Robotic Welding & Cutting in **The Mining Industry**

Although Australia has not been a leader in the development of robotics, it has produced some innovative, world leading applications. In 2015, a unique robot welding system was developed for adaptive maintenance welding of heavy mining buckets and dump truck bodies. The portable robot utilises a laser camera for multi-pass welding and to cope with complex weld joint geometry. Results show that weld completion time savings of 70% are typical, whilst 90% is not unusual. Peter Keubler, BOC's Key Customer Technical Solutions Engineer., described the innovations that enabled the rapid deployment of this system with minimal jigging and programming in challenging environments.

After developing and installing the most versatile multi-process welding robot in Australia last year, BOC and its integrator partner Robot Technologies Systems Australia (RTA) delivered significant improvements in safety, quality and productivity for its customer.

Presenting at the IIW International Welding Conference, Peter Kuebler shared the innovations that enabled the deployment of a portable robot, which utilises a laser camera for multi-pass welding and complex weld joint geometry.

Peter Keubler speaking at the IIW International Conference.

Background

In recent years, falls in iron ore and coal prices have led to a decline in profitability for mining companies. As a result, mining suppliers have been under tremendous pressure to reduce the costs of maintaining, repairing and remanufacturing mining and haulage equipment.

"With the downward pressure on costs, some companies started to investigate the suitability of utilising robotics to automate repair welding," explained Kuebler.

"This automation had previously been considered impossible due to extensive programming time, the size and geometry of the equipment, and the damage, distortion and uneven wear of components."

"Advanced laser seam tracking, adaptive welding software, a new generation welding system and a modular robot configuration were used to develop a unique robot welding system for adaptive maintenance welding of heavy mining buckets and dump truck bodies," said Kuebler.

Advanced Laser Seam Tracking

Laser imaging for welding and other processes has evolved into intelligent laser vision and sensing systems. Using a line configuration, the camera now only requires three measurements to recalculate the welding trajectory in 3D or 6D, allowing seam-finding to take only a matter of seconds.

"Today's advanced, real-time laser tracking enables high-speed adaptation to dimensional variations, requiring minimal programming and tooling. Tracking ensures precise weld wire positioning in the joint, which enhances weld quality and appearance," said Kuebler.

Adaptive Welding Software

The laser camera that was used includes adaptive welding software, which is essential for multi-pass welding. Travel speed and weave amplitude are modified to suit variations of root gaps and joint cross-sectional areas. If a gap exceeds a given dimension, the algorithm will stop the robot and move to the next tack or joint.

"The software enables real-time adjustment of weld placement and parameters for each pass using a fill control algorithm, which allows the controller to calculate the location of subsequent passes. This dramatically reduces programming time and maximises productivity."

The laser camera is also used 'visually' to inspect the completed weld. The 2D images can be recorded, providing a permanent record of the weld profile and an integrated video camera enables remote monitoring of the weld.

Minimal Programming Time

Conventional offline programming software has had mixed success. While the software can convert a 3D CAD job model into robot language for uploading to the robot controller, it does not cater for optimising torch angles, arc start/end sequences or multi-pass welding.

In response to these limitations, RTA developed generic program libraries for certain types of multi-pass welds, resulting in a range of fillet and butt weld libraries that are constantly being added to. Each library contains the essential welding program data and requires little to no intervention by the robot operator.

For welding insert pieces into bucket walls, an import utility was developed to convert data encoded within a DXF file into data the robot can use to scan and weld the piece. The operator only has to 'teach' the robot where the piece is located in space and the robot can then use the laser camera to search for the part and build weld paths based on data within the DXF file.

This has enabled SMW Group, BOC's mining equipment refurbishment customer to minimise programming time and rapidly deploy the robot as new jobs arrive. The robot can then be taken on-site to minimise downtime of critical components.

A New Generation Welding System and Modular Robot Configuration

The robot cell for SMW Group was manufactured by RTA and is comprised of a Kawasaki RA 15X robot equipped with an ewm Phoenix 552 welding package and a ServoRobot PowerCam laser vision system. A customised bracket on the robot wrist houses the laser camera, preheat temperature sensor and monitoring camera for the operator.

Built on a modular base, the robot cell can be positioned on, beside or beneath the component being welded. The robot is capable of operating at ambient temperatures of up to 45°C and weld continuously within its reach envelope, with minimal downtime between passes.

Utilising a liquid cooled torch permits welding of these components at currents up to 500amps. Deposition rates of up to 6kg/hour are regularly achieved even in the vertical welding position, using 1.6mm gas shielded flux cored wire.

"The robot has reduced overall production costs, improved safety, quality and reporting, and broadened customer range of work scope capabilities," said Kuebler.

"The savings in welding times are typically 70%, whilst 90% savings are not uncommon. Robot welding of new 25 millimetre floor plates into a dump truck took less than 10% of the time taken for manual welding."

The Future

By combining new generation robotics, laser camera, plasma cutting and welding packages with local innovations, these portable robot cells are proving to be extremely competitive and will continue to significantly improve efficiency in the welding industry.

A professional welding engineer and metallurgist, Peter has over 35 years experience in the construction, fabrication and welding products industries. He is a qualified International Welding Engineer and has a degree in metallurgy from RMIT. Peter has held management, technical and consulting positions with a wide range of companies, and is currently employed by BOC as Key Customer Technical Solutions Engineer. In this role, he is responsible for co-ordinating technical support for BOC's largest customers as well as marketing of welding automation equipment.