Afrox's 360-degree MCAW solution for HP piping

Following several years of persistence, Afrox's welding applications team, in association with Babcock International Group, has succeeded in qualifying a repeatable and robust procedure for welding high pressure piping using the Miller PipeWorx welding system with RMD and ProPulse technology coupled with metal-cored wire and a CO_2-rich shielding gas. *African Fusion* meets the team.

With Conn Roux of Babcock International Group are Arnold Meyer, Thembinkozi Matyeka, Johann Pieterse and Houston Isaacs from Afrox's development team.

"We started developing pipe welding procedures using Miller's PipeWorx solution several years ago but, while we have successfully qualified procedures before, we have never been able to demonstrate repeatable results on production welds for high pressure (HP) piping," begins Johann Pieterse, Afrox's manufacturing industries business manager and applications' team leader. "That is, until December last year," he adds.

Traditionally, high integrity pipe welding has always been done using gas tungsten arc welding (GTAW/TIG) for the root pass, followed by shielded metal arc welding (SMAW/stick) for the fill and capping runs. "For many years, this has been the only proven and trusted way of welding steam piping for the power generation industry. There has been some recent success using a TIG root followed by pulsed GMAW fill and cap welds but, by and large, the traditional way is the only widely accepted solution and few inspectors and plant operators are willing even to consider alternatives," Pieterse continues.

The traditional way is neither cost effective nor highly productive. However, Power Station shutdown deadlines often have to be extended, which further increases reputational damage to the utility. "Also, big-end users can no longer accept imported welders on their sites. The traditional process requires A-class welders with very high skills' levels, and it is difficult, even for good welders, to master these processes at the quality levels required for high-temperature pressure piping," says Babcock's IIW welding specialist/technologist, Conn Roux.

Several years ago, Afrox began to explore the use of semi-automatic welding procedures using solid wire gas metal arc welding (GMAW). "When the Miller PipeWorx welding machines first became available, we started to develop pipe welding procedures that used the machine's RMD function for root welding, followed by the ProPulse mode for the fill and capping runs.

"We were able to pass the X-ray tests consistently, but when it came to the bend test, we struggled. Sometimes everything would be great and we celebrated successfully qualifying a procedure, but results on production welds were never consistent," Pieterse reports.

Above and right: Flaw-free macro and bend-test samples of the qualified test piece. "For the first time ever, we have a repeatable welding solution that offers high efficiency while maintaining weld quality," says Conn Roux of Babcock.

The Miller PipeWorx™ 400 designed for high tech workshop pipe welding applications using Miller's proprietary RMD™ and ProPulse™ current control technologies.

The tenacious team continued to look for the reason for the inconsistency so as to develop a robust and repeatable semi-automatic welding solution. "While we were continuously being told we would fail, we persisted, going back to the drawing board and asking some fundamental questions to expand the success window: was the voltage too low or the arc too narrow because of the argon shielding gas, and what could we do to change things?" Pieterse relates.

The Afrox team's International Welding Engineer and Applications Development Manager, Arnold Meyer, describes how he viewed the problem: "Argon gas tends to create a narrow and relatively cold arc. Adding more CO_2 increases the average temperature of the arc. It also widens the arc and helps the heat to be distributed more evenly across the weld pool," he says, adding that this was key to achieving better sidewall fusion.

But with solid wires, there is a limit to how much CO_2 can be used before the metal transfer becomes globular and unstable.

"By using a metal-cored wire instead of a solid wire, the current density becomes higher, which enables the semi-automatic MCAW process to deliver spray transfer while using significantly higher CO_2 percentages in the shielding gas," Meyer notes.

This leads to better spreading of the arc, higher temperatures and far better sidewall fusion, which enables the inconsistency problem to be much more easily overcome. "The raised CO_2 level produces a more rounded fusion profile with sufficient sidewall fusion, but using raised CO_2 percentages is only possible by moving to a metal-cored wire," he says.

Following extensive trials, the new process produced repeatability and Afrox is now confident that all procedure specifications, including the bend tests, can be met by the procedure recently qualified for Babcock. "We are no longer seeing inconsistencies and we are routinely achieving perfect radiographs followed by beautifully clean macros and bend tests," Pieterse adds.

Having resolved the inconsistency problem, the many advantages of semi-automatic welding over the traditional GTAW root and SMAW fill and capping technique become immediately realisable. "Metal-cored wires offer higher deposition rates compared to solid wires, which are already significantly higher than GTAW or SMAW deposition rates. Higher travel speeds and deposition rates mean faster weld completion times and, therefore, lower costs per weld. The deposition rate is nearly double, or to put in a different perspective, welding time is reduced by 50%," notes Roux, adding that reducing welding time is the only way of significantly reducing costs.

"In addition, with SMAW/MMA electrodes the weld metal deposited is only 35% of the mass of the electrodes purchased. With metal cored wires, this deposition efficiency is up at 93%. Most important of all, however, is that compared to TIG and SMAW welding, the process is much easier for welders. It requires significantly less practice and training than the traditional approach and we see this as having the potential to eliminate the need to import foreign welding skills," Roux tells *African Fusion*.

TIG welding is particularly difficult and welders with the required skills are very scarce – and MMA welding skills are also becoming a big issue. "This is an excellent solution for local labour because a welder can be upskilled and qualified to successfully complete a weld within a week or two. It can take us up to a year to upskill a GTAW/MMA welder to the skills required for high pressure pipe welding," he says.

The Miller PipeWorx 350 FieldPro™, which includes ArcReach™ and Autoline™ technologies for Africa's harsh and challenging onsite applications.

"The only drawback with the use of metal-cored wires is that spray transfer mode is difficult to control in out-of-position pipe welding. This is where the Miller PipeWorx power source comes into its own, though. "The ProPulse feature of the PipeWorx system is used for the fill and capping runs. This optimised pulsed solution for pipe welding operates under constant voltage (CV) mode during peak and background periods, but the ramp up and ramp down rates and the initial peak and background current levels are under constant current (CC) control. This makes for much more manageable out of position welding," says Meyer.

For the root pass, Miller's RMD (Regulated Metal Deposition) technology is used to control metal transfer in short-arc mode. This controlled deposition technique provides less chance of cold lapping or lack of fusion, less spatter and a higher quality root pass around the pipe.

"The combination of a metal cored wire with a high deposition rate and a short arc helps to keep the weld pool cool, reducing the heat input and making the weld puddle easier for the welder to control," says Pieterse.

Roux continues: "The new solution is a paradigm shift for large bore welding in the power generation, oil and gas and industrial sectors. It offers us a better solution in terms of cost, efficiency, productivity and quality, without any of the past drawbacks associated with conventional GMAW welding. This is a breakthrough for the welding industry. Cost savings of 83% can be achieved and, for the first time ever, we have a repeatable welding solution that offers high efficiency while maintaining weld quality."

"This is another one of our 360-degree application solutions. We at Afrox strive to offer total support and we align our product offering and our development endeavours so that companies like Ntuthuko Generation get the very best end result possible.

"It has taken us several years to get this right in the power generation industry, which proves that our application team can deliver the total solution from an initial clear understanding of customer requirements all the way through to successful production welding with Afrox trained skilled labour to do the job," Pieterse concludes.

Process	MCAW	SMAW	GTAW
Consumable electrode/wire	B3, 1.2 mm	KV3, 3.15 mm	TIG B3, 2.4 mm
Gas Type	Afrox Fluxshield	N/A	Argon
Welding and Overhead Rate (R/hr)	R400	R400	R400
Deposition Rate (kg/hr)	5.5	1.2	1.2
Deposition Efficiency (%)	93%	60%	98%
Gas Flow Rate (l/min)	18	0	12
Gas Consumption (kg/hr)	1.65	0.00	1.28
Operator Factor (%)	35%	18%	18%
Labour & Overhead cost per kg (R/kg)	207.79	1 851.85	1 851.85
Weld metal cost per kg (R/kg)	69.89	116.67	56.12
Shielding gas cost per kg (R/kg)	8.98	0.00	32.00
Total cost per kg of deposited weld metal	**R286.66**	**R1 968.52**	**R1 939.97**

This cost comparison table shows how 85% cost saving are achieved due to the much higher deposition rate and efficiency of Afrox's 360-degree MCAW pipe-welding solution.