Autonomy: connecting safety, productivity and efficiency

Daniel Robertson of Siemens Industry discusses the potential benefits of operator assist features and eventual autonomy in surface loading operations.

Early in 2013, Deloitte issued a report highlighting the top 10 trends currently affecting mining companies. The number-one issue was the ever-increasing cost of doing business. Deloitte concluded: “Unless mining companies improve operational efficiency, proactively control maintenance costs, and invest in cost-reducing technologies, this trend is likely to continue.”

Siemens has provided AC-drive systems for mining equipment for over 30 years, and, for the past 13 years, it has been monitoring the effectiveness of these machines. The general finding is that the machines are not being utilised to their full design capability.

A case study was performed at a mine in Canada, with a fleet of four electric rope shovels.

The study revealed that the cycle times were routinely longer than the worst-case design scenario, and that the dipper loads were under the target capacity for 66% of the time. Underfilling the dipper leads to extra cycles per truck, which makes the overall time required to load a truck even longer.

Despite implementing traditional methods to address this issue, such as reporting and operator training, performance did not substantially improve. The question was then raised: “How can we ensure that the equipment is being operated to its full capability – to deliver the best cycle, every cycle?” The answer is autonomy.

CLOSING THE AUTONOMOUS GAP

Many mining original equipment manufacturers (OEMs) have autonomous programmes running at various stages of development. Drilling has been fully automated, and so too has haulage. However, little progress has been made in excavation. In order to realise the vision of “the autonomous mine of the future”, the gap between drilling and hauling must be filled. This is why Siemens is focusing its efforts on electric rope shovel autonomy.

It is Siemens’ philosophy that the road to autonomy will be paved with operator assist features. In other words, the best approach to achieve full autonomy is by systematically releasing operator assist packages with increasing functionalities.

This approach is similar to that taken by the automotive industry, another industry where operator assist systems are becoming mainstream. The Google car would hardly seem possible today, were it not for prior developments such as cruise control, adaptive cruise control, lane departure warning and traffic jam assist.

Siemens’ first operator assist package, Swing to Truck / Return to Tuck with Collision Avoidance, involves automating the transport functions of the shovel. The operator digs through the bank, then initiates a ‘cruise control’ function to safely and effectively load the truck and return to the tuck position where the operator takes control again.

In the case study, this solution reduces the average cycle time by up to four seconds – representing a 12% increase in the number of trucks loaded per day, per shovel.

Removing the inefficiencies

The key is reducing the inefficiencies while transitioning from the dig face to the haul truck and back again. When an operator starts to swing the dipper towards the truck, it is difficult for them to judge the exact height of the side of the truck bed. Therefore, the dipper is hoisted high enough to ensure it does not hit anything.

Until the dipper moves close to the dump location, it is hard to determine whether the handle is crowded out enough to reach the desired spot. The operator has to make these adjustments as they get close.

Additionally, when braking, the operator has to anticipate and/or react in order to stop the dipper in the desired location. Sometimes there is overshoot; sometimes there is undershoot.

Before unloading, the bucket has to be lowered close enough into the truck bed in order to gently unload the material. Similar delays are experienced when swinging back to the tuck position. Before swinging too aggressively, the dipper must be hoisted high enough to clear the walls of the truck bed. All motions must be controlled simultaneously when returning the dipper to the tuck position, all the while avoiding contact with the
crawlers below or the bumper on the boom. In order to avoid collisions, this motion often takes place at reduced speeds.

These delays can be eliminated while simultaneously increasing safety by using automation such as the Swing to Truck / Return to Tuck with Collision Avoidance operator assist feature.

**BEHIND THE AUTOMATION**

On the Siemens system, the perception module detects the presence of any nearby object, determines what kind of object it is and calculates its pose relative to the shovel. This system is capable of determining the optimum dump location inside the haul truck as well as detecting nearby areas where the machine should not enter in order to avoid a collision with itself, or another object.

The motion planner determines the optimal trajectory for the shovel to adopt in order to move to the ideal unloading spot over the truck. It then uses the kinematic model of the shovel to determine how each motion must move so as to realise this optimum trajectory. It factors in not only the kinematics, which define how the machine moves, but also the kinetics involved with each pass, ensuring the motion execution system is capable of following the path provided.

The motion execution system takes the references from the motion planner, and utilises the existing drive control system to precisely follow the planned trajectory. This allows the machine to move in the most effective manner, thereby eliminating delays, shortening cycle times and increasing safety.

While significant savings are obtained by optimising the transport functions, even more benefits could be realised when digging through the bank. By incorporating such concepts as deterministic digging and pre-emptive load weighing, the most effective loading for each particular haul truck can be achieved. In the case study, such operation would eliminate the extra cycle per truck, and could result in 26% more truck loads per day, per shovel.

Swing to Truck / Return to Tuck with Collision Avoidance is currently in the pilot testing phase with a leading shovel OEM and will soon be commercially available.

**TOO BIG TO IGNORE**

Substantial safety, productivity and efficiency benefits can be obtained through autonomy. In order to maintain profitability, mines need to invest in these cost reducing technologies.

The technology required for autonomy is here today. Using it will allow even more operator assist features to be developed, allowing mines to ultimately achieve full autonomy.

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**The road to autonomy will be paved with operator assist features**

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