Modern tank farm construction using EGW and AGW processes

***African Fusion* talks to Jannie Bronkhorst (right) of Renttech about tank farm construction using mechanised submerged arc, automatic girth and electrogas welding processes – and Renttech's total packaged solution, from project inception to the completion of the final weld.**

In the past, because tank farms are built on site and have to withstand the elements, SMAW electrodes were used for almost all of the weld seams of fuel tanks. "Gas shielded processes were not suitable and gas is not always easy to get, particularly in Africa. So the labour-intensive stick welding process, which is associated with many stops and starts and a high potential for discontinuities or defects, was generally used," says Bronkhorst.

"Today, we employ mechanised processes wherever possible, which are much faster, less prone to defects and offer significantly lower total project costs and greatly improved return-on-investment. Three factors govern the success of projects such as tank farm construction: time, quality and cost, and the mechanised approach improves all three," he argues.

Fuel tanks can be sized from 6,0 m in diameter to 150 m. The ones currently under construction in the Port of Beira in Mozambique have a diameter of 37 m and a height of 22 m, each with a capacity of 20-million litres. The Beira fuel terminal with five of these tanks is being built to support needs across Africa for petrol, diesel and jet A1 fuels.

"Every tank gets erected on a base. The ground is piled and different layers of reinforcing are put in and compacted down, with a final layer of bitumen on the surface completing the civil side of the construction project," says Bronkhorst.

"The steel tank is then built on top of the piles. The floor plates are laid down first, tapering down towards a conical drain at the centre of the base. This separates out any water that gets into the tank, because fuel floats on water," he explains.

The floor is made up of flat plates, curved at the corners and lapped over each over in an interwoven pattern. "The joints are all lap joints, but on thicker material they can look a lot more like fillet welds," he notes.

Before welding begins, the annular baseplate ring is placed around the tank underneath the floor, "but this ring does not get welded until the tank is completed," Bronkhorst tells *African Fusion*.

Commenting on replacing the use of stick electrodes, he says: "Today we employ a submerged arc process for the base, using Lincoln LT7 tractors and Lincoln Flextec 650 power sources. But it gets very hot on the tank floor, so when welding relatively thin plates, it is critical to weld them in a pre-set sequence to avoid distortion, bowing and buckling.

"We start with the longitudinal welds and we complete diagonally opposite seams to immediately counterbalance any distortion from the previous weld pass. Only after completing the longitudinal seams do we return to complete the cross seams.

"Once the floor plate is compete, welding of the 'strakes' begins. These are curved plates 2.4 m high by 10 m long, which form the cylindrical walls of the tank's shell. Each plate has a built-in curvature, depending on the diameter of the tank, and plate thicknesses vary from bottom (thicker) to top," he says.

There are two ways of building these large tanks, according to Bronkhorst.

All Time Welding's EGW and AGW welding systems are ideal for mechanising welding. According to Bronkhorst, the mechanised approach improves all three factors governing success: time, quality and cost.

The first and most traditional is the 'bottom-up' technique, which means the thickest strake sections are welded first. Then thinner sections are added until the height required is reached. Walkways, a wind girder – a reinforcing ring connected via knee braces to stiffen the top section of the tank – and a roof will then be added.

The alternative method is the 'jack-up' method, or the 'top-down' method. "The first ring of strakes is assembled – supported by temporary fishtails mounted onto the floor – and then tacked together. The vertical seams between the plates of the strake are then welded using the EGW process until the first ring of strakes is complete," Bronkhorst explains, adding that this section will end up being the top section and is therefore constructed from the thinnest material.

The roof, which is an aluminium structure, is immediately bolted on at the height of one strake. Then the whole ring and its roof are jacked up to allow another ring of strakes to be inserted below.

"This method has some access advantages, because all the welding work is done closer to the ground. Hooking up an EGW or AGW system and all of the peripheral equipment needed to complete a seam 22 m in the air is complex, so by keeping the bulk of the work at a height of 2.4 m, access is much easier," says Bronkhorst.

The EGW process for vertical seams

Electrogas welding (EGW) is a single pass welding technique developed for completing vertical seams in plate thicknesses from 10 to 40 mm. "We can use a gas-assisted flux-core wire or a self-shielded/gasless wire such as Lincoln Electric's NR431, which is designed specifically for EGW welding," continues Bronkhorst.

"With the gas-assisted process, CO_2 shielding is used and we find that this does result in slightly better mechanical properties – and we have done the tests. It also produces less fume and, although one has to add a gas cost, the gas-assisted process is a little less expensive," he adds.

The EGW carriage, due to its wind-shielding frame, also protects the gas shielding from wind, preventing porosity, and it shelters the operators. Describing how the process works, he says

Above: The 'jack-up' method, or the 'top-down' construction method has some access advantages, because all the welding work is done closer to the ground. "By keeping the bulk of the work at a height of 2.4 m, access is much easier," says Bronkhorst.

Right: A specialised flux belt is used to support the granulated flux around the outside of the strake while welding proceeds. The end result is a high quality butt joint completed in the 2G position.

that water-cooled copper backing bars with a weld-profile groove are wedged onto the inside of the tank to cover the full length of the strake seam.

On the outside surface, a spring-loaded travelling copper shoe, which is attached to a welding tractor, is pressed against the seam surface, forming an enclosed 'mould' for the weld metal. The welding head feeds wire into the top of the cavity striking an arc, which fills the joint with molten metal.

Making this process very simple and elegant, the welding head and the connected copper shoe is moved up the seam so as to keep the arc voltage constant. As the joint fills, at a rate dependent on the chosen wire feed rate, the voltage detected tends to drop, which triggers the tractor to move up. This is known as a closed-loop voltage sensing process.

"So the travel speed does not have to be set. To make the process faster, all that is required is to increase the wire feed rate, within the current limits of the power source being used, and the travel speed will automatically increase to fill the joint faster," Bronkhorst explains.

Comparing the process to SMAW, he says: "If welding a vertical strake seam on 20 mm plate by hand, the stick operator will take two days to complete the whole seam. The EGW process can do it in under an hour – and we once measured a joint on 20 mm plate, 2.4 m high being completed in just over 47 minutes," he notes.

"On a tank of 116 m in circumference, the use of 10 m strakes gives 11 vertical seams that have to be welded," he calculates. "On a strake height of 2.4 m, that gives a total vertical welding length of 26.4 m per ring and for every manually welded pass, one would have 132 stop-starts per strake joint. If, on average, five runs are required to completely fill a joint using SMAW, then 660 stop-starts have to be blended per ring section or nearly 6 000 for all of the vertical seams on the tank," Bronkhorst estimates

"For manual welding, 10 or 20 welders will be required, each with their own machines and dedicated grinders. This to keep up with an EGW machine that can easily complete 11 strakes in one day," he points out, adding that the EGW

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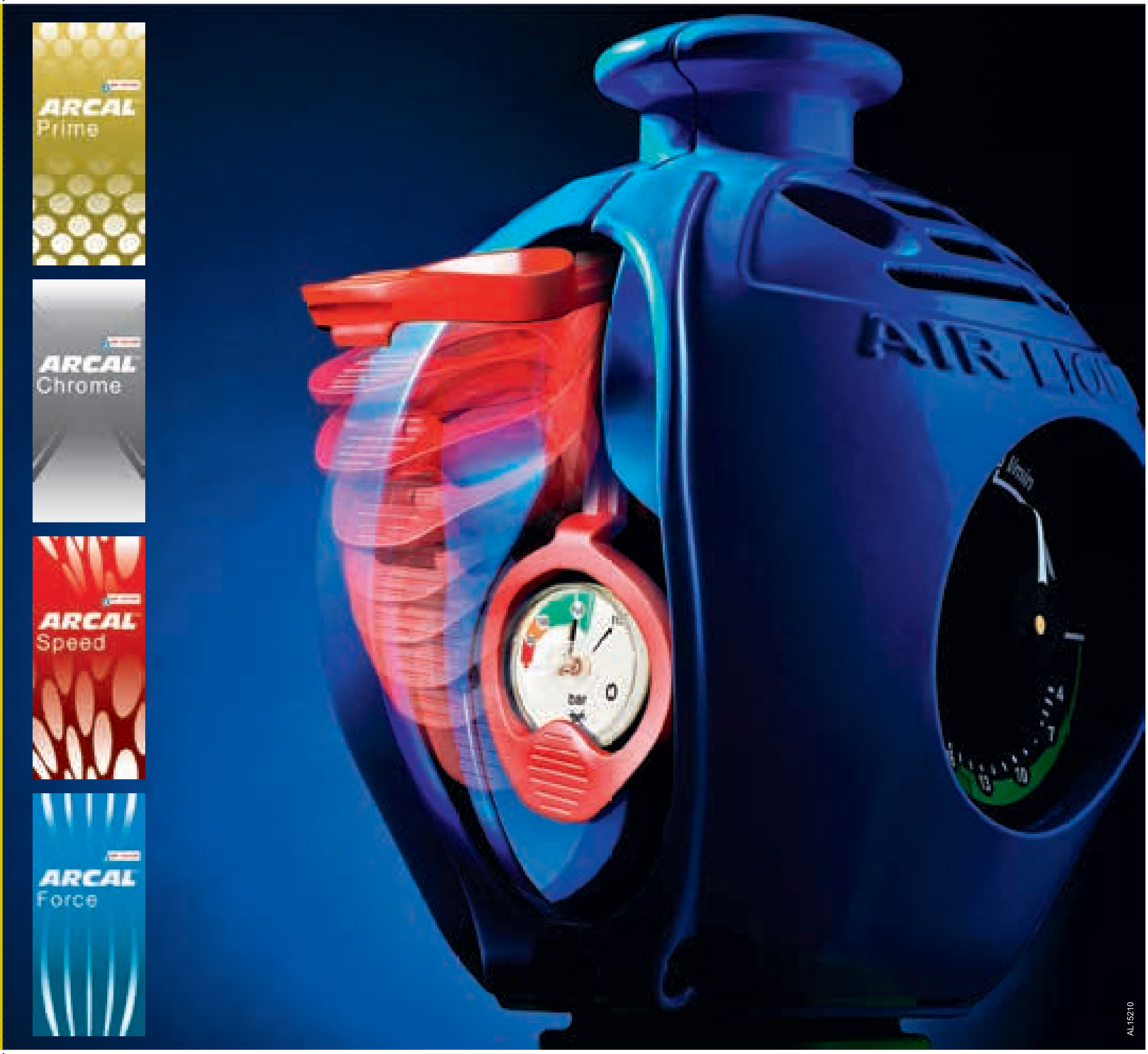

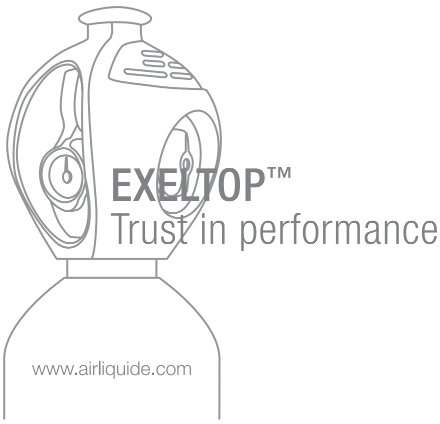

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process also eliminates the need for any back grinding.

AGW for the horizontal seams

An automatic girth welding (AGW) system from All Time in China is used to weld the horizontal seams between completed rings of strakes. "This is a submerged arc technique specially developed for welding horizontal girth welds of large tanks. The whole AGW system, which carries all of the welding equipment and two operators, travels around the outside of the tank to weld the long horizontal seams.

"Driven by dc motors, the AGW welding station is driven around the tank shell to close the seams between strakes. A specialised flux belt is used to support the granulated flux around the outside of the strake while welding proceeds. The end result is a butt-joint completed in the 2G position – a horizontal seam on a vertical structure – generally completed from the outside only," Bronkhorst tells *African Fusion*.

Again highlighting the advantages of the jack-up system, he says that the carriage rests on wheels against the shell and is driven from a ring system around the tank base. "If jacking up, cranes are not required to move the AGW welding system as it is supported on the ring at ground level – and all the seams are welded at about the same height. If constructing the tank from bottom up, then the cart would have to be driven off the top at increasing height. This has safety, wind and logistical implications that all complicate the process and add to overall costs.

"From a quality point of view, all of the inspection can also be done at the lower level and any repairs completed immediately, before jacking up," he adds.

Doing the comparison between AGW and SMAW, Bronkhorst says: "Using 4.0 mm electrodes, about 1.9 kg/h of material can be deposited and a 350 mm electrode can, perhaps, complete 250 mm of welding per electrode. On a 37 m diameter with nine rings of strakes and a circumference is 116 m, there will be 580 stop-starts for each welding pass on each section. Each ring will have 5 220 stop-starts per pass and, if we take an average of four passes per seam, that amounts to over 20 000 stop-starts on the horizontal seams before the tank is completed," Bronkhorst informs *African Fusion*.

Repeating the three factors governing success: time, quality and cost, he argues that every stop-start when using a stick electrode takes up time in blending the weld bead via grinding. The quality is affected due to discontinuity risks and because of skills shortages and the inconsistency of manual welding. Also, time costs money and non-welding activity such as grinding or repairing a discontinuity adds to the project cost.

"By using the AGW process, we can complete a full 360° girth weld without stopping. Productivity-wise this cannot be compared to the manual process. It is at least 20 times faster. And while it is associated with a little more capex, the investment is a 'no-brainer' relative to the contract completion costs," he says.

Overcoming challenges in Africa

From a skills perspective, Bronkhorst says that it used to be possible to take trained and experienced specialists from South Africa, China or Europe to a project in Africa. "But everywhere you go now, local people have to be employed on the job and these resources generally require upskilling and training.

"For the construction of the tank farm in Beira, we were able to train six local operators, in-situ, and all of them passed the training course. The best and most experienced welders are not ideal for mechanised welding and they are better used elsewhere, anyway. All that is needed is someone who understands the process and the art of welding. The mechanised system takes care of the physical manipulation, allowing the operator to adjust for the inconsistencies and to monitor and control the welding parameters and quality," he says.

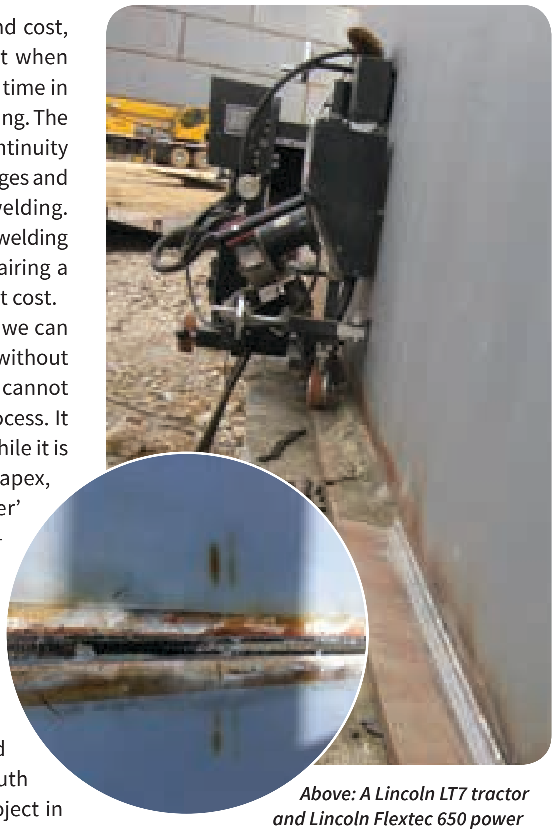
The quality and consistency of completed welds improves significantly and because of the more continuous nature of the processes used, project time improves and the costs drop.

In addition, the power draw of twenty welders in a tank versus two AGWs and an EGW working simultaneously is also favourable. "In Beira, a 600 kVA standby generator is available but the construction site is supplied by a 250 kVA transformer. In the past, the contractor told us, they needed a 450 kVA supply to power the equipment needed by all of the manual welders, their helpers and grinders," Bronkhorst adds.

Driving tank farm growth, he cites a growing need for fuel, oil and gas across Africa to support the industrial and infrastructure growth that is still taking place and is sure to accelerate. "Storage service providers are critical as links between exploration, production and downstream refining and marketing. This results in a growing need for more tank farms," he predicts.

"We at Renttech are proud to be an authorised distributor for All Time Welding's EGW and AGW welding systems. With our national footprint of 22 branches in South Africa, our growing pan-African presence and our extensive experience in the petrochemical industry, along with All Time Welding's customised products and experience in tank construction, we are in an ideal position to offer the latest and most appropriate technology to tank fabrication contractors.

"Renttech also understands the unique challenges that these projects present in Africa. With our rental offering, we have the capacity to equip sites with all the peripherals needed on construction sites and our internationally trained staff is available to ensure full technical support from planning to the completion of a project," he concludes.



Above: A Lincoln LT7 tractor and Lincoln Flextec 650 power source is being used to complete the floor-to-shell outside circumferential weld using the submerged arc process. The same equipment is used to weld the tank base. Left: A completed AGW weld on a 20 mm bottom strake.