ROBOFUEL ROBOTIC REFUELING – A SAFETY AND PRODUCTIVITY INITIATIVE FOR THE 21ST CENTURY MINE*

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Abstract

The Robofuel innovation from Scott Technology Limited revolutionizes the process of refueling, with game changing operational and productivity benefits. Safety risks to drivers and other personnel are eliminated, and truck fleets can be operated with significant productivity gains, yielding both capital and operational expenditure efficiencies. Robofuel solutions can be retrofitted to an existing fuel farm, or placed "on the circuit" or even "in-pit" allowing for a significant reduction in time dedicated driving to and from fuel stations. This paper outlines the key advantages of the technology, progress highlights for projects completed to date, and an outlook for further developments with Robofuel providing key capabilities as part of an integrated, automated, autonomous mining roadmap.

Keywords: Robotics; Refueling; Safety; Productivity

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1 INTRODUCTION

Global mining industries continue to drive operational efficiencies in support of every increasing production volumes, completing a transition from the previous focus on expansion and capital investment priorities. A targeted innovation and automation approach yields an ongoing improvement in safety and a step change in productivity.

Scott Automation and Robotics, the Australian subsidiary of Scott Technology Limited, identified the issues plaguing the mining industry, specifically around in-circuit developments. Refueling mining haul trucks is a dangerous job, operators are exposed to the harsh weather that can be associated with a mine site and to thousands of litres of flammable fuel. The operators handle the heavy refueling equipment around the wheel base of the haul truck, causing repetitive strain injuries. Mining trucks are often required to travel several kilometers out of the mine pit to refuel, causing a loss in productive working time and an extra cost on fuel.

With the issues being identified, Scott Automation & Robotics designed, developed and released Robofuel - Robotic Refueling System for Mining Trucks.

This process involves automated Refueling involves the application of a robotic arm to refuel conventional mining equipment to both increase productive hours and efficiency of trucks and reduce cash costs on site.

Typically, refuel facilities are manned by at least one person at all times and trucks can spend up to one hour per day travelling to refuel in isolated areas away from the pit.
As there is no manning required for an automated solution, refueling stations are able to be placed “on the circuit” or even “in-pit” so fleet productivity can be significantly enhanced.

The Scott Automation & Robotics Robofuel system uses a state-of-the-art vision sensing and detection system which allows the robot to locate the position and orientation of the truck’s fuel tank.

This information is used to couple the fuel nozzle with the tank. Fuel spillages are minimized through controlled coupling,pumping and monitoring.

FEATURES SUMMARY

- Mobile or fixed robotic manipulators:
    - Robofuel can be retro-fitted to existing fuel farms.
    - Robofuel containerized system can be deployed on-circuit or in-pit.
    - Robofuel robotic arm can be mounted to service vehicles for mobile replenishment.
- Flexible adaption to most truck fuel tanks:
    - CAT 773, 789, 793 models deployed already. CAT 797F and Komatsu 830e, 930e, 960e designs ready for implementation.
- Can utilize existing equipment, pumps:
    - Simple battery limits – power, I/O and fuel delivery line.
- Monitors fuel consumption & waste:
    - Fuel tracked and recorded into each vehicle.

    - Fuel flow rate recorded and monitored for leakage.
- Fully Automatic – no operator required:
    - Truck driver can remain in the cabin throughout the refuel cycle.
    - Also suitable for use with Autonomous Haulage Fleets.

Figure 1. Robofuel container, for on-circuit or in-pit deployment.

BENEFITS SUMMARY

The many benefits of the system at work, these include:

COST

No requirements for operators on site to man fuel stations and re-fuel mobile equipment. Supervision and confirm activities may be undertaken at a remote operations center.

PRODUCTIVITY

Reduced time, distance and specific fuel consumption to refuel as the Robofuel system can be installed on-circuit. This can enable trucks to complete up to an additional cycle per shift depending on locations of existing refueling infrastructure. Based on a 220 tonne payload and a 50 truck fleet, this equates to up to approximately 11,000 tonne per dayor 4mt of Productive Movement per year.

Productivity is also enhanced by a reduction in refuel time, typically 20 to 30 minutes, down to 6 to 10 minutes. Refuel time is somewhat dependent on pumping rate and vehicle tank inflow capacity, but the largest time component at most sites is the administrative controls associated with personnel movement and interaction with the vehicle. These control measures are no longer required as there are no technicians on the ground, and the driver remains in the vehicle cabin at all times.

At some sites, it may be preferable to utilize this benefit by operating to the same ore movement but doing so with a smaller fleet. Parking up just one or two trucks provides a significant operational expenditure saving.

Figure 2. Robofuel refueling a CAT 793F vehicle, on-circuit. Iron Ore Site, Australia

SAFETY

Robofuel eliminates exposure to flammable liquid.

Repetitive strain injuries by removing this manual process from site. As mine operators move to larger vehicles, the supporting infrastructure (nozzles, hoses, etc.) also increases in size and weight and now places serious strain on operations personnel through repetitive heavy lifting and manipulation actions.

Interactions between personnel and vehicles are also reduced, with the vehicle driver remaining in the cabin at all times during the process. This also reducing the risks of tire failure exposure, collision with vehicle, falling objects, slips and trips, etc.

QUALITY

Robofuel records data, activities and system conditions to a local server, and this information can be readily exported back to a corporate database. This facilitates quantitative analysis of performance and condition, and allows evidenced based continuous improvements to fleet operations to be conducted.

The Robofuel system may also be upgraded to include fuel sensors that provide fluid condition monitoring. By ensuring and recording that only acceptable quality fuel enters each vehicle, the replacement period for fuel injectors on the truck can potentially be extended, presenting a significant cost saving.

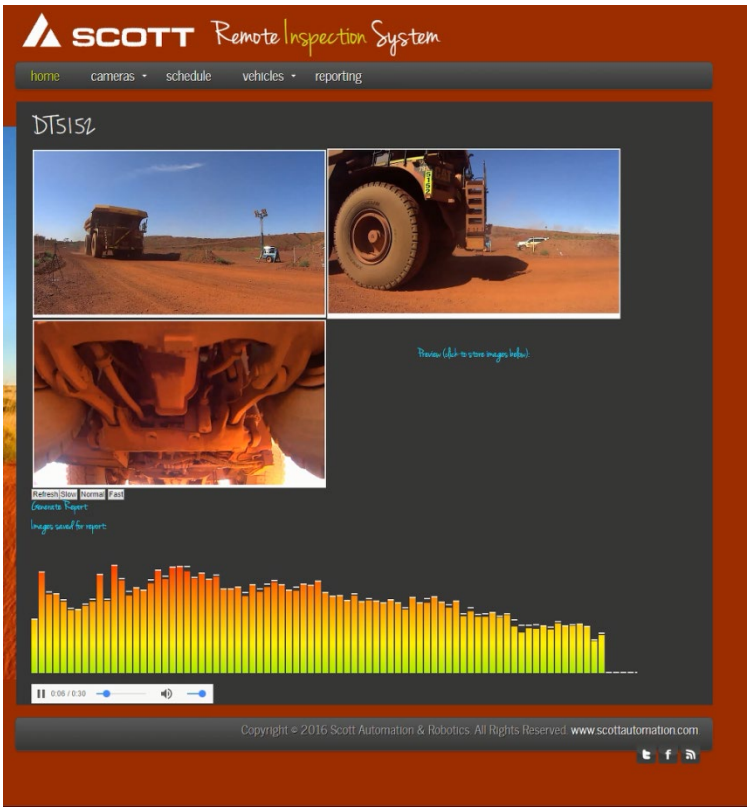

Figure 3. Robofuel Remote Inspection System upgrade – for detailed condition recording

Figure 4. Robofuel prototype – refueling a CAT 773E.Parkes, Australia

Figure 5. Robofuel on-circuit refueling of a CAT 793F. Iron Ore Site, Australia

Figure 6. Robofuel retrofit to existing refuel bay. CAT 789D/E fleet, New Zealand

Figure 7. Robofuel installed in-pit, with modular container, pumping and power for remote operation

THE FUTURE: 2019 & BEYOND

The Robofuel developments and deployments to date have been focused on haul truck fleets in Australasia, as this has presented the most immediate opportunity for improvement and adoption.

Going forward, there are key developments that form part of the Robofuel roadmap, including:

- Transition to permanent deployment configuration at operations where pilot tests have been successfully completed.
- Complete new pilot demonstrations, including in Canada, USA and South America.
- Configure system for installation on mobile fuel truck.
- Commence first Autonomous Haulage Refuel project – planned Q3 2018
- Extend connection and delivery options to other fluids (lubricants, coolants, LNG, etc.).

CONCLUSION

Robofuel provides a step change in productivity and safety for mobile equipment maintenance across the mining industry. Major benefits of the technology include minimised spillages and environmental contamination, improved operator safety by elimination of dangerous tasks, and increased availability and productivity across the haulage fleet.

In the near future, the benefits will be extended to drills, rail, road, excavator, aviation applications, and anywhere else that presents the opportunity to provide safety, productivity and quality outcomes for personnel and industry alike.