The effect of average truck speed on fuel consumption in surface mines

A. Soofastaei, S.M. Aminossadati, M.S. Kizil and P. Knights

School of Mechanical and Mining Engineering, the University of Queensland, CRCMining, Australia

Mining is one of the most energy intensive industries in Australia consuming a vast amount of energy in every stage of its operations including exploration, exploitation and minerals processing. These operations can be optimised to deliver more energy efficient processes, particularly through better management strategies. The mining system employed such as mining method and haulage operations, primarily determines the type of energy sources required on the mine site. Haulage operations are of particular interest, where haul trucks and excavators/loaders work in tandem to meet production goals and schedules. These haul trucks generally use diesel fuel as an energy source and as a result, the mining industry is constantly seeking ways to make them more fuel efficient and cost effective. A large number of factors contribute to the fuel consumption of haul trucks such as; haul road properties and condition, truck operation, truck speed, rolling resistance and environmental conditions. Truck cycle time is a function of loading, hauling, dumping, returning and spotting time as shown in Figure 1.

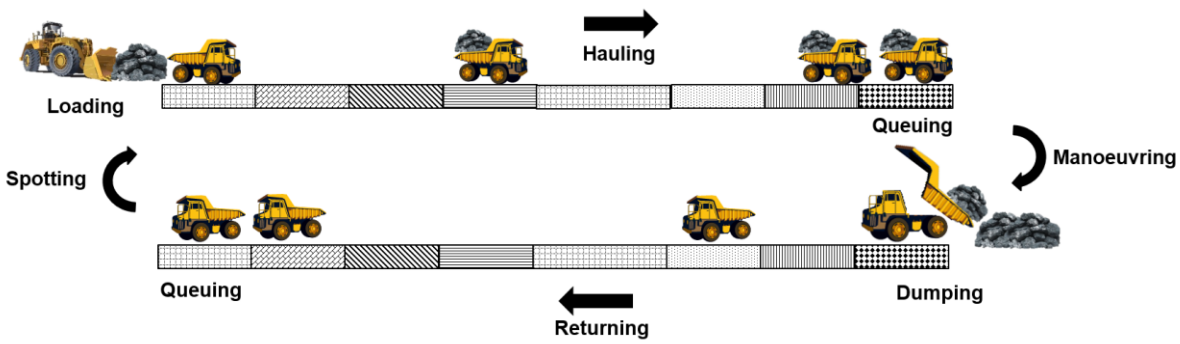

Figure 1: Truck Cycle in Surface Mines

The data collected from the Truck's Vital Information Management system (VIMS) at various surface mines show that the truck speed variation is a significant factor and must be considered when analysing mine productivity, diesel energy consumption, greenhouse gas emissions and associated costs. This project aimed to investigate the energy efficiency opportunities for truck haulage operations associated with truck speed management in surface mines.

In truck and shovel operations in surface mines, the speed of trucks is a variable parameter that depends on many factors, such as payload variance, the power of engine, haul road conditions, driver skill, safety limits, weather condition and Total Resistance (TR). The TR is equal to the sum of the Rolling Resistance (RR) and the Grade Resistance (GR) when the truck is moving up a haul road. The RR depends

on the tyre and haul road surface characteristics and is used to calculate the rolling friction force, which is the force that resists the motion when the truck tyre rolls on the haul road. The GR is the slope of the haul road and calculated as the percent ratio of the rise of the road to the horizontal length (Figure 2).

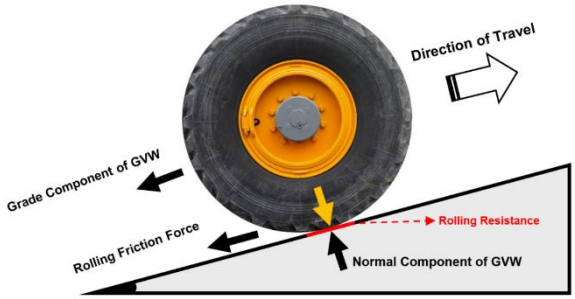

Figure 2: A schematic of a haul truck tyre showing the rolling and grade resistance

The variation of truck speed can be controlled by utilising the latest-developed technologies, such as the on-line fleet monitoring system, the truck on-board management system and its interaction with other vehicles on the haul road and fleet traffic manager in the site control room. Truck speed management affects the truck's availability, maintenance costs, production rate and fuel consumption. The CAT 793D model truck was analysed in this project, as it is one of the most commonly used trucks in surface mines in Australia.

The project was conducted by a group of researchers from the University of Queensland and was supported by CRCMining.

Fuel consumption index (FC_{Index}) was examined for the selected haul truck used in a large open-cut coal mine in Australia, operating on an eight-hour shift roster. This index calculates the amount of diesel fuel consumed by the truck to move one tonne of mined material through one kilometre of haul road. The data collected by an on-board VIMS computer device installed on a CAT 793D haul truck for a duration of 12 months was downloaded and analysed to determine the correlation between FC_{Index} and the average truck speed (Figure 3).

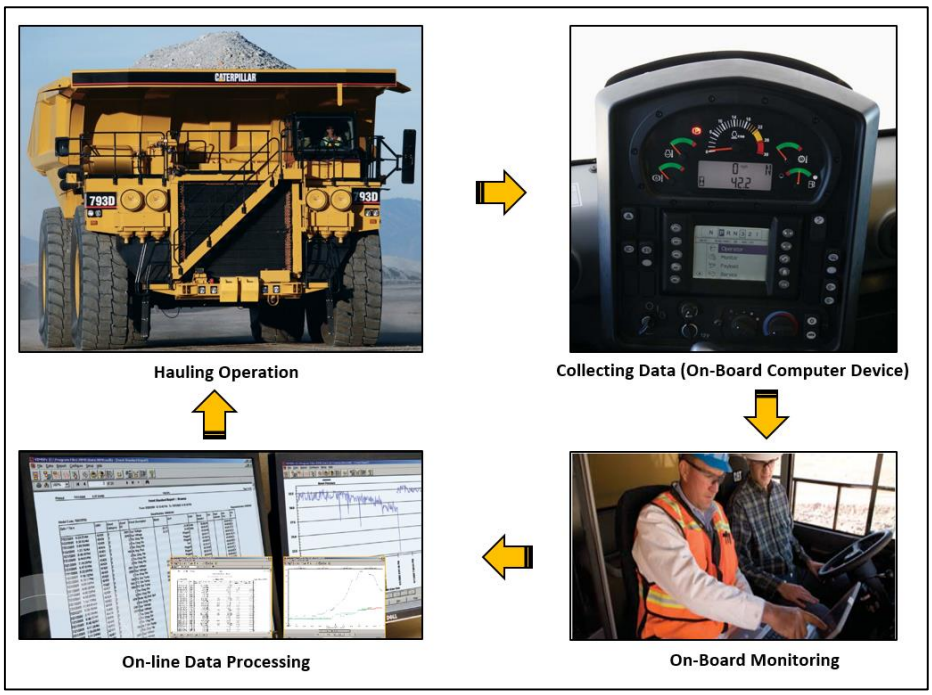

Figure 3: Collecting, Monitoring and Processing Data[1]

The results show that the fuel consumption increases with increasing average truck speed and the TR as seen in Figure 4.

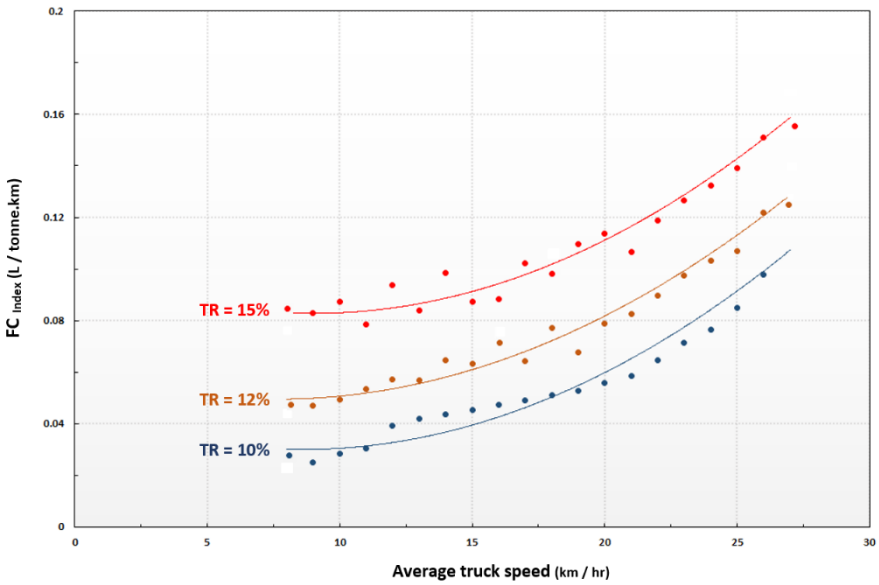

Figure 4: The Correlation between fuel consumption and average Haul Trucks speed and TR (CAT 793D)

The results of the investigation of energy efficiency opportunities associated with truck speed management for the case study mine show that by reducing the average truck speed from 27 (km/hr) to 8 (km/hr) in the worst haul road condition (TR=15%), a 45% reduction in FC_{Index} can be achieved, but this will have a huge impact on productivity of the operations therefore not advisable. However, an

[1] VIMS™ system availability, 2013 Caterpillar, U.S.A

optimal point between fuel efficiency and production efficiency could be found using this index to maximise the energy use. The next stage of this project is to investigate the development of a system that uses artificial intelligence methods to optimise the truck speed for minimising the fuel consumption and maximising the productivity simultaneously.

In summary, the results of this project indicate that truck speed management not only plays a critical role in fuel consumption but is also a key parameter in increasing the energy efficiency in haulage operations in surface mines. The mine managers have to control the variation of speed by utilising the latest-developed technologies, such as the on-line fleet monitoring system and the truck on-board management system. Furthermore, increasing the energy efficiency should not reduce productivity. Therefore, to minimise the fuel consumption of haul trucks and to maximise the productivity new approaches such as artificial intelligence techniques should be used to solve this complex problem.