Intelligence predictive analysis to reduce production cost

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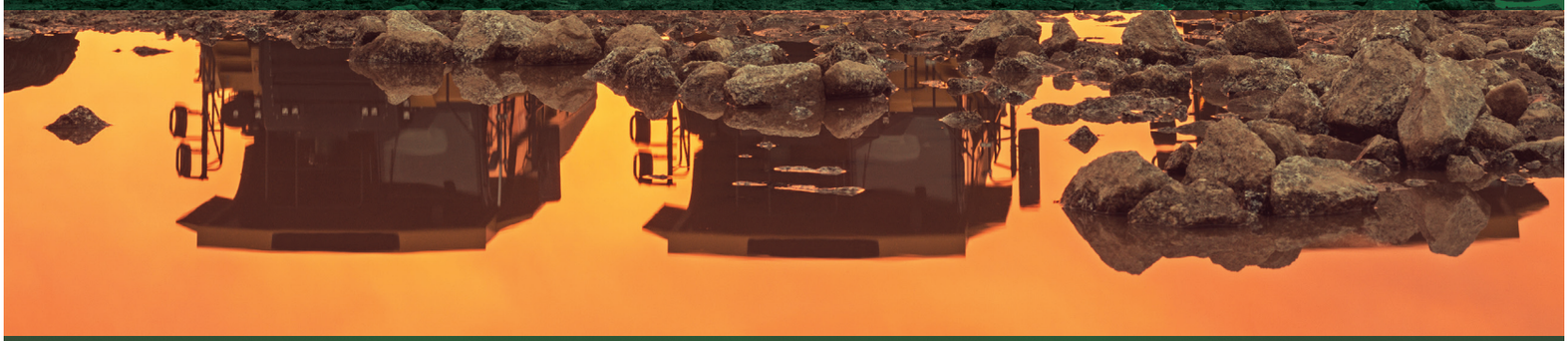
This article addresses the problem of estimating the rolling resistance in surface mines. The project is motivated by the enormous costs associated with haulage, which typically accounts for 50 per cent of mine operation costs, and the knowledge that the differential structure of these expenses is closely linked to the interaction between tyres and roads.



The hauling productivity in a surface mine is dependent on a haul truck's speed. In turn, the speed of a haul truck is affected by road quality. A prime indicator of haul road quality is rolling resistance (RR).

RR is defined as the sum of all external forces acting on the road surface and opposite to the direction of the moving haul truck. RR is caused by the friction force between the tyre and the road surface (See Figure 1). RR, as a part of total resistance, plays a critical role in the productivity, fuel consumption, gas emissions, maintenance and safety of haul-truck operations in surface mines.

RR can be measured using some different methods. RR measurement can be made under laboratory conditions, generally on a 'test drum surface'. This is a testing rig consisting of the tyre being tested and a drum with a different outer surface that can rotate, simulating the movement of the tyre over a road surface. Some sophisticated mathematical methods can then be applied to the values of drum torque, power and tyre force, which are measured during testing to determine the RR experienced by the tyre.

Measurement of RR can also be obtained for specific mine haul roads using on-site testing. This method uses a specially designed trailer towed behind a truck to measure the force between the truck and trailer, which is used to pull it across the road surface. They also measure the grade of the haul road

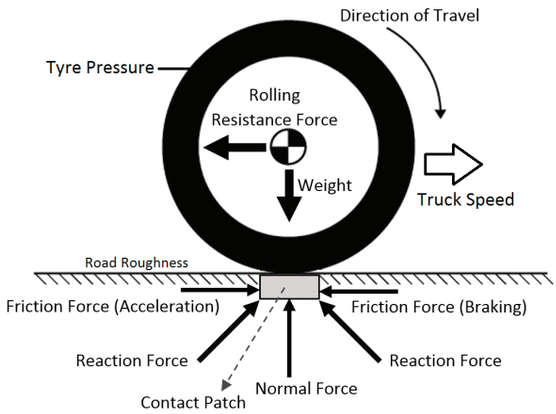


Figure 1. Rolling resistance and the most influential parameters

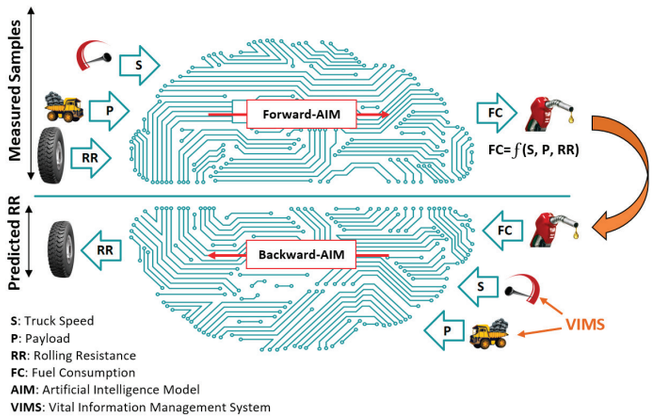


Figure 3. Rolling resistance predictive model

and the acceleration. This data is then used with the relevant mathematical expression to determine the RR of the haul road.

All of the aforementioned methods to measure the RR are very expensive and inaccurate. An investigation using advanced data analytics as an innovative approach to predict the rolling resistance on large off-highway trucks used by the mining sector has recently been conducted by a group of data scientists from Mining3. Mining3 is an industry-driven global leader in mining research and innovation, located in Brisbane.

Some parameters are affecting the RR, which can be categorised into four groups. These groups are road, tyre, system and weather condition. Identifying all of the effective parameters of RR, and finding a correlation between these parameters and RR, is very complex. That is because they are not independent parameters, and they have an effect on each other, as well.

To get information on the RR value of some haul road segments in the real conditions of a mine site, it is critical to use a vehicle information management system (VIMS[1]). VIMS can provide information for the total resistance (TR) value of the road surface. TR is defined as the sum of grade resistance (GR) and RR. GR is the resistance force caused by the grade of the haul road; it is equal to the gradient of the haul road as a percentage (see Figure 2).

In this project, a forward artificial intelligence model (AIM) was developed to find the correlation between haul-truck fuel consumption (FC), truck speed (S), payload (P) and RR (see Figure 3). This computer model was trained and tested by some collected data sets from a large copper mine located in the north of Arizona, in the United States. This mine represents one of the largest copper reserves in the United States and the world. The deposit of this mine had estimated reserves (in 2015) of 907 million metric tonnes of ore grading 0.26 per cent copper and 0.03 per cent molybdenum.

Simulation of RR was completed by developing a backward AIM (see Figure 3). This model could predict the RR based on the haul truck's fuel consumption, truck speed and payload. It means that the developed model can potentially be an RR estimation tool, resulting in tyre-life prediction and maintenance-cost reduction.

1 VIMS: Vital Information Management System

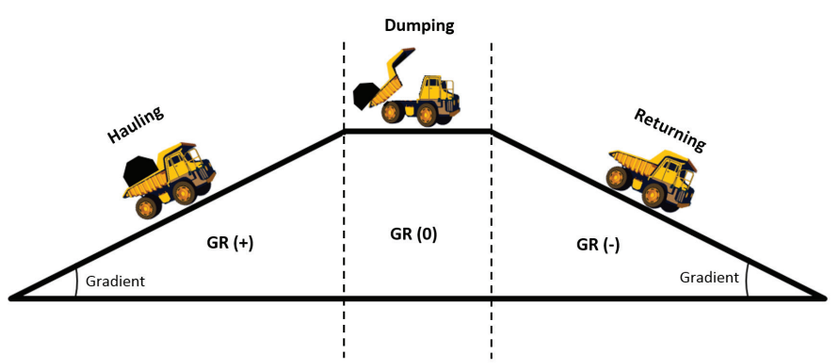


Figure 2. Grade resistance

References:

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2. Soofastaei A, Aminossadati SM, Kizil MS, Knights P. 'A Discrete-Event Model to simulate the effect of payload variance on truck bunching, cycle time and hauled mine materials'. *International Journal of Mining Technology*. 2016;2(3):167-81.