SMART speed management

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provides an insight into the future of speed management for minesite trucks.

Kinetic energy is calculated using the following formula:

$$e = \frac{1}{2}mv^2$$

Where: e = kinetic energy; m = mass; and v = velocity.

In mining, this equation means managing increasingly large equipment and loads against energy generated by the consumption of fuel, which must ultimately dissipate through equipment components, such as brakes, or transfer to another object in an accident. And while a loaded truck has higher mass than an empty truck, the kinetic energy of a haul truck is exponentially affected by its speed.

Physics tells us that managing the operating speed of heavy equipment is the most effective way to control kinetic energy and therefore mitigate many problems with safety, maintenance and operating costs. However, in order to determine an effective solution, we must first properly detail the problem.

Safety

The technical specifications of larger equipment indicate that manufacturers have been very effective in ensuring that operating (handling) characteristics remain fairly consistent with smaller fleets, even as truck size increases. However, what cannot be changed is how size affects overall visibility.

As equipment gets larger, operator blind spots become larger as well. This reduction in visibility dramatically impacts the ability of an operator to identify and react to potential hazards. Additionally, the operator's response window shrinks as equipment speed increases.

Specific conditions also determine the safest operating speed of an equipment unit at any particular point in time. Conditions affecting the desired speed include: intersections, weather, hill

Heavy equipment speeding message.

Light vehicle area warning.

Light vehicle hazard warning.

Light vehicle speeding warning.

crests, road watering, maintenance crews and equipment payload.

Maintenance

The forces generated by road imperfections increase as equipment speed increases. These forces must be absorbed by the tyres and suspension of the moving haul truck, which are also affected by the size of the current payload. If the impact forces cannot be absorbed by the suspension (i.e. 'bottoming out'), they can inflict costly damage when transferred to the chassis.

Tyre life is directly tied to speed and payload in the form of tonne mile per hour (tmph) calculations. Excessive speed increases cornering forces and weight transfer, leading to maintenance issues for tyres and suspension. Brakes must work harder for faster, heavier trucks, decreasing pad life. And of course, any mechanical failure can subject an operator to unnecessary safety risk.

Operations

What may not be obvious is that the maximum speed varies across equipment fleets and individual units. This variance translates to inconsistent haulage times, leading to greater truck queue/shovel hang times and unnecessary fuel consumption. Equipment damage caused by speed-related issues also reduces production by removing equipment from service.

Speed management

Traditionally, speed management has relied on speed limit signs posted at various points along the haulage road. The advantage of speed limit signs is that they are inexpensive and easy to deploy. However, speed limit signs are logistically difficult to maintain as operating and ground conditions change within the mine. More importantly, they are simply reminders, and require some other form of active enforcement to avoid being ignored by operators.

Reinforcement of posted speed limits has traditionally come from radar 'speed traps' set up at various locations along haulage roads. These usually consist of a radar gun that displays the speed of the passing equipment versus the posted speed limit. While better than speed limit signs alone, radar speed traps suffer from a number of limitations. Mobile displays often report overspeeds the same as non-overspeeds, leading to operator desensitisation. Additionally, the effectiveness of radar enforcement is limited to both individual speed trap location and the total number of radar traps in the mine. Radar traps also fail to provide an audit trail for measuring and managing the number of speeding incidences.

The common thread linking these limitations is that traditional speed management is tied to hardware with physical design constraints; this hardware must be physically re-located to set up a speed trap. In contrast, a software-based speed management solution allows for the following:

- Easier change of speed limits.
- Easier movement of speed traps.
- Intelligent operator feedback to reduce de-sensitisation.
- Centralised auditing of speed infractions.

Smart speed management

Monitoring technology

In defining a software-based speed management system, the first step is to select a technology that will be used to monitor the speed of the haulage equipment. To be suitable, this technology needs to meet the following criteria:

- Easy to deploy or leverage off pre-existing infrastructure.
- Widely available.
- Accurate to within 2.5 km/h.
- Real-time.

Technologies considered for this include Hall-effect sensors, OEM interfaces and GPS-derived velocity measurement.

Hall-effect sensors require a significant deployment effort and should be excluded based on cost. Most modern equipment units have OEM systems that provide velocity information, but each system is unique to that manufacturer. For mixed-fleets, deployment and administration of multiple interfaces quickly becomes unmanageable. When weighing cost, accuracy and ease of deployment/administration, GPS-derived velocity measurement is the preferred technology.

Depending on the implementation of the GPS receiver, a typical GPS reading has a dilution of precision of about 1 – 5 m (differentially-uncorrected). With a sample rate of 1/s, this positional information is not accurate enough to reliably calculate speed. However, most GPS receivers are more accurate when measuring displacement and can determine velocity within 0.06 m/s (or 0.22 km/h).

Central system functions

Once equipment speed can be continuously monitored, software-based solutions can address all the disadvantages of traditional speed management by using centralised administration.

Centralised speed management software allows the user to set up speed limits at various locations at any time. When a truck arrives at a location, the operator is sent the pre-defined speed limit for that location. The system then compares the speed limit to the current measured speed of the truck and records the event if the operator is speeding. Recorded information can include the operator name, equipment ID number, time of the event, speed of the equipment and the speed limit that was exceeded.

The operator, dispatcher and/or foreman can then be automatically notified of the violation for immediate feedback and correction. Because feedback is only provided for violations, operator desensitisation is minimised. Repeat offenders can be identified by reporting against the historical event database, providing an audit trail for disciplinary action.

With a centralised speed management process, mines can immediately change speed limits to compensate for weather and road conditions. The limit on the number of speed trap locations is removed, and the system is able to add context by connecting with other information sources (e.g. full/empty).

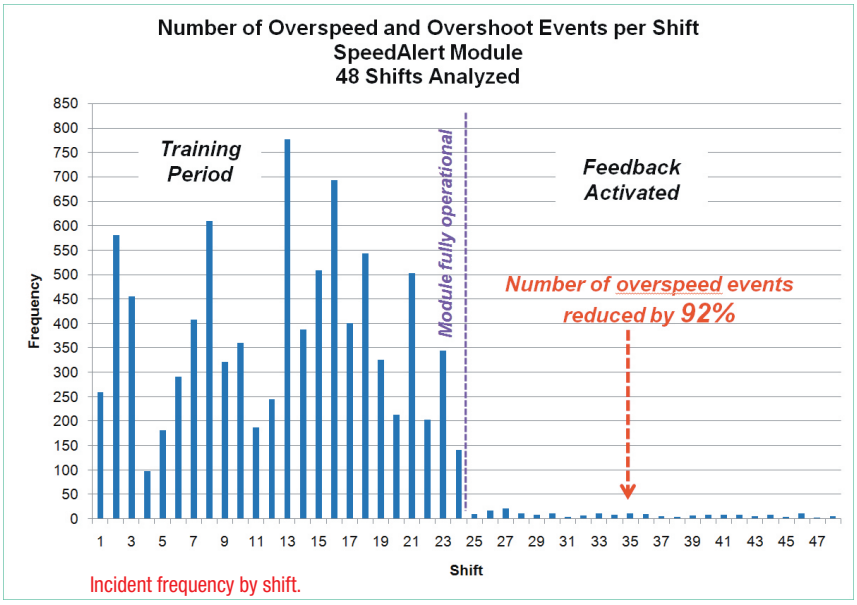
Case study

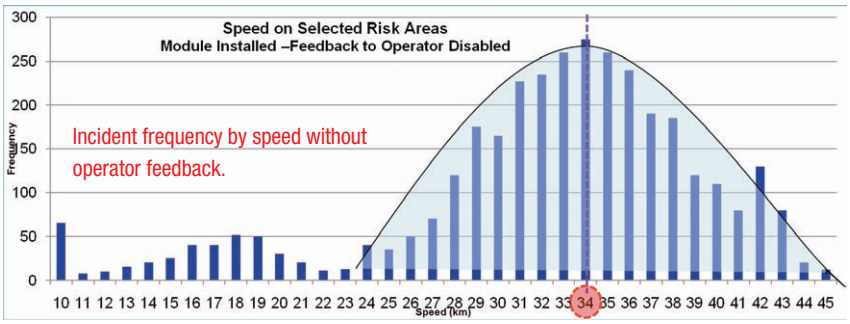
In order to verify the effectiveness of a software-based speed management system, a case study was conducted using the SpeedAlert™ module from Modular Mining Systems Inc.

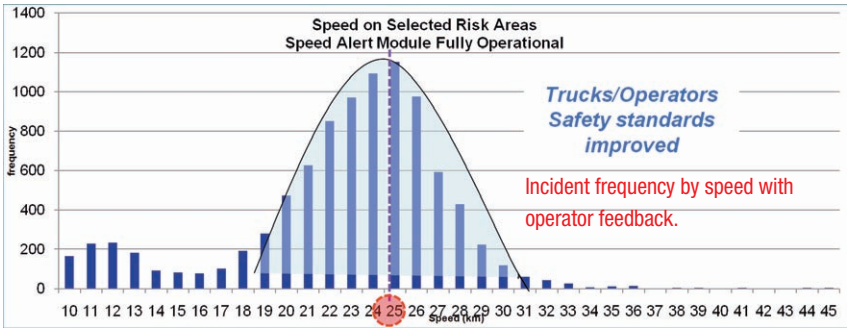
Speed was identified as a safety and business risk, requiring a speed trap in the event of the following conditions:

- A narrow running surface.
- Increased volume of haul truck traffic.
- Steep ramp grade.

Using onboard GPS receivers on all haul trucks, the system was configured to record equipment speed under 30 km/h, issue a speed warning to the operator between 30 and 35 km/h, and record a speed alarm over 35 km/h.







The study revealed a 92% reduction on overspeed events after the SpeedAlert module was fully implemented. The module also reduced the standard deviation of the average haul speed, resulting in more consistent haulage times and more manageable truck queue/shovel hang times.

The future of speed management

Opening up continuous, context-based speed management technology allows for the introduction of advanced speed-based functionality.

With payload data and GPS-derived angular velocity, it is possible to determine the speed at which a truck can safely corner without adversely affecting tyre wear. When unacceptable levels of vibration and acceleration occur, a safe operating speed can be calculated and indicated to the operator. Uncertified operators can be issued lower speed limits during training. Repeat offenders can be put on more stringent alarm thresholds. By managing speed with software, the possibilities quickly become endless.

Software-based speed management allows mines to be more effective in measuring, managing and controlling speed-dependent operations. This improves safety, equipment reliability and performance, resulting in lower operating costs and increased production. WC