
    - Road curve radius optimisation
    - Road superelevation optimisation
    - Road camber minimisation and camber profile optimisation

4. Reducing haulage bottlenecks, through:
    - Road width optimisation

The improvement in haulroad condition at Nimingarra between the 1985 pilot haulage program and 1987 production haulage – and the significant benefits gained in terms of truck productivity and tyre workload – were achieved mainly through the first of these elements (reducing unnecessary curves). However all four elements were incorporated into the upgraded Nimingarra haulroad, and all contributed to improved productivity and the ability for tyres to sustain an operational TKPH that significantly exceeded the tyres' TKPH rating.

Apart from productivity and tyre workload capability, overall tyre life and truck component life will also benefit substantially from improved haulroad condition.

ADDENDUM – DATA TABLES

Mine data		
Shift duration	8.0	hr
Production time (excl start/smoko/crib/end)	6.5	hr
Haultruck payload capacity	100	tonne
Scenario 1 - Short haul		
Haul cycle	**4.0**	**km**
Average travel speed	30.0	kph
Loading time (incl delay)	5.0	min
Travel time per cycle	8.0	min
Dumping time (incl delay)	3.3	min
Cycle time	16.3	min
Cycles per shift per truck	24.0	cycles
Workshift Average Speed	**12.0**	**kph**
Productivity (tonnes hauled per truck per shift)	**2,400**	**tonne**
Scenario 2 - Long haul		
Haul cycle	**8.0**	**km**
Average travel speed	30.0	kph
Loading time (incl delay)	5.0	min
Travel time per cycle	16.0	min
Dumping time (incl delay)	3.3	min
Cycle time	24.3	min
Cycles per shift per truck	16.0	cycles
Workshift Average Speed	**16.0**	**kph**
Productivity (tonnes hauled per truck per shift)	**1,600**	**tonne**

Table 1 – Truck haulage sample data

Nimingarra data	
Shift duration	8.0 hr
Production time (excl start/smoko/crib/end)	6.5 hr
Haultruck payload capacity	110 tonne
1985 Pilot haulage (actual) - Long haul	
Haul cycle	**45.0 km**
Average travel speed	30.3 kph
Loading time (incl delay)	5.0 min
Travel time per cycle	89.3 min
Dumping time (incl delay)	3.3 min
Cycle time	97.5 min
Cycles per shift per truck	4.0 cycles
Workshift Average Speed	**22.5 kph**
Productivity (tonnes hauled per truck per shift)	**440 tonne**
1987 Production haulage (expected) - Short haul	
Haul cycle	**32.0 km**
Average travel speed	30.3 kph
Loading time (incl delay)	5.0 min
Travel time per cycle	63.5 min
Dumping time (incl delay)	3.3 min
Cycle time	71.7 min
Cycles per shift per truck	5.4 cycles
Workshift Average Speed	**21.8 kph**
Productivity (tonnes hauled per truck per shift)	**598 tonne**

Table 2 – Expected 1987 Nimingarra haulage outcome

Nimingarra data	
Shift duration	8.0 hr
Production time (excl start/smoko/crib/end)	6.5 hr
Haultruck payload capacity	110 tonne
1985 Pilot haulage (actual) - Long haul	
Haul cycle	**45.0 km**
Average travel speed	30.3 kph
Loading time (incl delay)	5.0 min
Travel time per cycle	89.3 min
Dumping time (incl delay)	3.3 min
Cycle time	97.5 min
Cycles per shift per truck	4.0 cycles
Workshift Average Speed	**22.5 kph**
Productivity (tonnes hauled per truck per shift)	**440 tonne**
1987 Production haulage (actual) - Short haul	
Haul cycle	**32.0 km**
Average travel speed	33.8 kph
Loading time (incl delay)	5.0 min
Travel time per cycle	56.9 min
Dumping time (incl delay)	3.3 min
Cycle time	65.1 min
Cycles per shift per truck	6.0 cycles
Workshift Average Speed	**24.0 kph**
Productivity (tonnes hauled per truck per shift)	**660 tonne**

Table 3 – Actual 1987 Nimingarra haulage outcome