Jigless robotic welding in SA's catalytic converter industry

Cummins Emission Solutions, based in the Automotive Supplier Park in Rosslyn, Pretoria, is a subsidiary of Cummins Incorporated and a leading global manufacturer of emission solution products. *African Fusion* visits the facility and talks to Herman Niemandt about the company's pioneering development of a jigless robotic welding process.

Herman Niemandt, the manufacturing engineer who pioneered the development of a jigless robotic welding process for CES mufflers.

Cummins Emission Solutions (CES) is a global designer, integrator, manufacturer and distributor of exhaust after treatment systems and components for the on- and off-road medium, heavy and high power diesel engine markets. The company has key operations in Indiana and Wisconsin in the USA, and in the United Kingdom, South Africa, China and Brazil. Its products serve both the first-fit original equipment and the retrofit markets.

In South Africa, the company started life in November 2005 as Fleetguard Emission Solutions – part of the components segment of Cummins Inc, the world's largest independent manufacturer of diesel engines and related power products, making selective catalytic reduction (SCR) systems to reduce emissions in heavy-duty trucks. It was renamed one year later, in line with a new global branding strategy to unite all businesses and products under the Cummins brand name.

"We make catalytic converters which incorporate exhaust silencers," explains Niemandt, "mufflers for diesel trucks. Almost all of our production goes to Europe, and we are the sole South African supplier of units of this size," he adds.

He takes us on a tour of the facility: "Most of the components are made in ferritic stainless steel but some of the internal components are made of the exotic stainless, 904L, which resists acid attack. Urea is injected into the catalytic converter to promote the conversion process. This corrodes traditional stainless steels so we need to use 904L to combat that," he explains.

The manufacturing process starts with the supplied chemical converter elements, called the bricks. "Bricks are coated with vanadium pentoxide and a small region on the outlet side, called the platinum slip, is coated with 0,08 g of platinum," says Niemandt. They are then wrapped in a fibre mat and inserted into a cat-sleeve, made in the factory in ferritic stainless steel. "We make the sleeve from a squared blank, which is rolled and welded using the TIG or the Plasma process." Two bricks are pressed up against a dividing bead in the centre of each sleeve, one from each end. Forming beads on the outer ends make sure that the CAT brick can't move around inside the sleeve. These are then baked at 500°C.

"We guarantee traceability on every product," says Niemandt, pointing towards a 3D bar coding machine. "All the major component sets get an ID punched onto them so that they can be traced back to an exact time and batch."

Two encapsulated sleeves, called cans, are laid alongside each other and fitted through three internal flanges. These are then inserted into the oval main body of the muffler. "The main bodies are clamped down and then welded using OTC TIG welders," he points out. "The edges are then flared to assist when welding the thin material."

Once all the internal components and the inlet and outlet piping have been inserted, the muffler is ready for the jigless robot welding cell. "Before we changed to jigless manufacture, we used two robots to weld the seams

Jigless welding of CES mufflers using Motoman robots and SKS welding power sources. The handling robot and welding robot move simultaneously to access all of the internal seams. The process substantially improves reliability and cycle times, offers much better access to weld joints and cost savings over jig and manipulator-based systems.

The ridge-locking mechanism is used to locate each muffler before being lifted by the handling robot.

The gripper on the handling robot picks up the component to an accuracy of within 0,2 mm and the outside hold allows free access to all of the internal seams.

of the internal flanges to the body. We would then take the muffler out of the cell, lock it into a jig by hand, and a third station was used to weld the inlet pipe. We moved to jigless manufacture so that once the part was picked up, we could do as much as possible to it before we had to put it down again," Niemandt informs *African Fusion*. "We decided on a two-robot layout, one handling robot and one welding robot for each cell, and we have three parallel stations each equipped to do exactly the same job," he adds.

A key problem was the tolerances required: "We needed to pick up the muffler with an accuracy of within 0,2 mm every time. So we created these discs," he says pointing to an oval mechanism mounted on the edge of the welding cell. "When you put the muffler over the disk and open it up, it pushes the muffler into exactly the correct shape and locks it up into an exact holding position." We see a part loaded over the top of the disc. We hear a pneumatic hiss and the disc expands outwards. The component clicks into its clamped position. The handling robot then moves over and its grippers close around the outside of the muffler. The disc releases and the component is lifted off and taken around to the welding robot waiting alongside. Welding begins immediately and we see both the handling robot and the welding robot moving in a perfectly synchronised dance around the component.

"Both robots know the exact position of every seam. The first operation is the 360° circumferential internal flange weld that connects the two cans to the outer body. On the round seam, we are achieving speeds of 160 cm/min. using the KF pulse feature of the SKS power source."

"This is difficult weld," Niemandt says, "you need to fill the whole area, so we are running at 14,7 m/min wire feed speed, and at the back, where the gaps are created, we go to 22,9 m/min on the wire feed speed. With normal pulsed welding, you can only adjust the peak pulse and duration. The base current time varies with arc-length and voltage. But the KF pulse parameters can be specified exactly, so you can control the exact amount of material you deposit. If you deposit more material, then you can make the weld colder and visa-versa," he explains. "KF-pulse allows you to weld over a very wide range of parameters. In this case we are running very fast, just melting the edge away and depositing material."

Once the internal seams have been completed, the handling robot brings the muffler back to a second station. Again we hear the system open and the muffler click into place. "We now push the inlet pipe in and then we ridge lock it so that it fits snugly without gaps. Then the pipes are welded," says Niemandt. "We also add a piece called the plug flange."

When the robot stops, Niemandt points towards the welding torch: "The wire conduit passes through the middle of the torch-axis, which makes it easy to rotate the head. There are no problems with twisting the welding torch bundle because the neck is able to spin on a bearing unit."

Then he shows us the calibration tool: "If the torch gets hit and goes out of position, this is picked up by laser sensors, and if the position has shifted, a recalibration sequence will automatically be run to put it right again.

"Some other companies are using handling robots to pick up jigs, but as far as we know, we are the first company in South Africa to succeed with truly jigless welding," he claims.

Once the internal components are welded, the pancake-ends and a damping plate – to absorb some noise and heat – are added. "A few welds are still done manually," says Niemandt, "the beauty plates, brackets and the outlet pipe, for example."

All mufflers are leak tested before being passed through a computer controlled dimension checking system. Once they have passed all of the QA tests, they are packaged and taken by trolley to Schenker, a shipping agent just around the corner, to be shipped in batches to Sweden.

"The jigless system has been an excellent move," confirms Niemandt. "So much better than welding by hand. Because there are no jigs, maintenance is way down and machine availability is up – removing a regular bottleneck of the past. The jigless cell also gives much better access to the weld joints as there are no jigs or clamps in the way. You can weld wherever you want."

Cost is a third benefit – the handling robot replaces a two axis manipulator and "the VMF external manipulators are actually more expensive than the handling robot that replaces it," confirms Niemandt.

This system has already put us way ahead in terms of improved cycle times, and – although some challenges continue to present themselves and higher skills and training levels are required to ensure people can adapt to this new technology – there is still scope for the process to be optimised," he concludes.