Automated underground mining

David Noort and **Peter McCarthy*** examine what progress has been made and consider how the future may look

Automated production drills have been available since the mid 1980s, although at that time rig relocation and bit changing remained manual operations. INCO trialled bit changing and remote tramming on Tamrock production drills in the late 1990s, but these functions are yet to gain widespread acceptance. Automated LHDs are now commercially available, although automation of the dig cycle is a problem in anything but very well broken rock. At Olympic Dam mine, LHD automation produced an extra 2.4 hours per shift of production by operating the loaders manually and then swapping to automated mode during shift changes and meal breaks. Automated trucks have operated reliably at the Finsch mine in South Africa for some time (***IM***, January 2008).

Longwall coal mines achieved partial automation of a relatively repetitive (continuous) mining system in small steps by automating one easily defined machine operation or task while the rest of the operations remained manual. Debugging and redesign continued until the automated operation achieved the required degree of reliability. Then the process was repeated for another candidate for automation. Over several years, a reliable and integrated partially automated system was built.

By contrast, in drill and blast operations, the cycle of activity currently requires human entry and intervention for many tasks ranging from geological sampling to the relocation of pumps and electrical supplies. There has been no attempt at automation for a large number of tasks. Narrow vein mining operations such as those in South Africa are just beginning to make significant inroads into mechanisation, an obvious precursor to any consideration of the application of automation.

It is generally accepted that for safety reasons humans should be prohibited from entering an automated mining environment. Electronic lockouts or physical barriers ensure that the automated systems shut down before humans approach them for inspection, maintenance, or to perform tasks in their vicinity. These lockout measures have limited the use of mobile mechanised equipment to the production phase of block caving operations.

Typically only 50-60% of underground employees are direct operators of equipment and any labour saving through automation will be largely offset by the need for specialised maintenance support. Some productivity improvements are possible, notably at shift changes, but automation will be justified based on the improved occupational health and safety benefits.

Fully automated machines must be able to detect and correct their own operating problems. However, the automobile manufacturing industry does not currently consider this cost-effective, and has found that partial automation achieves 90% of the benefits of full automation. It seems unlikely that a transition to a fully automated environment will be possible unless mining passes first through an intermediate phase that enables the development of the platform technologies to a satisfactory level of reliability, a process that is likely to take at least two decades.

During this intermediate phase, non-repetitive manual tasks such as sampling, surveying, maintenance, and installation of services will be progressively mechanised and controlled by operators using adaptable multi-purpose manipulators from a specially designed cab on a general-purpose machine. These tasks could then progress to tele-remote operation and form part of the concept of a fully automated mine. They are however unlikely to attain a point where humans do not intervene in their cycle.

General-purpose vehicles will be fitted with falling object protection systems, rollover protection systems, and collision avoidance systems that communicate continuously with all other vehicles in the vicinity. Effectively the mine environment will be treated as hostile and a mobile safety capsule will be provided for all personnel entering that environment, in much the same way as is provided for workers in undersea or outer-space environments. Operators will remain within the vehicle cabin for the entire duration of a task or shift, and an alarm on the vehicle door will warn a control room operator and shut down operations if the door is opened while in the active operating area.

Machines such as drill rigs, trucks and loaders can be readily adapted to such specifications and in many other cases the capsule will be a robust four-wheel drive vehicle with general-purpose and specialised manipulators. Some applications are straightforward while others such as routine and breakdown maintenance may require fundamental changes in machine design. The primary intent is that if personnel are not outside vehicles then vehicles or rocks cannot strike them – any collision or impact is avoided or absorbed by the vehicle protection systems. Other safety benefits include removing personnel exposure to fumes, dust, radiation, heat, lifting and pinching hazards and uneven and slippery surfaces.

Consider the non-repetitive task of placing a portable pump in a sump using a hydraulic crane mounted on a flat bed truck. The operator stands beside the truck to operate the crane and then connects the pump manually. Automation of this process would require a redesign of the electrical and water couplings and the development of a sophisticated manipulator enabling remote unloading of the pump and then connection of the discharge line and power cable. An operator could use the same manipulator to perform many other tasks if it is of a universal design.

The first critical milestone will be to remove people from exposure to the underground mine operating environment by enclosing them in specially designed cabs. This will probably achieve the majority of any productivity and safety benefits gained from full automation in any case. It then becomes a question of when (or if) progression to tele-remote operation and full automation is desirable.

Substantial funding, strong leadership and belief in the vision of an automated mine system will be required from the industry. ***IM***

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