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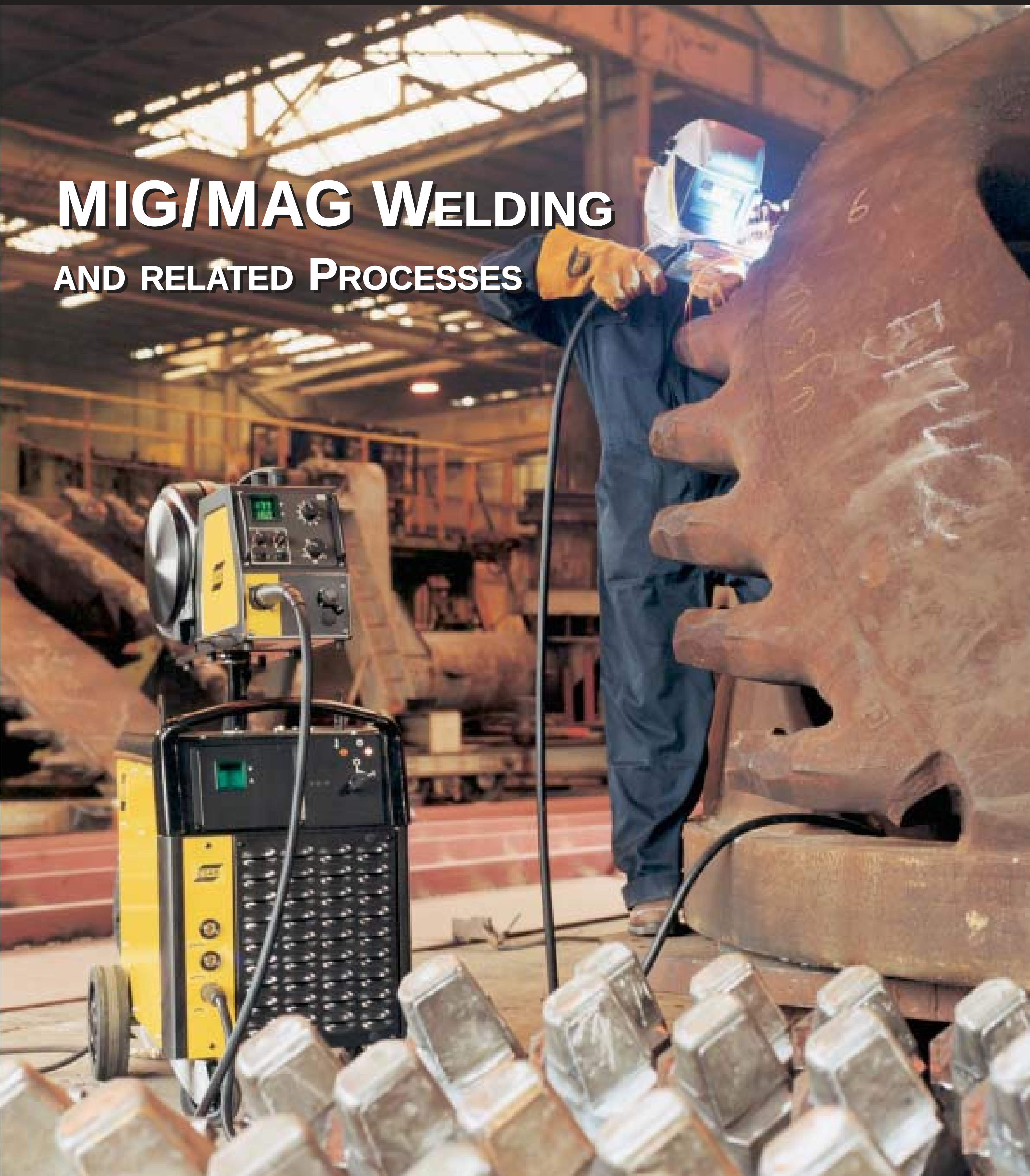
ESAB

THE ESAB WELDING AND CUTTING JOURNAL VOL. 58 NO.2 2003

MIG/MAG WELDING

AND RELATED PROCESSES



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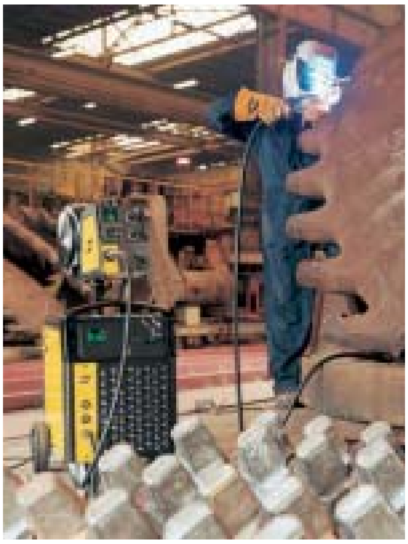

Cover photo courtesy Nista BV. Amsterdam, The Netherlands. MAG repair welding of cutter heads.

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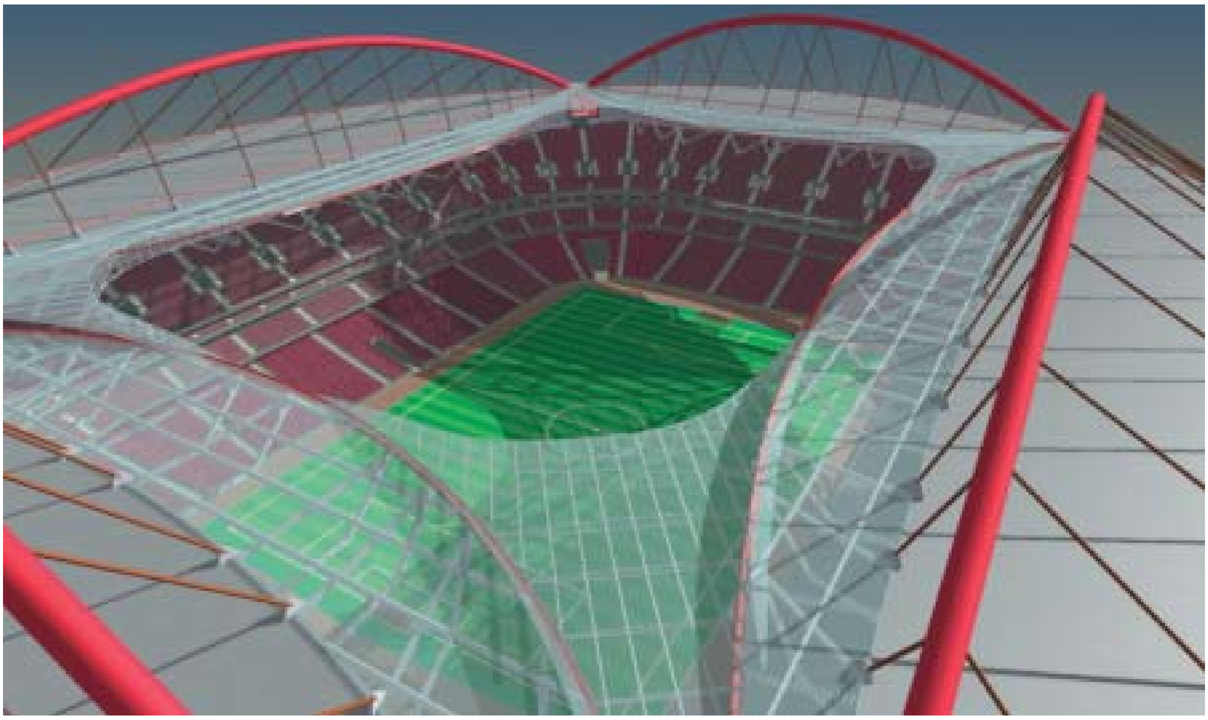


You'll never walk alone!

ESAB provides Martifer with welding and cutting technology for the construction of Euro 2004 soccer stadium.

By: Ben Altemühl, editor of Svetsaren.

Martifer, Portugal's largest metal construction company, and third in size on the Iberian Peninsula, is involved in the construction and renovation of stadiums for the Euro 2004 soccer tournament, of which the new Benfica stadium, Luz, in Lisbon, is undoubtedly the most impressive. ESAB Portugal provided Martifer with a complete, highly efficient solution for the robotic cutting and mechanised welding of 2m diameter and 40mm thick pipes.

Acknowledgement

We compliment our ESAB Portugal colleagues Jorge Lima, Sérgio Silva, João Henrique and Mário Cordeiro on their creative technical solution, designed and implemented under considerable time pressure. Their efficient teamwork symbolises the ESAB way of doing business, "your partner in welding and cutting".

Football and welding – not that far apart

From June 4th to July 12th 2004, it will be Portugal's turn to host the finals of the European soccer cup, that takes place every four years. As many as 50 countries have competed in the qualification rounds and, eventually, 15 made it to the finals to join Portugal in the tournament. Already, this soccer crazy nation is buzzing with excitement at the thought that they will be hosting the crème de la crème of Europe's players and that Portugal will be in the focus of the international sports media for almost a month.

The tournament – the world's biggest sporting event after the Olympics and the World Cup finals – will see 7 new stadiums being built and three others being extensively renovated. The project will cost around 550 million Euro, of which 20% is being paid by the Portuguese government and the rest by clubs and local governments.

Martifer is involved in four stadiums, two in Porto and two in Lisbon. ESAB welding products are a common sight at these construction sites but, technically, the most interesting is a tailor-made solution created for the construction of the new 'Èstadio da Luz', the Stadium of the Light, the home of one of Portugal's most famous clubs, Benfica. The new Stadium of the Light is being erected next to Benfica's previous, now demolished stadium in the north-west of the city. Already, four giant red arcs supporting the suspended roof, mark the skyline of that part of Lisbon.

These arcs required an intelligent cutting and welding solution, both for pre-fabrication and on-site assembly. After a fierce battle with the competition, ESAB Portugal won the welding and cutting contract for this prestigious project. ESAB's solution not only satisfied the high quality and

Figure 1. Two ESAB designed welding cabins at a breath taking height.

Figure 2. 24m long prefabricated arc sections waiting to be lifted in place.

safety demands placed on this public facility, but was crucial in providing Martifer with the speed of production that enabled them to meet the very tight project schedule.

Like a rainbow in the sky

Spectators lucky enough to witness the final or any other match in the Stadium of the Light, will be able to see the perfectly 'round' arcs like red rainbows in the sky. Television spectators will, no doubt, be offered an equally exciting zoom-in view at the start of the match. The eye is misleading, however. The arcs are not round but multilateral, consisting of many small pipe segments that are cut under a slight angle, and welded together – using ESAB technology.

To imagine that Martifer welders have been doing their high precision work in a cabin sliding over the arc as its construction proceeded (figure 1), sends shivers down my spine.

The majority of the welds were not made at high altitude, however. In prefabrication, six 4 meter long pipes (weighing 2 tonnes per meter) were joined to form a 24m long segment (Figure 2). In total, 41 of these segments had to be constructed within three months. A challenging piece of work!

Cutting

The 40mm thick pipes received a symmetrical X-bevel with a land of 3mm and a 30 degrees bevel angle, requiring three cuts, as shown in Figure 3. Two cutting processes were considered, oxyfuel and plasma cutting.

Cutting speed was obviously the predominant requirement, because of the very tight production time allowed by the stadiums' building schedule. In addition, a consistently high bevel quality was needed to enable efficient and defect-free welding with the planned mechanised welding processes for prefabrication and on-site assembly.

Plasma cutting is obviously the fastest process. For thin material, it can be up to 10 times faster than the oxyfuel process and the cutting quality is at least as good. There is a price tag attached to plasma cutting, however. Depending on the material thickness, it can be more expensive than oxyfuel cutting, and a return on investment depends on the price and complexity of the installation, and of course on the type of application.

In this project, the initial straight cut was in 40mm thick St 52-3, followed by two cuts through a smaller thickness under the bevel angle. Plasma cutting was calculated to be 2 times faster than oxyfuel cutting for the initial cut (Table 1), and three times faster for the complete bevel. A similar cutting economy was valid for the edge preparation for the on-site assembly welds. These could only be welded from the outside and therefore each prefabricated section received a 35 degrees V-bevel with a land of 2mm on both ends, for which two cuts were needed.

The bevel quality of a plasma cut is at least as good as an oxyfuel cut and has a smoother surface texture. It has the additional advantage that there is less dross (molten and solidified oxydes) on the edges. (figure 4).

A third advantage of plasma cutting is that there is no need for preheating, as with oxyfuel cutting, saving time and the cost of gas. With this solution, the tight production schedule could be met, justifying the higher investment needed.

The robotic cutting solution agreed by both ESAB and Martifer consisted of a PT 600 XLS plasma head and an ESP 400C plasma power source with programming box, supplied by ESAB Cutting Systems in the USA, mounted

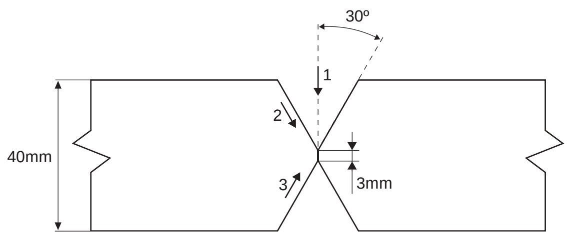


Figure 3. Symmetrical X-joint and cutting sequence.

Figure 4. Plasma cut X-bevel. Smooth surface and little dross.

on an industrial 6 axis robot. Special positioners for the installation were supplied by PEMA.
The installation acts on two different intelligence levels:

- The robot provides the 3-dimensional movement of the torch. Before the first cut, it reads the geometry of the actual pipe end and re-calculates the settings.
- The power source is pre-programmed with individual parameter settings for all three cuts.

The shielding gas was compressed air, the starting gas was N_2 and the cutting gas was O_2.

ESAB Portugal, assisted by ESAB Cutting Systems, installed and implemented the complete cutting solution within 60 days, including training of the operators. The cutting time per joint was about 30 minutes. Figure 5 shows a bevel being cut.

Prefabrication welding

For joining the pipes to 24m long sections in prefabrication, Martifer's existing column and boom station with single wire SAW head -applied for both the inside and outside welds – proved sufficiently productive to satisfy the production schedule. The flux/wire combination was ESAB OK Flux 10.71/OK Autrod 12.22, the most commonly applied consumables for this type of pipe application (Figure 6). Another industry that benefits greatly from the excellent welding characteristics of OK 10.71/12.21 is the fabrication of windmill towers. All welds were in the downhand position while the pipes were rotated on self-aligning 70 TAW Pema positioners. Figure 7 shows the joint design and bead sequence of the prefabrication welds. It took around 15 hours to complete each weld.

Assembly on site

Mechanised FCAW was chosen as the most dependable and productive solution for the assembly of the prefabricated sections at the Benfica stadium. ESAB supplied the welding equipment and assisted Martifer in the design of two welding cabins. Each cabin contained the following mechanised welding equipment:

- ESAB Railtrac FW 1000. Two tractors walking the circumference of the pipe from 6 to 12, clockwise and counter clockwise, over a rail attached to the pipe.
- 2 ESAB LAW 520 W water-cooled, heavy duty power sources.
- 2 MEK 4S wire feeders.
- 2 water-cooled PSF 410W torches.

The LAW 520 is a thyristor-controlled machine with very good characteristics for FCAW. Welding parameters are stepless adjustable allowing excellent fine-tuning of the welding parameters.

FILARC PZ6113 all-position rutile-cored wire, diameter 1.2mm was chosen as the welding consumable for the mechanised welding, together with the basic stick electrode OK 48.00 for the manual welding of the root run.

PZ6113 has excellent welding characteristics in all positions when welding upwards from 6 to 12 o'clock. The fast freezing slag supports the weld pool well and the soft and stable spray arc is very tolerant for irregularities in the path of the welding arc. The slag is always easily removed; well within the time that the tractors need to travel back to the 6 o'clock position. This allows the duty cycle to be as high as possible. The wire is welded in Ar/20% CO_2 mixed gas.

One parameter setting (190A/24V) was choosen for all beads throughout the joint, being the optimal setting for the most critical position between 4 and 5 'o clock. The travel speed varied as the filling of the joint proceeded, from 31cm/min. for the hot pass to 17cm/min. for the cap layers. The weaving width gradually increased to a maximum of 20-25mm. This is easy for the welders. They do not have to re-adjust parameters during welding, so there is no inherent risk of welding defects. Figure 9 shows the joint design and the positioning of layers and beads.

The equipment and the welding procedure was tested and accepted on a mock-up installation in the factory before being applied on-site. Still, the conditions 90m high above the stadium are not the same as in a comfortable workshop. ESAB specialists dedicated considerable time to

Figure 5. Cutting of a bevel edge.

	Thick-ness (mm)	Cutting speed (mm/min)	Cost difference oxy/plasma per meter	Cost/kg
OXYFUEL	40	420	3.87 €	0.56 €
PLASMA	40	940		0.53 €

Table 1. Cost comparison between oxyfuel and plasma cutting for the initial cut in 40mm wall thickness pipe. Plasma cutting is faster and cheaper. Triple torch oxyfuel cutting was considered, but was not easy to achieve for round profiles.

the fine-tuning of the welding parameters when depositing the first production welds. The changing angle of the girth welds along the circumference of the arc presented a particular problem, because of the changing action of the gravity on the weld pool. The solution was to apply a different weaving pattern for the most extreme locations.

In total 40 welds were produced to complete all four arcs. One weld took 1.5-2 days, including 6 hours of preheating to 150°C. The work in the two cabins proceeded 24 hours a day. All welds were 100% non-destructive tested. In prefabrication, the welds were X-ray tested and, in assembly, US testing was applied.

Martifer Group, a solid alliance

Martifer holds a strong position in the civil construction sector. It was founded in 1990 and has since expanded to become Portugal's largest metal constructor, specialising in shopping malls, sport stadiums, bridges, public housing and factory halls. The Martifer group incorporates five companies; Martifer, Martinox, specialised in stainless steel structures, Martifer Aluminios (glass facades) and the international initiatives Martifer Spain and Martifer Polska.

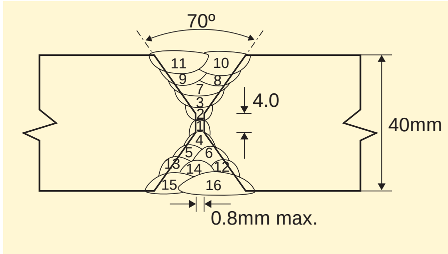


Figure 7. Joint design and bead sequence for sub-arc welds in pre-fabrication.

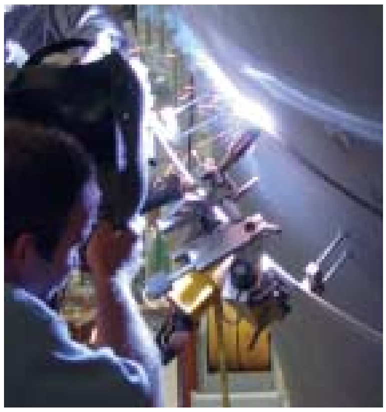


Figure 8. FCAW with FILARC PZ6113 and Railtrac FW 1000.

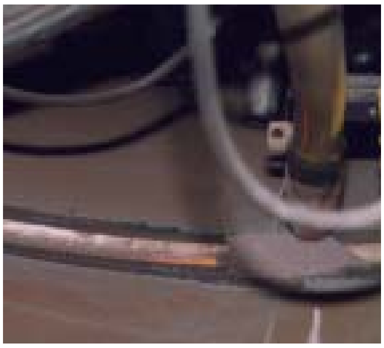


Figure 6. Single wire SAW with OK Flux 10.71/OK Autrod 12.22. Inside weld.

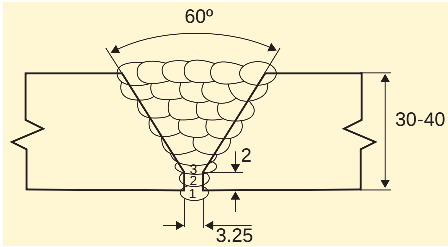


Figure 9. Joint design and bead sequence of assembly weld.

Stub-ends & Spatter

Fireman in heart and soul

The types of industry to which ESAB supplies its welding and cutting products vary from the smallest workshop to vast industrial enterprises like shipyards and automobile production centers. The company Luis Figueiredo SA in Cacia, Portugal could be typified as "small but beautiful".

Today it builds a range of trailers and special vehicles, but the company was founded when the owner turned his hobby, fire fighting, into profession. Luis Figueiredo has had a fascination for fire fighting since his youth and he was predestined to become a fireman. During his many years of service as a fire fighter, he developed an opinion of his own on how fire engines should best be built and equipped. It was 21 years ago, when Luis decided to bring his ideas into practice and started building the trucks that are nowadays in service at fire stations all over the country.

The fabrication principle has remained the same over the years. The chassis and cabin are bought in, but from there the fire engine is build up completely according to the ideas of Luis Figueiredo. A lot of welding is involved to fabricate the many components in steel, stainless steel and aluminium.
ESAB has been with the company ever since the beginning, represented by its distributor Unisolda. Over the years, sales engineer Alvaro Silva of Unisolda has earned a reputation throughout the company for his valuable support and advice.

Luis Figueiredo remains a fireman in heart and soul. 53 of age now, he is still member of the voluntary fire brigade.

AristoRod™ and MarathonPac™

take MAG welding productivity to new levels

By Per Sundberg, ESAB AB, Gothenburg Sweden.

OK AristoRod copper-free MAG wire is a recent ESAB innovation. Together with various MarathonPac bulk packaging options it makes a team that is hard to beat.

AristoRod™ A new generation of copper-free MAG Welding wire.

New OK AristoRod wires are given the unique copper-free ASC (Advanced Surface Characteristics) surface treatment, an important ESAB development. With this technology, ESAB is the first to produce bare wires with welding characteristics that are at least as good as those of the best copper-coated wires in the market – but with superior feeding properties.

Traditionally, the copper coating on MAG welding wires performs important functions. It lubricates the feeding process, improves the current transfer and protects against corrosion during storage. But the use of copper also has its downsides. The gradual build-up of copper dust and flakes can cause clogging in the feed system and lead to increased spatter and poor weld finish and, eventually, to a complete breakdown of the welding process. Regular maintenance and cleaning of the feed system is absolutely necessary to avoid feeding problems. However, this is time consuming and particularly costly when it concerns downtime of mechanised or robotic welding systems.

By removing the dust and flaking associated with copper, ESAB has removed the biggest contributor to the clogging of guns and liners and, with it, a major cause of production stoppages and increased cleaning schedules. In addition, greater arc stability results in less spatter, improved weld quality and finish and, consequently, in reduced weld cleaning.

The good feeding properties brought about by ASC are exemplified by the feed force diagram, figure 1, resulting from feeding force tests with OK AristoRod and high quality copper-coated wire. The steel liner had a length of 4.5m and contained a loop of 300mm diameter. The suppressed areas show the margins observed during the 30 min. test. In feeding, a constant and preferably low feed force is beneficial. The diagram shows that feed force variations are much higher for copper-coated wire than for OK AristoRod.

Contact tip wear is also a feature of the past. This characteristic, always associated with earlier generations of copper-free welding wire, does not apply to new AristoRod wires. ASC results in the lowest possible tip wear, comparable with the best copper-coated wires available.

ASC also minimises the risk of corrosion during extended periods of storage.

The absence of copper on the wire brings yet another advantage. The amount of copper in the welding fume is reduced to an absolute minimum (figure 2), helping to satisfy concentration limits in the work environment – even better than copper-coated wire. This contributes to improved working conditions for the welder, along with other necessary precautions such as adequate fume extraction.

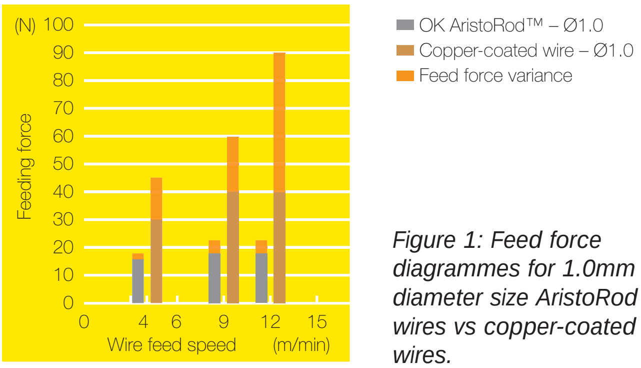


Figure 1: Feed force diagrammes for 1.0mm diameter size AristoRod wires vs copper-coated wires.

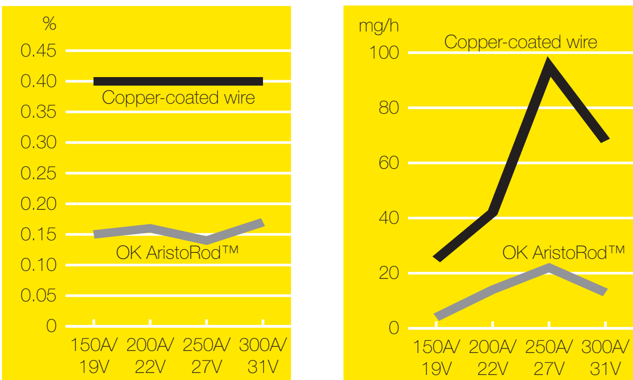


Figure 2: Quantity of copper in welding fume.

AWS and EN classifications.

Product	Classifications Wire		Classification Weld Metal	
	AWS A5.18	EN 440	M21	C1
OK AristoRod™ 12.50	ER70S-6	G3Si1	G 42 3	G 38 2
OK AristoRod™ 12.57	ER70S-3	G2Si	G 38 3	G 35 2
OK AristoRod™ 12.63	ER70S-6	G4Si1	G 46 3	G 42 2

Table 1: The AristoRod range.

OK AristoRod

Better performance at every stage of the welding process:

+ Low contact tip wear means fewer replacement stops.
+ Less spatter due to better arc stability.
+ Consistent feedability means improved production speed.
+ Lower feed force required for long distance feeding.
+ Fewer maintenance stoppages due to absence of dust and flakes in liners.
+ Reduced weld fumes means a better work environment.
+ Improved corrosion protection aids extended storage.

It all adds up to better overall productivity.

MarathonPac™ – "endless" wire feeding

For many ESAB customers, MarathonPac is a key element in maximising production efficiency. In fact MarathonPac can cut downtime on spool changes by almost 95%.
MarathonPac bulk packs are charged with either 250 or 475kg of welding wire. A new development is the endless version, combining the contents of a series of Pacs to form a continuous online supply source. As each drum empties, the next drum takes over and a new drum is added to form an uninterrupted supply.

Perfect delivery to the welding head. The special coiling technique used in packing the drum ensures that the OK AristoRod™ wire is never twisted, warped, or causes arc wander. Welds are always well positioned and perfectly straight. The unwind process from the drum is automatic, so no separate de-coiling equipment is needed and no forces are required to turn a traditional revolving spool.
MarathonPac™ is supplied in octagonal cardboard drums which can be folded flat after use for easier recycling. The high quality board can also fetch a price premium in the recycling market.

AristoRod and MarathonPac – the ultimate combination to boost welding productivity

AristoRod and MarathonPac form a combination that is hard to beat when it comes to welding productivity, not only for mechanised or robotic applications but also, increasingly, for manual welding. Many fabricators, in various sectors of industry, recognise the enormous benefit it brings to their fabrication efficiency. Suppliers to the automotive industry have identified many applications where the dependability of the welding process is essential for satisfying just-in-time delivery shedules. It is not surprising that the first users of the recently introduced Endless MarathonPac concept are found within this industry, where any improvement in downtime of the welding systems translates directly in lower cost per piece.

About the author

Per Sundberg E.W.E., BSc. Material Science, joined ESAB in 1996 as Development Engineer Consumables. He is currently Group Product Manager for low- and unalloyed solid wires.

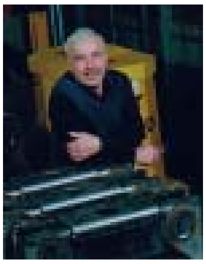
Automotive fabricator VBG embraces AristoRod welding wire

The VBG Group, a Swedish-German co-operation, develops, manufactures and markets trailer couplings and associated equipment, anti-skid devices and dropside pillars for heavy vehicles, as well as shaft-hub connections and friction springs for the machine industry. The group has production sites and sales offices in Sweden, Denmark, Germany, Norway and in the USA.

VBG, Värneborg

The VBG production site in Värneborg specialises in the serial fabrication of drawbeams for heavy trucks over 16 tons, and supply manufacturers such as Volvo and Scania. Two IRB 6400 robots, programmed for the various types of drawbeams and equipped with ESAB LAE 800 heavy duty power sources, are crucial for the highly efficient assembly welding of these high-safety components. The robots run 24 hours a day and only stop for scheduled maintenance.

VBG Production Manager Roger Johansson:



"We are very pleased with the performance of the new wire. Copper-coated wire has always performed well for us, but you cannot underestimate the importance of keeping the liners and guns clean and free from the build-up of copper dust, otherwise you’ll pay the price. Imagine the productivity loss you’ll get in serial fabrication when you have to repair weld defects caused by arc instability, not to mention the disaster when the whole system breaks down.

ESAB supplies their wire in 475kg JumboPac drums and we only have to clean our welding system once, when the drum is empty and we have to stop anyway. The copper-coated wire we had before was of a good quality, but we had to clean the system four to five times per drum to avoid feeding problems. This brought a loss of productivity that we can now avoid."

Perfect delivery to the welding head. The unwind process from the drum is automatic with no feed forces required to pull the wire as with a traditional revolving spool. Photo courtesy VBG

Saipem's Blue Stream Project:
a daring piece of engineering establishing new records

Translation of an article by Ferruccio Mariani and Francesco Vago, ESAB Italy, first published in the Italian Welding Journal, Revista Italiana della Saldatura, January/February 2003.

In many feats of engineering, human genius has taken technology to new levels. The Blue Stream pipeline, that now symbolically unites Russia and Turkey across the 2km deep Black Sea, is a classic example. It was created by Saipem, making use of new welding techniques developed in collaboration with ESAB.

Introduction

New records are set to be broken. This particularly applies in engineering, although the general public may not always be aware of it. The longest bridge, the tallest skyscraper or the fastest train would generally be publicised by the mass media. But, some equally daring projects, requiring just as much, if not more technological effort and creativity, pass unnoticed, simply because they do not hold any public appeal.

The Blue Stream project is one of them. It passes through the Black Sea at an absolute depth record of 2200m – or 2 kilometres and 200m! The complexities involved in the construction of this hidden energy highway, connecting the Russian and Turkish gas infrastructures, were enormous. How, for example, do you lower a pipeline from a barge 2km deep onto the seabed? How do you dig a trench at this depth and, even more interesting, how do you get the pipeline to end up in the trench? Taking everything into consideration, the development of suitable MAG welding procedures for the special 'on board' welding machine, carried out for Saipem by ESAB, was probably the easiest part of the project!

Figure 1. The gas pipeline route

The Saipem 2000 lay barge.

Saipem

Saipem, a construction company within the Eni group created in 1969, is a large international enterprise supplying to the oil industry. It is an ISO 9001 certified company working on five continents, active in drilling, production and transportation of oil and gas, both on- and offshore. Owning some of the most technologically advanced vessels and a highly qualified workforce, it is able to respond to the oil market's most difficult challenges (deep water, extreme environments). One sector in which Saipem excels is the installation of underwater oil and gas pipelines at great depths, often between different countries.

Welding is a crucial technology for Saipem. The company has a long-standing relationship with ESAB as a welding partner that has resulted in collaboration on many major engineering projects.

Blue Stream

The Blue Stream pipeline project runs from Dzhubga on the Russian coast through the Black Sea to Samsun on the Turkish coast, and on to Ankara (Figure 1). The objective of this new line is to boost the supply of methane gas to Turkish industry and households. A 50/50% joint venture – the Blue Stream Pipeline Company (BSPC) was created between GAZPROM and SNAM, specifically for the project. Saipem was appointed as the contractor for the project.

The most challenging part of the project was the 385km double subsea pipeline. Saipem deployed two in-house designed lay barges: the Castoro Otto for operation in shallow waters; and a special vessel, the Saipem 7000, for service in deep waters (see introduction photo). The latter is fitted with the so called J-Lay system by which the pipeline is lowered vertically into the sea (Figure 2). This

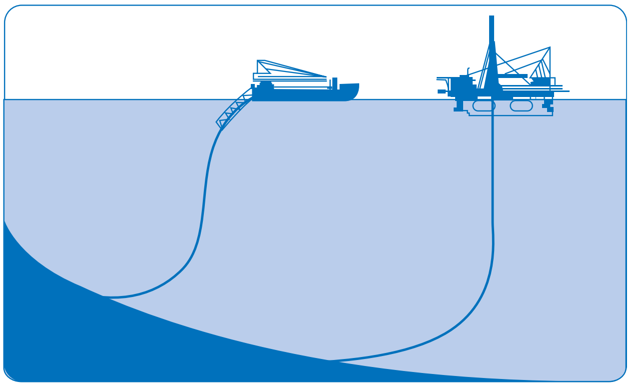


Figure 2. S-laying and J-laying techniques.

Pipeline specifications

• Thickness	31.8mm
• Base material	API 5L X65
• Total length	770km
• H_2S content	1,200 ppm at PH min 6.7 (on seabed)

Weld requirements

• Yield Strength	>528 MPa
• Hardness	<248 HV10
• CVN impact toughness	45J min / 60J average at –30°C
• CTOD	0.2 min/ 0.25 average at –10°C

Table 1. Pipeline specifications and weld requirements.

technique is vital in deep waters to avoid the dangerous situation when the weight of a few kilometres of pipeline rests on one side of the barge – as would be the case with the traditional S-laying technique.

The J-Lay system requires the Saipem 7000 to be equipped with a 135m high tower, to accommodate the 48-meter pipe sections (diameter 20”/wall thickness 31.8mm) that are pre-fabricated (quadruple joined) in a special custom-built plant in Samsun.

Figure 3 shows the Saipem 7000 passing under one of the two bridges spanning the Bosphorus. Two on-board cranes had to be completely dismantled to give at least 5 meters clearance under the bridges.

Another gem of technology is the Beluga, a robot controlled from the surface that is attached to the pipeline by means of a roller system. It digs the trench and buries the pipe 5m deep in the sea bed.

Welding demands steadily increasing

Over the years, pipeline diameters and wall thicknesses have gradually increased to meet the demands of Saipem’s clients for higher capacity. At the same time, subsea pipelines have been laid at greater depths and exposed to higher pressures, lower temperatures and more corrosive environments. Accordingly, the mechanical and corrosion requirements for the welds have been stepped up, as have the requirements for defect free welding.

Against this background, ESAB supported Saipem in the development of productive systems for high quality welding in pre-fabrication and on site, on board of the Saipem 7000.

Offshore pipeline specifications and the derived weld requirements are given in table 1. The CTOD requirement, together with the high wall thickness, is less common in onshore pipeline fabrication. It places special demands on the microstructure and the purity of the weld metal. In addition, the weld metal had to pass stress corrosion cracking tests, because of the presence of H_2S in the gas to be transported.

Prefabrication

In pipe pre-fabrication, standard 12-meter pipes are joined using submerged arc welding to produce 48-meter sections (figure 4). The photograph shows the welding portal with two ESAB twin-arc heads.

To meet the special mechanical requirements and provide the best possible welding productivity, ESAB developed a new cored wire for (twin-arc) submerged arc welding. The OK Tubrod 15.28S is a basic cored wire alloyed with 0.8%Ni and 0.3%Mo that satisfies the mechanical requirements, including CTOD, when used in combination with OK Flux 10.61. In addition, superior welding economy is achieved, compared with solid wire. The cored wire/flux combination allows the deposition of thicker beads at higher melting rates, substantially reducing the number of runs needed to fill the joint. Wires were supplied in MarathonPac bulk drums – ideal for highly automated welding processes.

The wire/flux combination has the AWS classification A5.23-97 F8A6-EC-G.

On-board welding

On-board Saipem 7000, prefabricated 48-meter pipes are joined and lowered onto the seabed. Saipem developed its own state-of-the-art technology for welding the pipes in PC (2G) position. The advanced welding machine, known as Presto, consists of a carousel with six specially designed Aristo power sources, six wire feeders and three tandem GMAW heads that weld simultaneously (figure 5). The carousel turns around the pipe at the same speed as the welding heads that move along a rail. An internal clamp, with an incorporated crown of copper shoes, is lowered into the pipe to provide the backing for the root pass.

Figure 3. The Saipem 7000 passing under a bridge over the Bosphorus.

The whole process is fully automatic. Parameters are preprogrammed in the control system for each head and for every individual run, including the weaving width.
This welding system has allowed Saipem to weld at a superior productivity level and with a defect rate that is practically zero.

ESAB supplied the Aristo power sources, selected for their excellent arc characteristics, their ease of programming and their reliability. The solid welding wire used was OK Autrod 12.66 – another wire specially developed to satisfy the mechanical demands of this project. ESAB developed the welding procedure specifications and conducted the mechanical tests for the procedure qualification.

Table 2 gives the minimum values of mechanical properties determined on production test samples. They are well above the minimum required levels required in table 1.

• Yield	>540 MPa
• Hardness	<240 HV10
• Strength	>70J average at –30°C
• CTOD	>0.5 –10°C

Table 2. OK Autrod 12.66. Minimum values for the mechanical properties observed in production tests.

Figure 4. The submerged arc welding portal with two ESAB twin-arc heads.

About The Authors:

Ferrucio Mariani joined ESAB in 1991. He has a background in metallurgy and welding engineering. Today he is Marketing Director Consumables for ESAB Italy.
Francesco Vago joined ESAB in 1999 as Automation Product Manager, a position he still holds. He has a background in electrical engineering. During the Blue Stream Project he was responsible for equipment design and development.

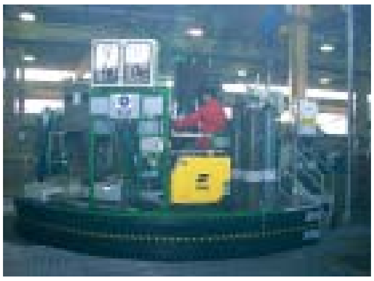


Figure 5. The Presto welding machine in development

Stub-ends & Spatter

Van Hool happy applies new ESAB stainless steel MIG wire

The internationally renowned bus and trailer manufacturer, Van Hool, in Koningshooikt, Belgium, is pleased with ESAB's new matt surfaced stainless steel MIG welding wire. It ensures that Van Hool's robot stations have the problem-free feeding needed for the serial fabrication of frames and other chassis components. MarathonPac bulk packaging is another 'productivity raiser' for Van Hool, by limiting the downtime for wire spool changes to an absolute minimum. ESAB's new matt surfaced stainless steel MIG welding wire, on 16kg spools, is used throughout the production process for the manual fit-up welding of stainless steel buses. Welders are very positive about the new wire's welding properties. In combination with ESAB push-pull guns, it has resulted in the complete absence of feeding problems.

Essential Variables for MIG Welding Aluminum

By George Rowe – AlcoTec Wire Corporation

Influencing factors in the MIG-welding of aluminium.

The high quality MIG-welding of aluminum is a much more sensitive operation than the welding of some other more common materials, mainly due to aluminum having very different physical characteristics, such as its thermal conductivity. To achieve necessary levels of repeatability, all variables in the process must be carefully considered.

An everyday analogy would be the production of high quality photographs, where type of camera, lens used, filters attached, film speed and make, type of lighting, subject composition, camera settings, depth of field, and processing, can all make a profound difference to the end result of a photograph.

A change in any one of the MIG-welding variables, when transferring established data, may produce an adverse effect on the finished weld characteristics and quality.

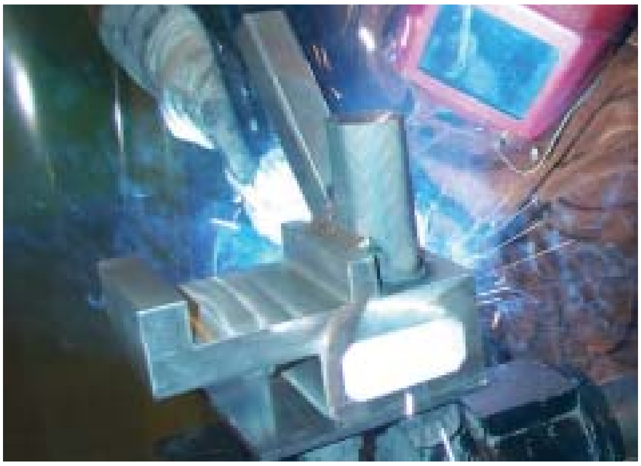


Figure 1. The author MIG welding a thick 6xxx series (Al/Mg/Si) extrusion using a 5356 (5%Mg) filler alloy and high current spray transfer settings.

Welding power source

Many different types of power sources may be encountered, and the assumption could be made that they should all provide the same results as the power source used to establish the initial welding data. This assumption may be incorrect. Welding parameters established with one type of power source may not necessarily provide the same welding characteristics with another.

The range of power sources can include DC rectifiers, constant voltage or constant current, DC inverters, pulsed self-created programmed systems, and pulsed synergic systems preprogrammed by the manufacturer. Another area of concern is that voltage and current meters installed on the power source equipment are, often, not calibrated. This may result in misleading data being provided.

Wire feeders

If digital read-out values of the wire feed rate is provided as part of the equipment, it may be advisable to verify their accuracy, as large variances have been recorded on some equipment when using calibrated external reading devices for verification. This situation strongly suggests the need for using external calibrated equipment in order to verify the wire feed rate, as even small differences in this variable, can produce changes in the welding characteristics that are unacceptable for aluminum welding.

Another area of concern relating to wire feeders is the equipment's ability to consistently feed the spooled aluminium welding wire when MIG welding, without interruption, during the welding process. Feeding is a far more significant issue with aluminum than steel and is probably the most common problem experienced when moving to MIG welding of aluminum. This is primarily due to the difference in the mechanical properties of the materials. Steel welding wire is comparatively rigid and can withstand far more mechanical abuse. Aluminum is softer, more susceptible to being deformed or shaved during the feeding operation, and, consequently, requires far more attention when selecting and setting up a feeding system for MIG welding.

Feeding problems often express themselves in the forms of irregular wire feed or as burn-backs (the fusion of the welding wire to the inside of the contact tip). In order to prevent excessive problems of this nature, it is important to understand the entire feeding system and its effect on aluminum welding wire.

Starting with the spool end of the feeding system, the brake settings should be considered, first. Brake setting tension is required to be backed off to a minimum. Only sufficient brake pressure to prevent the spool from freewheeling, when stopping welding, is required. Inlet and outlet guides, as well as liners, which are typically made from metallic material for steel welding, must be made from a non-metallic material such as Teflon or nylon to prevent abrasion and shaving of the aluminum wire.

Drive rolls should have a proper U-type contour with edges that are chamfered not sharp, be smooth, aligned, and have correct drive roll pressure. Excessive drive roll pressure can deform the aluminum wire and increase friction drag through the liner and contact tip.

Welding guns

Length of gun cable assemblies can produce a voltage drop. Contact tip internal diameter and quality are of great importance. If the internal diameter is too large, and there is too much clearance between the wire and the contact tip, arcing can occur. Continuous arcing inside the contact tip can cause a buildup of particles on the inside surface of the tip, which increases drag and produces burnbacks. Contact tip design can affect electrical conductivity and resulting arc characteristics.

Shielding gas supply

Back pressure values need to be taken into account when supply lines are run over long distances. Differences with these values can have an effect on arc characteristics, especially with respect to aluminum-silicon filler alloys AlSi. If the shielding gas is supplied through bulk liquid delivery systems, then all conditions are basically similar. However, this is not necessarily true with cylinder supply of argon gas.

Aluminum filler alloy

Surface condition should be free of slivers, tears, cracks, seams and laps that are able to entrap impurities. These surface conditions can introduce impurities during welding, which in turn can change the arc characteristics and result in remarkably different weld results. Also, actual wire diameter can vary from spool to spool depending on the manufacturers production system. A change in wire diameter, even within the manufacturing specification allowable range, can produce very significant differences in wire cross-sectional area. These differences in wire diameter can relate to extremely different welding characteristics and the potential for major welding discontinuities. This problem is most serious on robotic or mechanized applications. Wire cast and helix can also have an effect on arc conditions.

Base material surface condition

Oxide thickness can vary from part to part depending on method of storage or heat treatment. Areas of a work piece that have had direct and lengthy exposure to water and that show a white staining will produce an erratic arc when welded. Aluminum oxide should be removed prior to welding in order to prevent its interference during the welding process and its potential for causing weld discontinuities.

Arc length

Due to the high thermal conductivity of aluminium materials, additional energy is gained from the velocity or kinetic energy produced by the force of the droplets impacting the weld pool and base material. Although these distances may appear very short, slight changes will have a significant effect on heat input that may produce lack of fusion or lack of root penetration discontinuities. The usually recommended distance of 12 to 15 mm is a reasonable degree of tolerance. By increasing this distance, the focal area on the base material that is being impacted by the droplets is increased, and the distance that the droplet travels will increase with a consequent reduced velocity and final energy being delivered to the weld pool. Care must be taken when changing gun angles or changing the position of the gun on the circumference of rotated tube, pipe or tank fabrication as this can significantly affect the actual arc length employed.

Aluminum welding requires that the contact tip is recessed into the gas nozzle. A recess in the range of 3mm to 8mm, depending on the voltage in use, is reasonable, i.e. low voltage work requires a short recess (17 to 21 volts), conversely high voltage work, (22 to 30 volts) requires a long recess. It is, therefore, important to monitor and record this variable as this will affect the arc length and the energy being delivered to the base material.
For example, if procedure data is developed with a contact tip recess of 3mm and actual production work is using a 8mm recess, one would expect a different result.

Alloy type

Weld data developed on one alloy may not apply for another. This is due to the great differences of thermal conductivity values for the different materials. An example of the range is as follows.

AA 1100	1540 BTU	AA 5083	810 BTU
AA 3003	1340 BTU	AA 6063	1510 BTU

It can be seen for example that AA6063 would require very different weld parameters than AA5083 with the former requiring far greater heat input. When welding dissimilar grades to one another this needs to be taken into consideration.

Heat sink value affecting weld conditions

Weld data on one set of geometry will not necessarily work for another even if they may appear to be similar. When welding different section thickness, the thicker aluminum sections require significantly more heat to effectively weld. Applying procedures designed for thin materials can result in weld discontinuities if applied to thicker sections. Special care is required when designing welding procedures for joints between sections having large differences in sections.

Local environment and base material temperature

For the robotic and mechanized welding of production components, the base material temperature can have an effect on the start of the weld. Conditions developed at a local workshop temperature of 22 ºC could be different to that if the temperature was 12 ºC, for example. On large complex components requiring significant welding time, the base material may see a gradual increase in temperature. As the part gets hotter, welding conditions may require a change to accommodate this increase.

Figure 2. The author welding a thin heat exchanger made of 3xxx series (aluminum/manganese) with pulse spray and 4047 (12% Silicon) filler alloy… a very different welding procedure than that used in fig 1.

About The Author:

George Rowe is a welding specialist at AlcoTec Wire Corporation in Traverse City, Michigan, USA. He is responsible for coordinating the laboratory section of the AlcoTec Welding Technology School. George is an American Welding Society Certified Welding Inspector (CWI) and has previously held certification for ASME Boiler and Pressure Vessel Inspection.

Szczecin Yard making comeback

Re-opened Polish shipyard bolstered by success in building the world's largest duplex stainless steel chemical tankers.

By Dariusz Wojtaszewski, ESAB Sp.zo.o.,Poland, and John van den Broek ESAB B.V., The Netherlands.

The Bow Star, the second of six 39,500 dwt duplex chemical tankers to be build by Stocznia Szczecinska Nowa.

After a painful episode of bankruptcy and massive lay-offs, the Szczecin shipyard is making an impressive come-back under its new name Stocznia Szczecinska Nowa. It is now controlled by the Polish State who took over financial responsibility in an attempt to rescue the shipbuilding activity which is of great economic importance to the Szczecin region.

The new management has carried through a drastic modernisation of the yard's organisation and work routines, to make it competitive again and secure the jobs of its 3,000 direct workers and the interests of its many suppliers in the region.
The Norwegian shipping company Odfjell has been crucial to the revival of the yard by extending its existing order from four to six 39,500 dwt duplex chemical tankers, with an option for two more vessels. The first ship, The Bow Sun, has recently been delivered to its owner, the second one is now being assembled in dock and is due for delivery late 2003, and the third one is in the pre-assembly stage.
The yard has a new lease of life in today's highly competitive shipbuilding market. Not so long ago, however, the future looked grim when the production of the Bow Sun came to a complete standstill due to the occurrence of weld cracks.

How crucial can welding be to a shipyard?

The problems occurred in 2000, during the assembly welding on the slipway, when the Bow Sun was nearing completion. At that time, a Greek shipping company owned the vessel. They had ordered four of these tankers and four more were ordered by Odfjell.
The vessel, the world's largest duplex chemical tanker, was being constructed under direct supervision of DNV. In accordance with the contract, all classification documents, including welding procedures, were approved by both classification societies involved – DNV and ABS.

The duplex stainless steel came from two different, well known manufacturers. The yard had decided to use all-position rutile flux-cored wire in the assembly of duplex structures on the slipway. At that time, ESAB was not involved in the supply of welding consumables.

The most severe cracking problems occurred while connecting the transverse separation walls of the tanks, the corrugated bulkheads, to the tank top (= bottom) of the duplex cargo tanks (figure 1). Figure 2 shows the joint fit-up and the nature of the cracks. End craters in the root pass formed the initiation point for hot cracks that ran through great lengths of the root pass. This was not an incidental defect that could be repaired, but a phenomenon that occurred persistently whatever the welders did to overcome it. At a certain point DNV took the dramatic decision to stop production on the slipway and requested to prepare corrective actions.

Figure 1. Corrugated bulkhead in the Bow Sun.

Improved or adapted welding procedures had to be found quickly. In a very practical approach, the yard invited various suppliers, including ESAB, to demonstrate welding procedures with their own consumables on test coupons with exactly the same joint preparation as the real weld and under the same full-restraint conditions (figure 3). The test coupons welded by ESAB Welding Instructor Arie van Cuijlenborg with OK Tubrod 14.27 all-position rutile cored wire, were the only ones that did not crack. This positive outcome was later confirmed by various test welds in the actual construction, using the same welding procedure that was optimised in every possible aspect (discussed further on). In principle, the method had been found to overcome the cracking problem, without the need to change the joint preparation, and ESAB offered to train the welders and supervise the welding.

Unfortunately, events had taken their own course. The Greek ship owner had opened a discussion around the geometry of the joint preparation, which had been worked out by the shipyard and was, initially, accepted by all parties – ABS, DNV, the ship owner and the suppliers. After a long period of discussions, the ship owner withdrew their acceptance of the relatively small groove angles, referring to relevant recommendations from consumables suppliers and duplex stainless steel manufacturers. After tough negotiations between the yard and the ship owner, it was finally decided to implement wider angles, in accordance with these recommendations.

They were only willing to accept the new welding procedure together with the correct joint preparation, not only for the welds between the bulkheads and the tank bottom, but also for all other joints identified to be under very high restraint.

This nightmare scenario had dramatic consequences for the yard. Many parts of the construction had to be dismantled and taken out of the slipway to receive a new bevel or to be replaced by new components. The slipway was blocked for a very long time and caused delay that led to the collapse of the yard when the Greeks finally cancelled their order.

So, "How crucial can welding be to a shipyard?". The plight of the Szczecin yard shows that welding knowledge, technology and skill are fundamental, not only for the shipyard itself, but for the whole economic activity in the region around a shipyard.

Stocznia Szczecinska Nowa

The intervention of the Polish State marked the beginning of a new era for the new Szczecin Yard, together with the extension of Odfjell's order to six chemical tankers, including the Bow Sun, which provided an economic basis for continuation. Under completely new management, from July 2002, Stocznia Szczecinska Nowa entered an impressive path of recovery. This period was marked by the urge to get the production of the duplex tankers moving again while, at the same time, carrying through a drastic reorganisation.

The disassembly of critical components from the Bow Sun, which had started under Greek ownership, was continued.

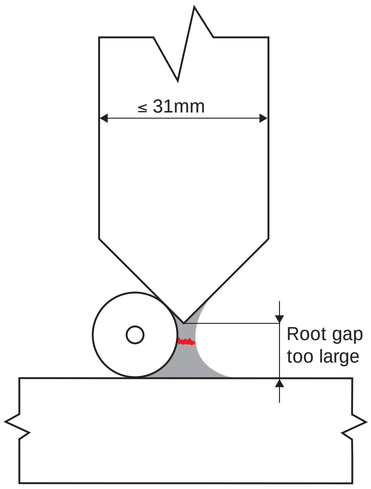


Figure 2. Joint fit-up and nature of the cracks.

Figure 3.Test coupons welded under full restraint.

Many components, including corrugated wall sections ordered and received for the second ship, were given a new bevel. At the same time, an impressive amount of new WPS'es with OK Tubrod 14.27 for the dock assembly was established in very close co-operation with ESAB, and subsequently presented to DNV for approval. DNV representatives played an important and helpful role in obtaining a set of reliable welding procedures.

The main objective of the reorganisation was to provide the yard with a cost-efficient, transparent and skillful organisation that could carry the yard into a new future. In this painful and complicated process, many workers had to be made redundant. The yard reduced from some 7500 workers, including many welders on temporary contract, to a staff of 3000 personnel that were identified to have the best skills for the new organisation.

The welding of thick-walled duplex stainless steel under very high restraint

The Bow Sun is the first in a series of six 39.500 dwt duplex chemical tankers - the largest ever built. Each has 34 cargo tanks made of duplex stainless steel. Because of international width limitations, extra load capacity was obtained by building higher tanks than ever before constructed.

Not seen before in naval construction, are the heavy duplex stainless steel tank walls that are up to 31mm thick in the bottom area of the tanks. The high restraint situation during the assembly of the tanks is an aspect that places very high demands on the welding procedure and welding skills.

The correct and crack-free welding of the T-joint between corrugated bulkheads and tank tops, will be discussed, serving as the most critical example of joints under very high restraint. It is one of the many newly established welding procedures applied by the new Szczecin yard for all six tankers.

Welding of root runs with rutile flux-cored wire on ceramic backing materials is a commonly applied, productive technique in the assembly of duplex chemical tankers and normally it does not lead to cracking problems. In very rigid constructions, however, end crater cracks can easily form and propagate over parts or over the full length of the root run. A series of preventative actions can and must be taken to counteract the phenomenon. Each of these actions, can make the difference under conditions of high restraint.

1. Joint design.

The bevel angle on both sides of the corrugated bulkhead must be min. 50° –0/+5° (figure 4). This is to allow the arc to reach the heart of the joint and give a full penetration. Duplex stainless steel has lower heat conductivity than CMn steel. A land of a few millimeters on the nose of the standing leg increases the heat drain and makes it easier for the welder to obtain a smooth tie-in.

The root gap must be set at 4-6mm. Smaller root gaps must be made wider by grinding to ensure good penetration. When larger root gaps occur during fit-up, a buttering technique must be applied to bring the gap within this tolerance (see later). Trying to bridge the larger gap, which is common shipbuilding practice, will create thin root runs. Thin root runs, having a small thickness/width ratio, are a favourable condition for the initiation and propagation of hot cracks.

2. Consumable, welding parameters and torch position

It is important to create a root pass with a thickness/width ratio around 1. This is a matter of selecting the best consumable, but also of choosing the optimal welding parameters and torch technique. Thicker root passes have a better resistance against the initiation and propagation of hot cracks. OK Tubrod 14.27, although a rutile flux-cored wire, is slightly more basic than comparable rutile wires in the market. It is easier to build-up thicker root passes. The flat to slightly convex form of the root pass is something shipbuilding welders have to get used to (Figure 4). Such a weld can be produced by trained welders using 160-170A/21-23.5V/15-20mm stick-out with the trailing technique and 45° torch angle (DC+/ mixed gas). For filling, 200-210A/25-26V is applied to ensure proper fusion. Since the use of correct welding parameters is so essential, all power sources used must be calibrated.
More than ever, it is crucial to train the welders for this particular application in the use of cored wire. The quality requirements are high and clamps and braces often hinder the accessibility of the joint.

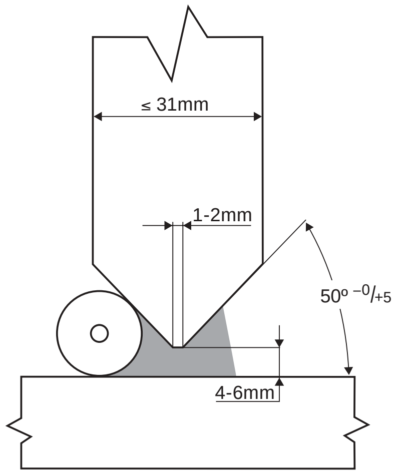


Figure 4. Optimal design for high restraint joints in thick-walled duplex stainless steel.

Figure 5. Macro structure of the T-joint taken from a test sample.

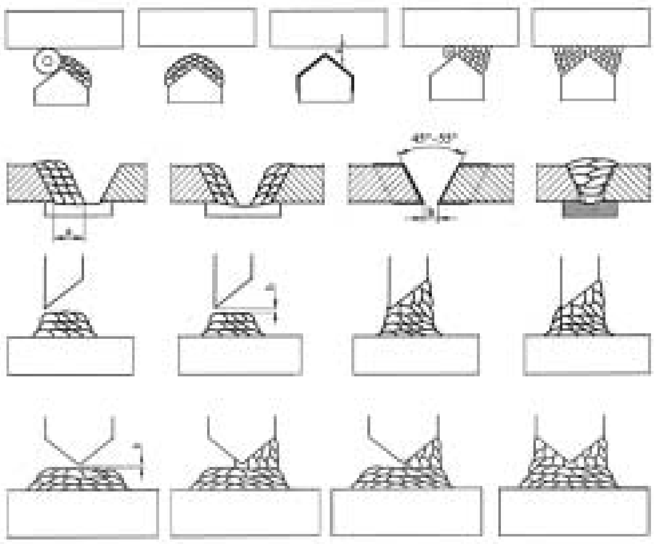


Figure 6. Different joint configurations used in structures of duplex cargo tanks, with buttering techniques applied to correct the root gap.

3. Crater cracks

In general, crater cracks are hard to avoid when using rutile consumables on ceramic backing material. It is common practice in shipbuilding to re-melt and fill up the starts and stops with the arc when the welding is continued, but with duplex stainless steel this can have a detrimental effect. Crater cracks must always be ground away completely, because they form the initiation point for hot cracks running into the root pass, especially in this kind of rigid constructions. This is also applies to craters without visible cracks. The crack can be hidden under the surface. The use of a proper grinding technique is essential.

4. Buttering techniques

Root gaps must always be corrected when they do not fall within the tolerance prescribed by the welding procedure, no matter the welding position. Figure 6 gives an overview of buttering and filling techniques for various joint types and positions.

5. FCW properties

During the assembly of prefabricated corrugated bulkheads to the cofferdam walls, the vertical welds require a cored wire with good positional welding properties. The corrugations of the bulkheads are placed horizontally in the construction, so the positions overhead (under an angle), vertical-up and uphill are all encountered when making the vertical welds. The formulation of OK Tubrod 14.27 provides a fast freezing slag that supports the weld metal well. With correct welding parameters and torch technique, flat welds with a fine ripple can be produced requiring minimal grinding. The wire can be used in M21 shielding gas or in CO_2.

6. General recommendations when welding duplex stainless steel

Before welding

- For joints welded on ceramic backing, apply a slightly wider root gap and joint angle than those used for standard stainless steel to obtain good penetration.
- Use ceramic backing to facilitate root pass welding.
- The joint and the adjacent base metal should be thoroughly cleaned.
- Only stainless brushes should be used for cleaning.
- Preheating is normally not recommended.
- Dry electrodes should always be used. ESAB electrodes in VacPac are dry and factory fresh.

During welding

- Relate the heat input to the plate thickness and welding method, but avoid too high or too low heat inputs.
- Avoid striking the arc outside the joint. Arc strikes can act as initiation points for pitting corrosion and cracks.
- Maintain proper arc length and stick-out to avoid nitrogen pick-up.
- A correct root gas shield is important, if welding is performed without ceramic backing. Suitable backing gases are high-purity Ar and mixtures containing N_2 and H_2.
- Excessive weaving should be avoided, It can result in an overly high heat input.

After welding

- Thorough cleaning after welding is essential to obtain good corrosion resistance. All slag and oxide on and around the weld must be removed.
- Brushing should be done manually and only with stainless brushes. Rotating brushes can result in micro-crevices in the weld metal.
- Subsequent heat treatment is normally not needed. Duplex steels and weld metals can, however, be solution heat treated according producer's recommendations.
- Stress relieving should be avoided as this can cause embrittlement of the steel and the weld metal.
- The flame straightening of deformed plates can be applied, if the recommended procedure from the steel supplier is followed.

Continuous progress

Under new management and with a new organisation, Stocznia Szczecinska Nowa has made an impressive comeback. The lessons from the Bow Sun and the steep learning curve after the re-opening have brought the yard to the point where they are now successfully building the world's biggest duplex chemical tankers. Welding procedures for the welding of duplex under very high restraint have been improved and optimised, as have the skills and confidence of the welders, many of whom have been trained by ESAB welding instructors Peter de Boer and Arie van Cuijlenborg. This has resulted in a more cost-efficient production of the second and subsequent ships. Also, DNV has regained confidence in the yard's performance. Generally, the whole shipyard has gained a lot of experience since the first crack appeared, giving the yard a leading edge into the future.

About the authors

Dariusz Wojtaszewski, has an M.Sc. in Electrical Engineering and a PhD in Welding Engineering. He joined ESAB International in 1991 as Sales Manager in Poland, after having been a lecturer and researcher at the Welding Division of the Production Engineering Faculty in the Warsaw University of Technology, for 13 years. Since 1996, he has been Product Manager Consumables for ESAB Sp. z o.o. in Warsaw.

John van den Broek, is Application Engineer working within the Shipbuilding and Offshore Group of ESAB Europe. He is located in Utrecht, The Netherlands. He joined ESAB in 1996, after having worked as a welding consultant for the TNO Research Institute in The Netherlands.

Buildings Tall and Small, Convention Centers, Bridges, and Airports

Welders' Love Affair with New Self-shielded Flux Cored Wires

By Fritz Saenger, welding consultant and freelance writer.

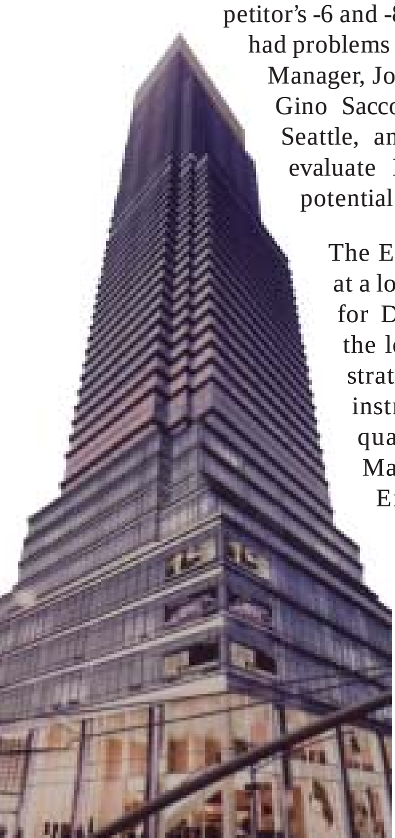
Self-shielded flux-cored wires were introduced in the United States in the early 1960's. Early products produced welds with limited ductility, were difficult to use properly, and smoke and fume levels were very high. Nonetheless, because of their major productivity advantages compared with SMAW, and the fact that they can be used without external gas shielding, they have become commonplace for outdoor construction in North America.

Later products exhibit much better mechanical properties, but most still operate properly in a very narrow voltage range, and require extensive operator training for safe and effective use. This can result in a very limited pool of qualified operators, and the risk that they may leave to take advantage of other employment opportunities.

ESAB has now introduced two new self-shielded FC wires that overcome many of the drawbacks of these products. They are Coreshield 6, meeting the requirements of AWS A5.20 Type E70T-6 for flat and horizontal welds, and Coreshield 8, meeting requirements of AWS A5.20 Type E71T-8 for all position welding.

Tall Buildings

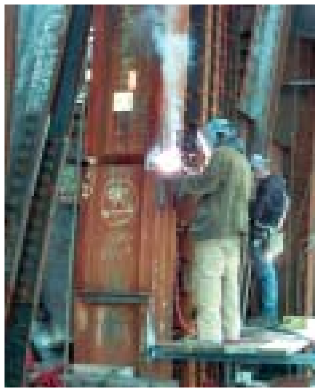
DCM Erectors is a Canadian based erector with many large projects in the US. DCM is well underway with construction of the Bloomberg building at the corner of 59th street and Lexington Ave in New York. (Photo) This building will be 60 stories high. For many years DCM have been using a competitor's -6 and -8 self-shielded wires, but they often had problems certifying local labor forces. Project Manager, John Scott, asked for assistance from Gino Saccon of The Erection Company in Seattle, and Gino recommended that they evaluate ESAB Coreshield 6 and 8 as a potential solution.



The ESAB products were demonstrated at a local fabrication shop in New Jersey, for DCM staff, and two welders from the local union hall. After the demonstration of Coreshield 6 and some brief instruction, both welders prepared qualification test plates. Jerry Mathison, ESAB Sales Application Engineer, assisted with the demonstration and the qualification, and he pointed out that tests for the PQR (Procedure Qualification Report) were carried out using a copper backup bar rather than the customary steel backup. Since many codes require removal of a steel backup bar, the use of a copper backup results in significant cost reduction during construction. Mathison and ESAB technicians had tested this procedure in the ESAB laboratories with excellent results, so they were confident that production welders could produce satisfactory welds as well.

Welding conditions for the 5/64-in (2.0mm) Coreshield 6 qualification tests were 290 amps, 25 volts, on a single V-joint with a 45 º included angle and 6mm root opening.

Test results were outstanding. Both welders passed all requirements on the first try, as did several more in later tests. The weld mechanical properties exceeded all requirements with DCM commenting that they were the best they had seen for a self-shielded flux-cored wire. Due to the highly satisfactory results obtained with Coreshield 6, DCM undertook their own testing with Coreshield 8, with comparable results. Both products are now being used on the construction project: Coreshield 6 on moment connections, Coreshield 8 on columns for both full and partial penetration joints. These are big welds. Box columns on the lower floors utilize 4-in thick A-36 steel.



Mike Pignatelli, DCM's Welding Foreman says that all welders like to make good looking welds, and these products make it easier for them to do this. Though they don't measure productivity directly, he is having no difficulty meeting the erection schedule. Ultrasonic and penetrant inspection is going smoothly with very few rejectable defects. The same is true for other erectors, such as Builders Steel, where the lower operating currents have meant fewer troubles with portable wire feeders – and this lets his welders keep welding!

A New Open-Looking Courthouse-with Earthquake Resistance

Across the nation in Seattle Washington, a new $215million Federal Courthouse is rising 118 meters (387ft) above the skyline. Seattle is earthquake territory, so the designers had the challenge of building in resistance to seismic disturbances without making the building look like a fortress. The structural system, considered at first, is the cover story of the February 24 edition of ENR (Engineering News Record). The " hybrid shear wall" core combines steel plate, braces and beams in cells "guarded" at the corners by giant steel "cans" filled with concrete.With this extremely rugged "core", there are no perimeter columns on the tower face. This structure was erected by The Erection Company of Arlington, Washington. Adam Jones, owner and president, calls the system "the thing of the future" for high seismic zones, despite some fit up difficulties. "At one point, we had 15 welders joining 5-1/2-in flanges, using more than 1200lb of electrode per day. ESAB couldn't believe we were using wire so fast, but they stepped up deliveries and kept us going—keeping our part of the project ahead of schedule." And all of this despite the sometimes troublesome coordination problems between concrete and steel work.

Key to the steel-plate, shear wall core are large-diameter pipe columns filled with 10,000-psi concrete.

The Erection Company has consolidated its self-shielded electrode use on Coreshield 6 and 8 based on their experience with procedure development, operator training, and reject rate in production. They have found that the ESAB products work satisfactorily in a wider arc voltage range, resulting in easier welding training and qualification. These factors have combined to produce a much lower rate of rejects and repairs in actual construction.

River Bridge, Charleston, SC

Federal Courthouse, Seattle, WA.

Bridges

In Charleston South Carolina, two existing bridges across the Cooper River are being replaced with the largest cable-stayed bridge in North America.This new bridge will soar over the existing bridges, providing ample clearance for the rapidly expanding commercial shipping on the Cooper and Wando Rivers upstream of this crossing. After the new bridge is opened the existing bridges will be demolished.

Palmetto Bridge Constructors is the prime contractor for this project, and is currently constructing the bases for the bridge towers and a wide variety of support structures to aid in the bridge erection. John Ross, QC Manager, Palmetto Bridge, selected Coreshield 8 for welding the foundation caissons and numerous construction support structures. As actual erection begins, he expects to use this product for major connections between the prefabricated components arriving from offsite shops.

Ross has long experience with welded construction using self-shielded electrodes. After reviewing highly satisfactory procedure qualification results, he proceeded with operator qualifications, and found that training and qualification efforts with Coreshield 8 were dramatically reduced compared with his past experience. In addition, welders like the operating characteristics so that productivity is running above expectations. Part of the increased productivity is due to the lower operating current of the 1.6 mm (1/16 inch) diameter wire. These wires operate below 300 amperes, and reduce the overheating of portable wire feeders commonly used for these applications.

Small Buildings

Builders Steel of Riverside, California, has about 50 employees and half of them are welders! John Reed is President and owner of this company, as well as being a Certified Welding Inspector. There is little doubt that satisfactory welding makes or breaks this company!

Builders Steel specializes in construction of light industrial buildings, office buildings and schools, typically not more than 5 stories high. This company does the whole job, bringing steel plate and structural shapes into its shop for prefabrication where possible, then erecting the building frame at the site. The most common material is ASTM Grade A992, similar to A572, Grade 50.

Reed has seen dramatic changes in design and construction requirements since the earthquakes of the early 1990s. Recommendations of FEMA 353 have been incorporated in California building codes, requiring major changes in design and construction practice. For example, FEMA requires that procedure qualifications take into account any access restrictions that may occur in fabrication and erection, using mock-ups of actual welded joints with "rat holes" or other obstructions. Structural designs now must accommodate the major vertical ground movement found to occur with major earthquakes, something not considered previously.

Builders Steel uses Coreshield 6 and 8 in the shop, and primarily Coreshield 8 for field erection. The major reason for expanded in-shop use of self-shielded electrodes is the change in allowable air movement in the welding area using gas-shielded electrodes. The maximum allowable velocity is now 3 mph (4.8km/hr) vs 5 mph (8km.hr) in the past. Reed found that "wind" velocity in his shop could easily exceed this new maximum unless special shields were set up. The most efficient solution was to change to self-shielded electrodes.

Builders Steel Project-Costa Mesa City Hall, new framework and closeup of connections.

Builders Steel hires experienced welders, then does training for their specific applications. They found that the new Coreshield 6 and 8 were more "operator friendly" than products they had used for many years. This reduced the time require to "upgrade" and qualify welders, and they estimate that productivity has increased 10 to 20 percent. The level of defects and rework has also been substantially reduced.

Convention Centers

Omaha, Nebraska's, new $281 million, 336,200-square-foot convention center and arena is scheduled to open in August 2003. The flexible main exhibition hall will offer 195,000 square feet of continuous flat floor area. The center's horseshoe-shaped arena will accommodate up to 17,000 people and the 30,500-square-foot grand ballroom will seat 2,183, banquet-style. The center will also offer more than a dozen meeting rooms that will total 32,700 square feet of space. A large pre-function area, as well as a 9,000-square-foot open-air terrace will be available.

Peter Kewitt is the Prime Contractor for this project, with Haven's Steel Erectors responsible for steel fabrication and erection. Mike Thompson, an ironworker with nationwide experience in heavy construction is welding foreman. Mike had used self-shielded flux-cored wires on many projects in the past, but found resistance in Omaha due to lack of experience with large buildings in the area. Mike realized that fabrication of 4-in thick steel would "take forever" with covered electrodes, and lobbied successfully for approval of Coreshield 8, as he had found it superior to competing products on previous jobs. "I have skilled welders, but they had very little experience with welding 4-in steel. I didn't have to do formal training, but I had to gain their confidence, and it's easier to gain the confidence of welders with this product compared with others." Mike said.

Mike stated that one of the advantages of Coreshield 8 is its ability to weld over moderate rust and the zinc-based primer that coats most of the steel arriving from the fabrication shops. On past jobs he also found it would perform well over galvanizing structures to be exposed to the weather.

Customer Input

Back in Hanover, Pennsylvania, Stan Ferree, ESAB's Vice President- Technical, credits Senior Research Engineer, Mario Amata, and his team for achieving this milestone. "Our team has many years of experience with flux-cored electrodes. They talked with customers, learned what they wanted, and defined clear objectives for improvements over existing (competitive) products. These included better control of the molten slag, slag entrapment, and a wider operating voltage range. To the welder this means improved operator appeal, reduced training and qualification time."

Amata pointed out that ESAB's proprietary flux-cored manufacturing process allowed them the flexibility to select electrode diameters, core composition, and core ratios that would produce the improvements seen in Coreshield 6 and 8. An engineer is never satisfied, and Amata predicts that the superior characteristics now seen in Coreshield 6 and 8 will be seen in other ESAB products in the near future.

The bottom line is that fabricators and refurbishers of all types of steel structures need to have reliable, easy-to-use welding materials, materials that will operate in outdoor construction, allowing contractors to meet their construction timetables, and keep their customers satisfied. The new Coreshield 6 and 8 self-shielded electrodes have set a new standard for this type of product.

About the Author

Fritz Saenger is a registered Professional Engineer, and an International Welding Engineer. He held a variety of technical and management positions in his 32-year career with ESAB North America and predecessor companies, Union Carbide and L-Tec. He retired from ESAB in 1995 as Vice-President, International Marketing, and joined Edison Welding Institute as Director of Marketing and Membership, retiring "again" in 2002. He remains active as a consultant and freelance writer.

BSI

Welding Procedure Specification BSI-WPS-Core8-6

WPS No. BSI-WPS-Core8-6 Revision ____ Date ____ By ____
Authorized By J. Reed Date 3/7/2001 Prequalified ☒
Welding Process(es) FCAW ____ Type: Manual ☐ Machine ☐ Semi-Auto ☒ Auto ☐
Supporting PQR(s) ____

JOINT
Type BUTT / B-U4b-GF
Backing Yes ☒ No ☐ Single Weld ☒ Double Weld ☐
Backing Material A-36
Root Opening 0-1/8" Root Face Dimension 0-1/8"
Groove Angle 45 deg. Radius (J-U) N/A
Back Gouge Yes ☒ No ☐
Method Carbon Arc

BASE METALS
Material Spec. A-572 to A-572
Type or Grade Gr 50 to Gr 50
Thickness: Groove (in) 1/4" - Unlimited
Fillet ( ) ____ - ____
Diameter (Pipe,) ____ - ____

FILLER METALS
AWS Specification A 5.2
AWS Classification E-71T-8

SHIELDING
Flux N/A
Gas N/A
Composition N/A
Electrode-Flux (Class) N/A
Flow Rate N/A
Gas Cup Size N/A

PREHEAT
Preheat Temp., Min. 50 f
Thickness Up to 3/4" Temperature 50 f
Over 3/4" to 1-1/2" 50 f
Over 1-1/2" to 2-1/2" 150 f
Over 2-1/2" 225 f
Interpass Temp., Min. 50 f Max. 550 f

POSITION
Position of Groove 4G Fillet ____
Vertical Progression: ☒ Up ☐ Down

ELECTRICAL CHARACTERISTICS
Transfer Mode (GMAW):
Short-Circuiting ☐ Globular ☐ Spray ☐
Current: AC ☐ DCEP ☒ DCEN ☐ Pulsed ☐
Other 1/2"-3/4" electrical stick out
Tungsten Electrode (GTAW):
Size N/A Type N/A

TECHNIQUE
Stringer or Weave Bead Stringer
Multi-pass or Single Pass (per side) Multiple
Number of Electrodes 1
Electrode Spacing: Longitudinal N/A
Lateral N/A
Angle N/A
Contact Tube to Work Distance 1/2"-3/4"
Peening N/A
Interpass Cleaning Chip and Brush

POSTWELD HEAT TREATMENT PWHT Required ☐
Temp. ____ Time ____

WELDING PROCEDURE

Layer/Pass	Process	Filler Metal Class	Diameter	Cur. Type	Amps or WFS	Volts	Travel Speed	Other Notes
All	FCAW	E-71T-8	5/64"	DCEP	200-225 a	21-24	7-9imp	Flat
All	FCAW	E-71T-8	5/64"	DCEP	180-200 a	18-22	6-8imp	Vertical
All	FCAW	E-71T-8	5/64"	DCEP	180-200 a	18-22	7-9imp	Overhead

BSI

Welding Procedure Specification BSI-WPS-Core6-

WPS No. BSI-WPS-Core6-2 Revision ____ Date ____ By ____
Authorized By J. Reed Date 3/12/2001 Prequalified ☒
Welding Process(es) FCAW ____ Type: Manual ☐ Machine ☐ Semi-Auto ☒ Auto ☐
Supporting PQR(s) ____

JOINT
Type BUTT / B-U4b-GF
Backing Yes ☒ No ☐ Single Weld ☒ Double Weld ☐
Backing Material A-36
Root Opening 0-1/8" Root Face Dimension 0-1/8"
Groove Angle 45 deg. Radius (J-U) N/A
Back Gouge Yes ☒ No ☐
Method Carbon Arc

BASE METALS
Material Spec. A-572 to A-572
Type or Grade Gr 50 to Gr 50
Thickness: Groove (in) 1/4" - Unlimited
Fillet ( ) ____ - ____
Diameter (Pipe,) ____ - ____

FILLER METALS
AWS Specification A 5.20
AWS Classification E-70T-6

SHIELDING
Flux N/A
Gas N/A
Composition N/A
Electrode-Flux (Class) N/A
Flow Rate N/A
Gas Cup Size N/A

PREHEAT
Preheat Temp., Min. 50 f
Thickness Up to 3/4" Temperature 50 f
Over 3/4" to 1-1/2" 50 f
Over 1-1/2" to 2-1/2" 150 f
Over 2-1/2" 225 f
Interpass Temp., Min. 50 f Max. 550 f

POSITION
Position of Groove 1G Fillet ____
Vertical Progression: ☐ Up ☐ Down

ELECTRICAL CHARACTERISTICS
Transfer Mode (GMAW):
Short-Circuiting ☐ Globular ☐ Spray ☐
Current: AC ☐ DCEP ☐ DCEN ☒ Pulsed ☐
Other 1" electrical stick out
Tungsten Electrode (GTAW):
Size N/A Type N/A

TECHNIQUE
Stringer or Weave Bead Stringer
Multi-pass or Single Pass (per side) Multiple
Number of Electrodes 1
Electrode Spacing: Longitudinal N/A
Lateral N/A
Angle N/A
Contact Tube to Work Distance 1"
Peening N/A
Interpass Cleaning Chip and Brush

POSTWELD HEAT TREATMENT PWHT Required ☐
Temp. ____ Time ____

WELDING PROCEDURE

Layer/Pass	Process	Filler Metal Class	Diameter	Cur. Type	Amps or WFS	Volts	Travel Speed	Other Notes
All	FCAW	E-70T-6	5/64"	DCEN	390 a	22-26	8-12imp	Flat Only

Stub-ends & Spatter

The only Waterjet Gantry in the world with 4-process capability and with all process parameters set via the CNC control.

Shown with Waterjet, Plasma Marker, (2) 600 Amp Plasma, and (2) Oxyfuel Stations

This unit features underwater plasma/waterjet cutting with height control on the same part without any operator intervention.

Similarly oxyfuel/waterjet cutting can be carried out on the same part, again without any operator intervention. This dual process combines the benefits of two processes in a single gantry.

Adding the plasma marking capability, allows three different processes to be used on a single part. If needed, plasma marking, waterjet, plasma and oxyfuel can be used on a single part program, without manual intervention, with all process parameters being set via the CNC. Get the best of all worlds in one machine. Accuracy, high production and lower cost per part!

One + one is more than two!!

By Kari Erik Lahti, ESAB AB Automation, Gothenburg, Sweden.

The combination of two welding processes results in improved quality, faster welding speeds and improved weld appearance. No joke, it's a fact. In laser hybrid processes, laser beam welding is combined with assisting arc-welding processes such as TIG, MIG/MAG or Plasma, and the resulting welds have a smooth profile and deep, full penetration with excellent mechanical properties.

Figure 1. Laser hybrid welded telescopic beams. DinoLift Oy, Finland.

Laser welding has been around for a number of years and has proven its capabilities in applications where accessibility is limited (welding of gears), where high welding speeds are critical for productivity (longitudinal seams on pipes) and where heat-input must be very precisely controlled (components for electronics). Arc welding, on the other hand, is widely used in all branches of metallic joining. However, typical material thicknesses for arc welded products are thicker than those for laser welded. When combining the processes, an attractive overlapping zone is created: high-speed, full-penetration, one-pass welds on thicknesses between 3 and 8 millimeters. This makes the process suitable for all applications where welding heat can cause deformation or harmful changes in the microstructure of the steel. Panel lines in shipbuilding, beams, containers and vessels are just few of the potential application areas for laser hybrid welding.

How to weld?

In laser hybrid welding, two powers work on the same molten weld pool simultaneously: the power of the laser beam, and the arc power from the MIG/MAG process. This results in a combination where the benefits of both processes are utilised to their full degree. The fast welding speed and deep penetration of laser welding is combined with the higher tolerance for edge preparation of MIG/MAG welding. This alone makes the process attractive for applications where edge preparation accuracy becomes costly. Instead of having 0,1 mm air-gap maximum, typical for laser-welding, up to 1,5 mm can be used when laser hybrid welding. Savings in time and money are obvious.

The key-hole formation typical for laser welding assures full penetration welding and very even root runs, even with long welding lengths. Welding can be performed without any backing bars or strips from one-side on thicknesses up to 8 mm possible with only one run, at speeds above 1 m/min. High welding speeds result in low heat input and hence very low heat-induced deformation in welded structures. Savings are immediately gained in applications where straightness and flatness are important – for example, cranes and bridges.

The low heat input is also a benefit for welding materials sensitive to heat, or with heat input limitations, in order to avoid microstructural changes. Duplex stainless steel and high strength steels are suitable application areas for laser hybrid welding. In Figure 1, an application of high strength steel beams is shown, and the respective test results for non-destructive and destructive tests are summarized in Table 1.

Equipment needed

Laser hybrid welding can be achieved with either CO_2 lasers, or NdYAG lasers. The main difference is in the wavelength of the beams – 10,6 mm for CO_2 and 10-times shorter for NdYAG. This means that CO_2 laser is guided with mirrors, but NdYAG can be guided via optical cable. From a practical point of view this means that NdYAG is more flexible and can be used in robotic applications, as in Figure 2. The photo shows a basic configuration needed for robotized laser hybrid welding: sophisticated power source, laser hybrid welding head and an industrial robot.

Excellent welds!

In Figure 4, macros of typical laser hybrid welds are demonstrated. The deep penetration profile caused by the laserbeam is clearly visible. With proper parameter settings the shape of the MIG/MAG weld bead is smooth and transition to base material is good. This is an important feature in applications where fatigue is an important design or service life consideration.
Welding can be performed in all positions, but optimized

Test method	Application standard	Result	Requirements, quality level	Accepted (Yes/no)
Visual	EN 970	No defects	EN ISO 13919-1, B	Yes
Penetrant	EN 571	No defects	EN ISO 13919-1, B	Yes
Radiographic	EN 1435	Some pores	EN ISO 13919-1, B	Yes
Tensile	EN 895	753 / 816 MPa	>744 / 768 MPa	Yes
Bending	EN 910	180º	180º (EN ISO 15614-11)	Yes
Bending	EN 910	180º	>120º (EN 288-3)	Yes
Hardness	EN 1043-1	Max 343 HV5	<380 HV (EN 288-3)	Yes
Microhardness	EN 1043-2	Max 392 HV0.3	No requirements	Yes
Macrograph	EN 1321	Misalignment	<0.3 mm	Yes
Micrograph	EN 1321	No defects	No requirements	Yes

Kankaala T. 2003. Quality of CO_2-laser hybrid welded high strength steel beams. In: Proceedings of LUT JOIN ´03. International Welding Conference in Lappeenranta, Finland, 20.-22.5.2003. 7 p.

Table 1 . Test results from non-destructive and destructive testing of the beams shown in Figure 1. Kankaala, 2003.

welding conditions in the flat position give the best results. Since welding is done with multiaxis manipulators or by using welding robots, curved joint paths are not a problem for the process as shown in Figure 5. The picture shows that the weld can be optimized to suit specific requirements. In this case deep penetration and spatter-free welding were requested – and fulfilled. As a bonus a welding speed of almost 2 m/min was achieved.

Where is laser hybrid welding used?

Shipyards, car manufacturers, fabricators of earth moving equipment, lifting equipment and crane makers are all industries where laser hybrid welding is applied. However, most of the industrial applications today are in the automotive industry where cycle time requirements are pushing towards faster and more effective joining processes. For shipyards, where deformations are a constant problem, laser hybrid welding has proven to be a good alternative to conventional arc welding processes. At least two european shipyards are already using the process.

In the automotive industry there are two main drivers for the use of laser hybrid welding: aluminium as a construction material, and the capability to manage larger tolerances than with laser welding. The laser hybrid welding of aluminum results in a low heat input and a very smooth weld. The high power density from the laser beam makes it “easier” to get to the welding temperature, despite the high thermal coefficient of aluminum. When using only the laser process, the high cooling rate typically results in cracking in deep and narrow welds, which has excluded the use of the process for many applications. Welding consumables are used to ensure the proper alloying in the weld.

Figure 2 . Laser hybrid welding head installed on a KUKA welding robot. Lappeenranta University of Technology, 2003.

Figure 3. Laser hybrid welding head designed and engineered by ESAB and Permanova Lasersystem AB.

Laser welding with cold wire addition has been applied to overcome this problem, but too much of the laser beam energy is consumed for melting the cold wire.

When the MIG/MAG arc is combined with laser welding, most of the problems mentioned above are solved in a simple and effective way.

When welding thin plates in car manufacturing (see Figure 6), it is a challenge to meet the tolerance requirements with laser welding and cold wire addition. One idea is to use a separate roller in front of the laser beam to press the plates together and secure minimal gap between the plates. As the thickness increases, the forces needed to press the plates together also increase, and this often makes the welding cell very stiff and clumsy.

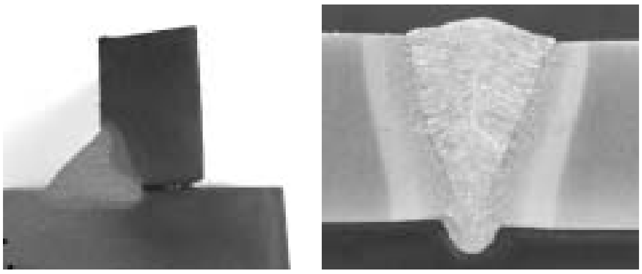


Figure 4. Macros of a 12 mm thick T-joint in AA5086 steel and a 6 mm thick weld in RAEX 640 steel. The "deep" effect of the laser beam is easily noticed.

Laser hybrid is the solution – the acceptable gap size is increased to the magnitude of MIG/MAG welding.

As the welds get longer and shapes more complicated, it is recommended that integrated seam tracking on the welding head is used . This ensures the correct positioning of the laser hybrid weld pool and helps to optimize the welding conditions. This is also a very important factor for joint preparation. Wider tolerances can be used, resulting in more economical ways to prepare the joints. Instead of machining, cutting with oxy-fuel or plasma may be the perfect solution.

The Future looks bright!

Laser hybrid welding is a process with an exciting future. Laser welding and laser hybrid welding are growth areas in the relatively mature welding industry. Much research is still to be done but, as a process, laser hybrid welding has gained recognition. Technological innovations in the field of laser resonators are the driving force behind the process development.

Think about your future- Think Laser-hybrid.

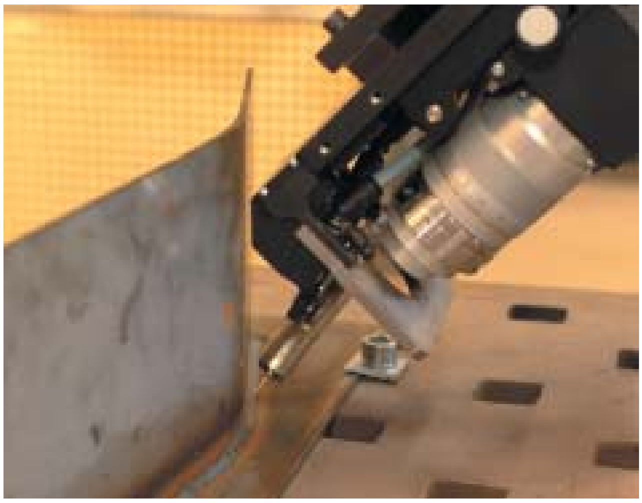


Figure 5. The picture shows that the weld can be optimized to suit specific requirements. In this case deep penetration and spatter-free welding were requested – and fulfilled. As a bonus a welding speed of almost 2 m/min was achieved.

Figure 6. Laser welding of a Volvo XC 90 roof, with pressure roller in front of the laser beam. Permanova Lasersystem AB

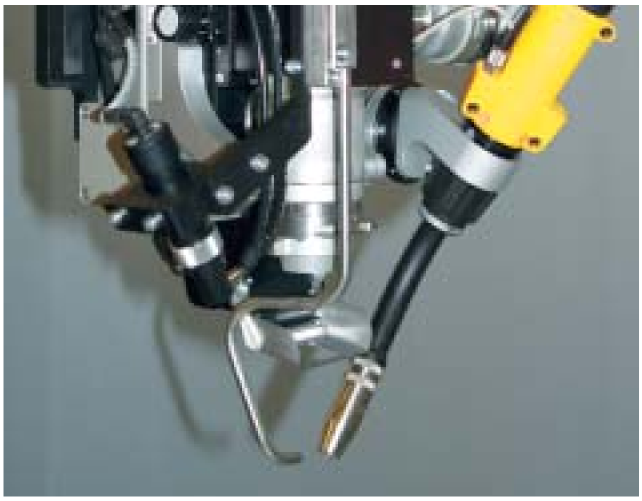
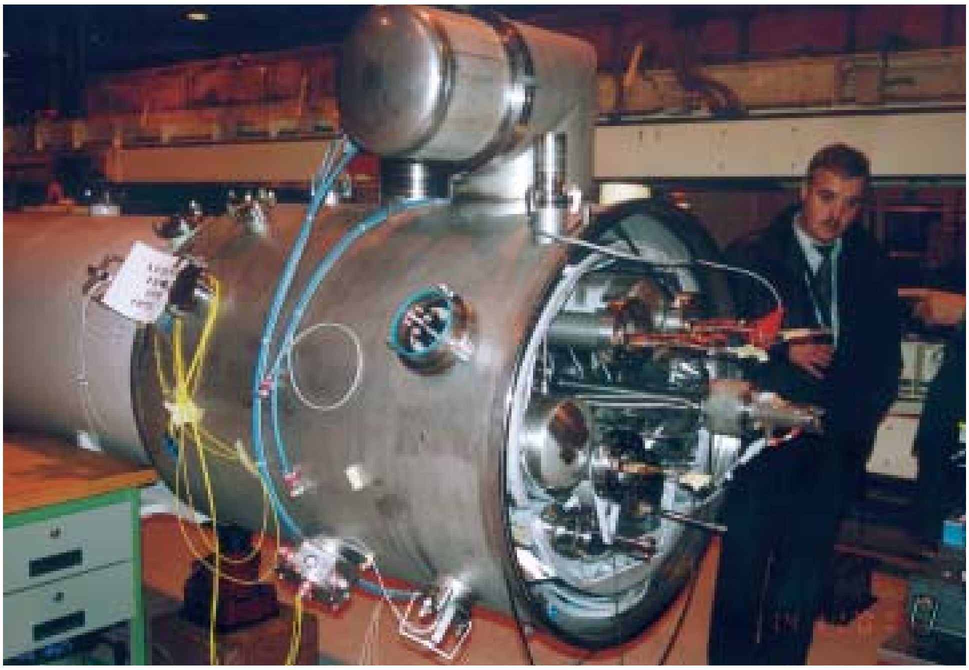


Figure 7. Laser hybrid welding head with integrated seam tracking. Permanova Lasersystem AB.

About The Author:

Kari Lahti obtained an M.Sc. in materials technology in 1994 and a Ph. D. in welding technology in 1998 at the Helsinki University of Technology. After having worked in the field of welding research, he joined ESAB as Product manager Welding automation for Finland and Estonia. He is now employed by ESAB AB in Gothenburg as Marketing Manager Advanced Engineering products.



The CERN cyclotron under construction in Geneva.

Welding of austenitic vessels for new CERN cyclotron

By Jan Kotora, Daniel Stano. SES TImace, Slovakia, Miroslav Mucha, ESAB AB.

A contract for the delivery of 423 stainless, vacuum proof vessels for the new CERN cyclotron particle generator in Geneva, Switzerland, has been successfully completed by the Slovakian company, SES Timace. The CERN cyclotron has a diameter of 9km and is constructed 100m below the ground. The demanding quality requirements for the welds were met by MIG welding with OK Tubrod 14.30 rutile cored wire.

SES TImace

Founded in the 1950s, SES Timace is now one of the biggest industrial enterprises in Slovakia with a range of power plant equipment that includes steam boilers, condensors, heat exchangers, fluidised-bed boilers, waste heat boilers, combined steam-gas cycles and co-generation systems, and also includes components for nuclear power plants. Products are exported to 29 countries. The company meets the quality standards of DIN, ASME Code, ISO 9001:2000 and Merkblatt HP0.

In January 2001, SES won a contract for the delivery of 432 vacuum proof vessels in austenitic stainless steel, for the newly constructed CERN cyclotron in Geneva, Switzerland.

Requirements for welding joints of vacuum proof vessels.

The vacuum proof vessels, essential components in the cryogenic circle, had to fulfil specific dimensional demands and mechanical properties, stipulated by the client. The flange and cover (Figure 1) are made of austenitic steel X2 CrNi 18 9 (AISI-304L, DIN W.Nr.1.4306).

The dimensions of the vessel (WT= 6mm, OD =1018mm and L =1338mm) make the construction vulnerable to deformation which could result in poor alignment of the flange and other components to be welded onto the shell. The vessels operate under vacuum at a temperature of 20ºC. Under certain circumstances, the pressure can rise to 0.15MPa and the vessel wall may cool, locally, to -43ºC. These conditions place severe demands on the quality and integrity of the welds.

All welds are X-Ray inspected and all vessels are helium vacuum tested. The welding procedure specification must be approved according to EN 288-3. Mechanical properties of the weld metal, including Charpy-V-Notch toughness, are tested at -50ºC.

Figure 1. Finished vacuum proof vessel.

Welding procedure – flange and cover.

Surface cleanliness and a crack free joint preparation are most important. Before welding, the weld bevels are dye-penetrant tested, ultrasonically cleaned in an alkalic solution, washed in de-mineralised water and dried in an infrared drying cabinet.

TIG, MIG (or FCAW) and plasma welding were the only processes allowed by the client. Manual TIG welding was selected to ensure the integrity of the root of the circumferential joint.

Mechanised FCAW welding was selected for filling. Comparative tests between solid wire and flux-cored wire showed the latter to give the best results in terms of integrity, penetration, bead-on-plate wetting, and bead appearance – including a lower level of spatter.

The welding wire was ESAB OK Tubrod 14.30 (EN: T 19 9 LRM 3/AWS: E308T0-1), a rutile flux-cored wire for downhand applications (Table 1). It has excellent wetting properties, easy slag release and a superb weld appearance.

Consumable	Chemical composition %					Note
	C	Si	Mn	Cr	Ni	
OK 14.30	0.03	0.90	1.5	19.0	10.1	Typical value

Table 1: Chemical composition OK Tubrod 14.30.

Two important factors had to be observed; the precise positioning of the weld edges and the protection of the inside of the root. A special clamping device was prepared, with a ring groove divided in six sections with an individual argon supply (Figure 2). The device served to set the root gap at exactly 4mm, before tack welding. After depositing six 30mm long tack welds, the device turns so that each sector covers the distance between the tack welds, to ensure protection with backing gas for the root run to be welded. TIG rods (W 19 9 L Si) had a diameter of 2.4mm.

Figure 2. Device for clamping and backing gas.

Figure 3 shows the joint design of the circumferential welds and gives the corresponding welding procedure specification.

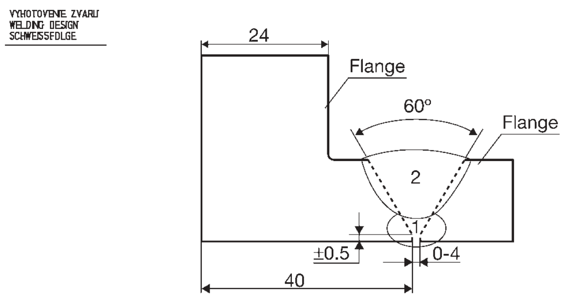
Besides circumferential welds there was also a need to join components such as manholes, tubes and nozzles. The biggest problem was the accurate placement of these components relative to the axis of the vessel.

Welding equipment.

ESAB welding equipment was used for all welds. The ARISTO LUD 450 W multi-process power source was used for manual TIG welding.
Mechanised FCAW was carried out in the downhand position with an ESAB column and boom station MKR 300, 3x3m with A6 welding head, automated GMD seam tracking, LAF 635 power source and a water cooled MTW 600 MIG torch. The column and boom station was controlled by a PEH unit.

WPQ and finished product tests

Before starting the production, it was necessary to qualify the welding procedure specification in accordance to EN 288 – 3 and specific customer requirements (WPAR). The WPQ comprised tensile and bend tests as well as CVN toughness tests at -50 °C.
With individual values of 576 and 580, the weld tensile strength was well above the minimum required level of 485 N/mm^2. Charpy values were 96 and 101, well above the requirement of >28J/cm^2 at -50 °C. All samples in the bend test reached 180°. All welds were X-Ray tested. Even the mechanised FCAW circumferential welds achieved a defect rate close to zero.
High importance was attached to vacuum testing of the vessels at a pressure of 10-9 Pam^{3}s-1, at ambient temperature – a very demanding test in helium. The whole procedure was approved by CERN.



VRSTVA LAYER LAGE	METÓDA PROCESS PROZESS	PRÍDAVNÝ MATERIÁL FILLER METAL SCHWEISSZUSATZ	Ø (mm)	ZV.PRÚD AMPS. STROM (A)	NAPÄTIE VOLTS SPANNUNG (V)	POLARITA POLARITY POLUNG	RÝCHLOSŤ ZVÁR. SPEED WELDING GESCHWINDIGK. [cm/min]	RÝCHL. ZV. DRÔTU WIRE FEED SPEED VORSCHUB [m/min]	TEPELNÝ PRÍKON HEAT INPUT GESANDVERMEEINTR. [kJ/cm]
1	141	W 199LSi	2.4	120-150	14-16	G-	14	-	5.85
2	136	T 199 L R M3	1.2	160-200	23-26	G+	40	4-6	5.83

OCHR. PLYN / PROTECTION GAS / SCHUTZGAS: I1/M21 podľa EN 439 / ACCORDING TO EN 439; PRIETOK PLYNU / FLOW RATE / GASDURCHFLUSSMENGE: 12–15 l/min	SEKUND. OCHRANA / BACK SIDE PROTECT. / WURZELSCHUTZ: I1 podľa EN 439 / ACCORDING TO EN 439; PRIETOK PLYNU / FLOW RATE / GASDURCHFLUSSMENGE: 8-10 l/min

Figure 3. Welding specification of the circumferential joint.

About the authors

Daniel Stano, M.Sc. is welding engineer at SES Tlmace and head of the welding department.
Jan Kotora, M.Sc. is welding engineer at SES Tlmace.
Miroslav Mucha, PhD, joined ESAB in 1994 and works for ESAB's Sales & Marketing application Group as application engineer with a responsibility for Eastern Europe.

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ESAB high-alloyed welding consumables for ferritic stainless steel exhaust systems.

Translation of an article by Bruno Schwarz and Frank Tessin published in Fenster, the customer magazine of ESAB Germany.

Although today's car fuels are very low in sulphur, a certain amount of sulphur dioxide remains present in the exhaust gases. Together with the condense water, it forms sulphurous or sulphuric acid that deposits in the exhaust system. Ferritic stainless steels resist these acids very well, and have good heat resistance. They are increasingly preferred over austenitic stainless steels for exhaust systems. Table 1 gives an overview of the most common ferritic stainless steels.

W-Nr.	Composition	AISI/SAE
1.4002	X6CrAl13	405
1.4003	X2Cr11	-
1.4006	X12Cr13	410
1.4016	X6Cr17	430
1.4511	X3CrNb17	-
1.4512	X2Ti12	409
1.4513	X2CrMoTi17-1	-

Table 1: ferritic stainless steels

Photo: Benteler, Warburg, Germany. Hot ends of a ferritic stainless steel exhaust system robot welded with OK Autrod 430LNb. This wire belongs to ESAB's new range of matte stainless steel MIG wires with excellent feeding properties and arc stability.

Welding

Ferritic stainless steels are sensitive to the heat cycle generated by welding. Grain growth and hardening due to martensite formation can reduce the toughness of the steel and increase the risk of cracking in the heat-affected zone of the weld. This can be avoided by using special filler materials and by the correct welding procedure.

- In general, preheating is needed when the carbon content of the steel is above 0.08% and the thickness of the steel exceeds 3mm.
- Welding should be carried out with the lowest possible heat input (pulsed arc).
- Unstabilised steels require a post weld heat treatment at 700-750°C to avoid intercristalline corrosion.
- Steels stabilised with titanium or niobium (columbium) do not need a post weld heat treatment.

Ferritic stainless steels can be welded with either austenitic or ferritic filler materials. The austenitic filler metal composition 18 8Mn (1.4370/ER 307, see table 2) is commonly applied. However, this type of welding consumable is sensitive to corrosion in sulphur containing media and can therefore only be used for exhaust systems when extremely low sulphur content fuels are used.

Ferritic filler materials, such as type G13, G17 and G18 (EN440) provide the advantages of fatigue strength and corrosion resistance. The thermal expansion coefficient and the carbon content of both the steel and the weld metal are the same. Unfavourable stress peaks along the fusion line, and the diffusion of carbon, are therefore avoided.

ESAB offers a comprehensive range of filler materials for the welding of ferritic stainless steels, see table 2. The new Arcaloy metal-cored wires for MAG welding provide a productive option for specific exhaust applications. They enable higher deposition rates than common solid MAG wires, and low spatter results in less post weld cleaning.

ESAB	Type	Werkstoffnr.	Composition	AWS A5.9
OK Autrod 430LNb	Solid MIG/MAG wire	1.4511mod	G Z 17 L Nb	ER430LNb
OK Autrod 16.80		1.4009	G 13	ER410
OK Autrod 16.81		1.4502	G 17(Ti)	ER430
OK Autrod 16.82		-	G 13(Nb)	ER409Nb
OK Autrod 16.95		1.4370	G 18 8 Mn	ER307
OK Tubrod 15.34	MAG metal-cored wire	1.4370	T 18 8 Mn	ER307
Arcaloy 18 CrCb		-	(T 18 TiNb)	-
Arcaloy 409Ti		-	T 13 Ti	ER409
Arcaloy 409CB		-	T 13 Nb	ER409Nb
Arcaloy 430LCB		1.4511	T 17 (Nb)	ER430
Arcaloy 439Ti		-	(T 18 Ti)	-
OK Tigrod 16.81	TIG rod	1.4502	W 17(Ti)	ER430
OK Tigrod 16.95		1.4370	W 18 8 Mn	ER307

Table 2: ESAB welding consumables for ferritic stainless steels.

Tandem MIG/MAG Welding with ESAB

By Petter Unosson and Håkan Persson, ESAB AB, Welding Automation, Laxå, Sweden

When speed with quality is desired, an ESAB Tandem station is an option that soon pays back the investment. The station can be equipped with either Thyristor- or Inverter-technology power sources to suit different material types and thicknesses.

They come complete with power source and wire feeder, process controller and the multi-functional MTT1200 tandem MIG/MAG head. The upgrading of a customer's existing single wire station with accessories for tandem welding is another possibility worth considering. ESAB also offers valuable application research at its Process and Application Center, to pre-determine optimum welding parameters on samples from the client's production. This ensures successful implementation of the station in the customer's production process.

Two process varieties for high speed welding

Twinarc- and Tandem MIG/MAG welding are two high-productivity variations of the MIG/MAG process where two wires are welded at the same time. In Twinarc welding, both wires are connected to the same power source and, consequently, the electrical potential on both wires is the same. Only one wire type – with the same diameter – can be used, because different wires have different electrical characteristics. Twin arc equipment can have either one or two wire feeders.

The Tandem system is much more flexible, because each wire is individually connected to a power source and wire feeder. With two power sources and two wire feeders, parameters can be set for each wire individually, making it possible to weld with different wire types and different wire diameters, for instance with a combination of a solid wire and a metal-cored wire. The choice of consumables can, therefore, be exactly tailored to the application, resulting in an optimal weld quality and, often, superior welding productivity. Tandem welding equipment initially consisted of two heads placed in sequence but, nowadays, both wires are normally fed through specially developed Tandem heads.

High speed welding saves you money

The tandem process is more than 100% faster than the single wire process, resulting in significantly lower costs per meter weld (Figure 1). As an example, consider a fabricator using single wire MIG/MAG welding at a travel speed of 120cm/min, who has production costs of 50 Euro per hour. If he changes to tandem welding at 250 cm/min, the production cost/hour (including his investment in new equipment), can increase to as much as 117 Euro before the cost per meter is at the same level as with single wire welding. This means, that he could accept an extra cost of 70 Euro per hour, and still find the cost of the tandem process lower than that of the single wire method.

The ESAB Tandem MIG/MAG Head MTT 1200

The torch, together with the power sources, constitutes the heart of the Tandem welding system. ESAB has developed a torch with a number of adjustment possibilities to giving the welder complete freedom to set optimum parameters for all base materials and joint types. The torch fits all possible joint types and materials, such as stainless steel, aluminium and carbon steel.The most important adjustment possibilities are (see Figure 2):

- One of the two contact tubes is adjustable in height to compensate for the angle of the tandem head, keeping the contact tip to work piece distance constant.
- Individual angle settings of each contact tube, and therefore an adjustable distance between the contact tips. This enables optimum positioning for individual materials.
- Different gas cups optimised for different torch angles.
- The torch is water cooled all the way to the gas cup, to handle high welding currents.

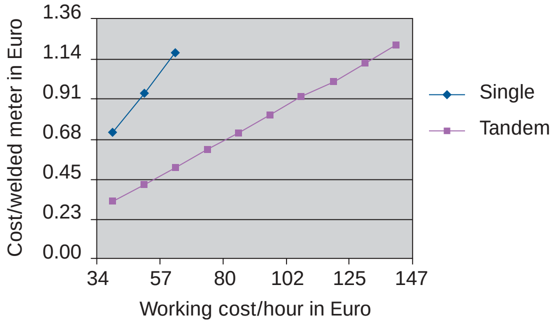


Figure 1. Cost comparison between Single wire welding and Tandem welding. The consumable price used in the calculation is not an existing price, but the diagram accurately indicates the relationship between the two arc technologies.

Figure 2. Torch configurations.

Figure 3: ESAB Tandem MAG station.

Two different process packages

ESAB supplies two different process packages for Tandem Welding. The difference lies in the power source. The LAF package uses a 635A thyristor power source, developed to weld in short and spray arc. The AristoMIG 450 package is based on a 450A inverter power source to weld short, spray or pulse arc. Table 2 shows the composition of the total package:

Power source	LAF or AristoMIG
Wire feeder	Tandem feed for wire diameters from 1.0 to 1.6mm
Tandem torch	MTT 1200 (2 x 600A at 100% Duty cycle)
Process controller	PEH (for LAF) and Aristo Pendant U8 (for AristoMIG 450)
Assembly	All necessary connections, brackets, etc.

Table 2: Composition of ESAB's two Tandem MIG/MAG packages.

Applications and Segments

Tandem MIG/MAG welding is suitable for a variety of applications across industry. Up to a certain material thickness, it provides an economic alternative to SAW. Below, some typical applications of Tandem MIG/MAG welding are presented. They are found in industries such as shipbuilding (stiffeners), civil construction & general fabrication (bridge constructions, lamp posts, containers, cranes) and automotive.

Fillet weld

Tandem MAG welding with OK Autrod 12.51, Ø1.6mm.

Fillet size: a=4
material: CMn-steel
position: PB
shielding gas: Mison 8
penetration: 3mm
travel speed: 1.8m/min.
plate thickness: 15mm

Overlap joint

Tandem MAG welding with PZ6105R metal-cored wire, Ø 1.6mm.

material: CMn-steel
position: PA
shielding gas: Mison 8
penetration: full
travel speed: 2.2 m/min.
plate thickness: 5mm

Fillet corner joint

Tandem MAG welding with OK Autrod 12.51, Ø1.2mm and OK Tubrod 14.13 metal-cored wire, Ø1.2mm. OK 12.51 is used as the leading wire in travel direction to ensure a good penetration. It runs with a higher welding current than the cored wire that leaves a good weld surface with a minimal amount of spatter.

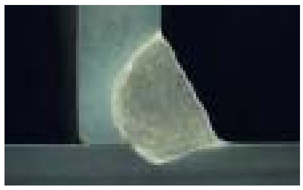
material: CMn-steel
position: PA
shielding gas: Mison 8
penetration: full
travel speed: 2.4 m/min.
plate thickness: 5mm

Fillet weld in aluminium

Tandem MIG welding with OK Autrod 18.04, Ø1.2mm.

Fillet Joint of Aluminium.

material: Aluminium
position: PB
shielding gas: Argon
penetration: 2mm
travel speed: 3 m/min.
plate thickness: 4mm



Double-sided Tandem MAG welding of stiffeners in a panel line

At the Kvaerner Werft in Rostock, Germany, double-sided Tandem MAG welding is applied with OK Tubrod 14.11 metal-cored wire, Ø1.4mm. The a=5 size fillets are deposited at a travel speed of 1.2 m/min. Engineered by ESAB, the automated installation consists of 4 power sources, 4 wire feed units and programming boxes.

About the authors

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Power sources for arc welding

By: Klas Weman

The main purpose of a power source is to supply suitable electric power. The characteristics of the power source are vitally important to welding processes. Today, a a variety of power sources is available which can make the selection process difficult. This articles provides usefull guidance.

The welding power unit converts the high voltage mains supply to a safe level. It provides the means of controlling the current or voltage to produce the necessary static and dynamic characteristics required by the welding process.

Modern electronics and computer technology have had a considerable impact on the development of arc welding equipment. This applies not only to the power circuits, but also to the control circuits. Rapidly changing technology potentially adds to the confusion by introducing new settings and control requirements.

Architecture

Motor-generator sets have been popular for many years, and are still sometimes used, although no longer manufactured. High cost and poor electrical efficiency made it difficult for them to compete with modern welding power units. However, their welding characteristics can be excellent. They consist of a (3-phase) motor, directly coupled to a DC generator. As the motor speed depends mainly on the mains frequency, these units are relatively insensitive to variations in the supply voltage. They can be remotely controlled by varying the excitation current of the generator.

Petrol or diesel engine driven welding generators are popular and are produced in high volume: they are used at sites without a supply of mains electricity.

Welding transformers provide alternating current, and are the cheapest and simplest type of power unit. They are used primarily for welding with coated electrodes, although they can also be used with other welding methods when the use of alternating current is required. More advanced power units, for use with TIG, submerged arc and occasionally MIG welding, can be controlled by thyristors or transistors using square-wave switching technology. In such cases, it is common for them to be able to switch between AC and DC, producing what is known as AC/DC-units.

Alternating current introduces a complication in welding because unless special steps are taken, the arc will extinguish on each zero crossing. The need to restrike the arc restricts the choice of coated electrodes and requires a sufficiently high open-circuit voltage, of at least 50 V, preferably higher. However, electrical safety requirements restrict the open-circuit voltage to 80 V. Voltage Reducing Units limit the open circuit voltage to < 50 V, which is compulsory when welding in confined spaces.

Advantages of alternating current are reduced risk of magnetic arc blow effect and good oxide-breaking performance when TIG-welding aluminium. AC welding can be a good alternative with certain coated electrodes, as it provides a high melting rate and low smoke generation.

A traditional welding rectifier power source produces DC, and usually consists of a large 3-phase transformer with some form of rectifier on the secondary side. Power sources having a constant voltage characteristic, for use with MIG/MAG welding, generally feature a tap-changer on the transformer for voltage control. An alternative is to use a thyristor-controlled rectifier bridge.

Unfortunately, this has the disadvantage of chopping the output voltage, which makes it also necessary to fit a smoothing inductor. This is because the smoothness of the current has a considerable effect on the welding characteristics. Thyristor control also provides a means of stepless remote control and insensitivity to variations in the mains supply voltage. Overall efficiency is 70–80 %.

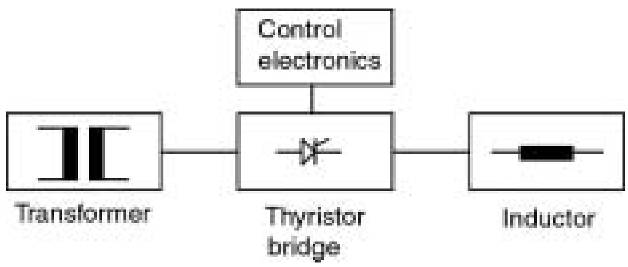

Figure 1. A thyristor power unit comprises a three phase transformer, a thyristor rectifier controlled by electronics and an inductor.

The response speed of the thyristors is limited by the mains frequency, but is nevertheless sufficiently fast to allow the static characteristics of the power unit to be controlled. This means that the characteristic can be given varying slopes, from flat to drooping, so that the unit can be used with several different welding methods.

Welding rectifiers usually incorporate an inductor in their output. For short-circuiting MIG welding it is important to reduce the current surge during the short circuit, as this otherwise would result in spatter. The aim is to achieve a high, steady short-circuiting frequency, with small droplets.

Figure 2. Inverter power sources. Left is an example of low weight and size. Right is inverter based advanced MIG equipment.

Welding inverters appeared on the market during the second half of the 1970s. In a primary-switched inverter unit, the 50/60 Hz mains supply is first rectified and then, using power semiconductors, turned back into AC at a much higher frequency, usually in the range 5– 100 kHz. This reduces the size of the transformer and inductor to a fraction of what is needed for a 50/60 Hz unit, making the power unit small and portable. Low losses result in high electrical efficiency, in the order of 80–90%. The high working frequency also allows the unit to be controlled at a speed that is comparable with the rapid processes occurring in connection with droplet transfer in the arc. Such units, therefore, have excellent performance. In comparison with traditional power sources, inverter units offer the following advantages:

- Low weight and small size
- Good welding performance
- Several welding methods can be used with the same power source
- High efficiency

Its major drawback is difficulty in making adjustments for different mains supply voltages.

Trends

Where welding characteristics were previously determined by the design and limitations of the heavy current circuits, control can now be provided by electronics and computers. The high speed of response of the power source provides new opportunities not only for control of the welding parameters, but also for control of the process itself (Fig.3).

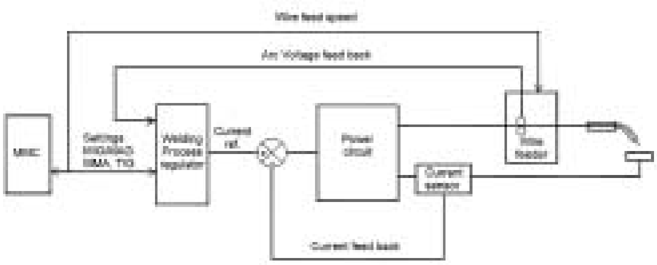

Figure 3. Advanced MIG units adopt sensors and feedback functions to achieve exact parameter settings and fast digital control of the welding process.

Electronic control increases the flexibility of the power source, and it is relatively simple to incorporate features enabling it to be used with several different welding processes. In addition to MIG/MAG, a power source may perhaps also be suitable for use with coated electrodes, without necessarily involving any significant extra cost. Many of the more advanced units are therefore suitable for use with several different types of welding.

Weld defects can be reduced by using functions such as gas pre-flow, hot start, crater filling, etc. (Fig.7). Advanced quality welding machines use developing man-machine communication to facilitate the setting of all parameters on a computer based programming unit.

Reliable starting properties (Fig.4) and good welding characteristics are particularly important when using short-arc welding, especially when considering the stream of molten droplets to be transferred to the weld pool.

Detachment of each droplet is critical, bearing in mind possible spatter formation and the forces that can cause surging of the molten metal in the weld pool. Correct control can maintain a high, consistent short-circuit frequency, resulting in stable transfer of fine droplets with a minimum of large spatter droplets. These characteristics are particularly important when using CO_2 as the shielding gas.

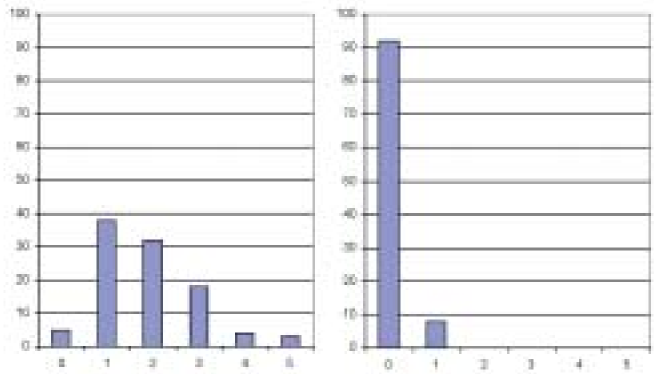

Figure 4. Amount of stubbing in the start of MIG welding. Left: before and right: after corrective measures of the power source characteristics have been inserted.

Pulsed arc MIG welding is a process made possible by fast, controllable power sources. Fast current pulsation in the range 30–300Hz, provides an excellent method of controlling metal transfer in the arc. It has dramatically improved the welding processes for aluminium and stainless steel.

Rating data

The power source rating plate lists the design ratings of the power source, with the most important being the related values of rated current, rated voltage and duty cycle. Other information shown includes efficiency and power factor, open-circuit voltage, insulation class etc. The standard IEC/EN 60974-1 defines important design principles, rating and testing of the equipment to ensure safe operation.

Figure 5. Example of a rating plate.

The rated current is the current for which the power source is designed. In some cases, a number included in the model name of the power unit may give the impression that it can supply a higher current: always check the technical data or the rating plate to make sure the actual value of rated current.

The power source rating is also determined by its duty cycle, which indicates for what proportion of a period of ten minutes, the power source can be operated at the specified load. For example, 400 A at 35 % duty factor, means that the power source can supply 400 A for 3.5 minutes in every ten minutes, indefinitely, without overheating.

The choice of power source

Today there are not only power sources for different welding methods and current range. Equipment is available more or less adapted for different applications.

Portable light-weight equipment in robust casing could be ideal for repair and maintenance. Ideal for this is the welding inverter – extremely mobile but still offering professional performance. Flexibility is excellent for MMA welding where just a carrier strap is needed. For TIG welding, the small inverter also offers advantages and it is possible to use a trolley for the gas bottle.

Figure 6. A modern MIG welding rectifier.

Low cost equipment, with a high degree of electrical safety is needed to satisfy hobby users. It is often a simple welding transformer for MMA welding or single phase MIG equipment. Compact MIG units with built in wire feeder is a popular solution. The duty cycle is normally rather low.

Industrial production equipment should be robust, reliable and easy to use. Most users believe that production rate is the major priority. Welding is often carried out using the same welding data every day. A MIG unit with a separated wire feeder is a popular choice of equipment (Fig. 6). For low welding current, a tap-changed rectifier is normally used while, at higher currents, thyristor controlled stepless power sources with water cooling units are more common. An inverter power source with its low energy consumption and excellent welding performance might also be considered. High energy consumption not only costs money, it can also increase temperatures in the workshop to uncomfortable levels.

For quality welding, equipment needs to satisfy the control requirements of the process and be capable of welding stainless steel, aluminium and other advanced materials. TIG, PAW (Plasma Arc Welding) or MIG welding is common and the natural choice of power source is a welding inverter. Pulsed MIG welding offers spatter-free, high quality welds for stainless steel and aluminium. An AC/DC inverter power source is the best choice for TIG and plasma welding of aluminium, and the emerging MIG/MAG hybrid laser welding process.

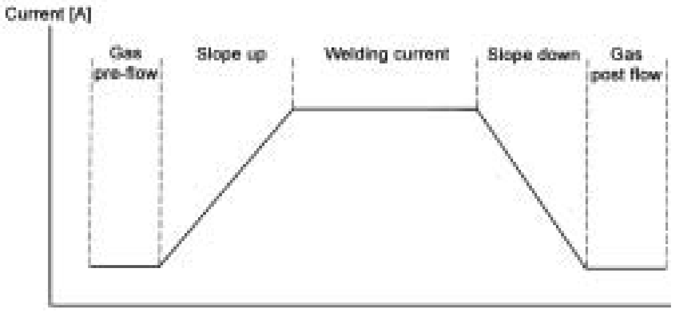

Figure 7. High quality TIG welding often uses extra functions to avoid defects at start and stop.

Power sources for mechanised welding operate generally at 100% duty cycle. Submerged arc welding (SAW) also demands high currents of 800 – 1600 A. For these high current applications, thyristor controlled power sources are used for both DC and AC. Robot MIG welding or mechanised TIG is most often carried out with a MIG welding inverter. Feedback and output control of parameter settings are very important in mechanised processes.

About the author

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Status report on NOMAD.

By: Lars-Erik Stridh, ESAB AB, Gothenburg, Sweden.

In Svetsaren 2/2002 we announced NOMAD, a project within the European Commission Framework 5 growth programme. In this issue we update you on the project that will run until August 2004.

The European steel fabrication industry has seen many changes over the past 30 years. Some industries, such as shipbuilding, have almost disappeared, only to re-emerge in other parts of the world. Today's fabricators have achieved a high level of mechanization and automation in their production. For example, the number of arc welding robots in operation is steadily increasing.

At the same time, the welding profession has lost status among young people, who regard it as an unattractive job and, increasingly, fabricators encounter problems in contracting welders. The solution to these problems is more robots.

Current robot welding technology focusses on large-volume production. In low-volume applications, the use of robots has been hindered by expensive and complicated fixturing, costly work-piece positioners, and long programming times.

NOMAD will develop the technology for unmanned robot stations that are suited for cost-efficient low-volume production, with the ultimate objective of enabling the European steel fabrication industry to maintain its competitive edge.

Industrial partners in the project are Caterpillar, TWI, ESAB, Delfoi, Reis Robotics, Fraunhofer Institut-IFF, Robosoft, and Nusteel Structures.

The project embodies the following innovations in the field of robotic welding:

- Use of manufacturing simulation for automated process planning and real-time system monitoring.
- Autonomous robot navigation for high accuracy positioning of a 6-axis robot arm.
- Design and building of an industrial rugged Robot Transport Vehicle (RTV) with all the attributes required for welding tasks.
- Specially developed welding consumables, welding procedures and sensor systems designed to allow all-positional robotic welding with a degree of control and flexibility unmatched by current systems.

Approach

The objectives of NOMAD are to remove the constraints of using welding robots in low-volume fabrication and to minimise the time from initial design to final product. To accomplish this, a new approach to robot welding is taken. The pictogram of figure 1 shows the concept of the NOMAD project.

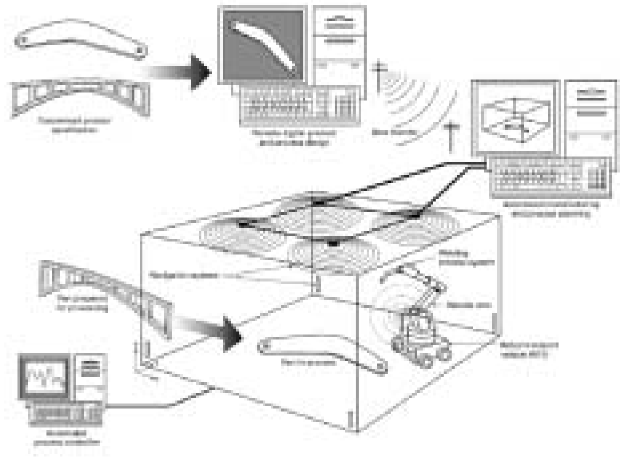

Figure 1. Pictogram of the NOMAD project.

NOMAD will use a 6-axis robot arm mounted on an autonomous robot transport vehicle (RTV) that will allow the robot to move to the part. The structure to be welded will be placed above floor level on a platform so that the robot arm can access all the joints to be welded, while the RTV moves around the structure. This system will also allow for tack welding at the same location, reducing the need to transport these large structures between workstations. For maximum flexibility, all essential welding equipment will be carried by the RTV.

Vision system

Successful implementation of an autonomous robot will require accurate measurement of the position of the robot arm relative to the structure. This is expected to be achieved with an accurate vision based sensor system that detects the location and orientation of both the structure and the robot.

Figure 2 shows pictures taken during development work on the vision system. The left picture is what the system records through its four cameras. Right is the simulated CAD model the system creates to direct the robot arm. Bottom is a superimposition of the two images, carried out to check the accuracy of the CAD model.

Information on the location of the robot and the structure will be passed to specially adapted robot simulation software, which will calibrate the simulation model. After calibration is complete, the simulation system will calculate the motion path for the RTV and the robot arm based on the location and orientation of the parts in the cell.

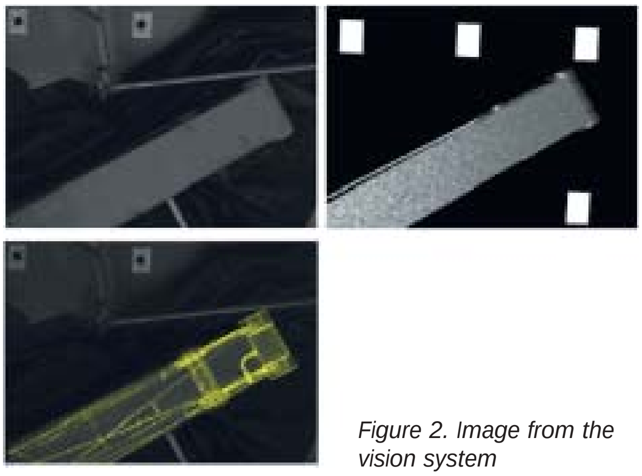

Figure 2. Image from the vision system

Although it is believed that the RTV will reach its destination with unprecedented accuracy, it is not anticipated that the accuracy of the welding torch position will meet the welding requirements.
Therefore, local sensing in the form of touch-sensing, laser-based vision and through-the-arc seam tracking will be used to guide the robot arm during welding. It is believed that the combination of global and local sensing will provide sufficient precision for welding.

Robot programming

Long programming times are a major constraint on the use of robots for welding large sized, low-volume fabrications. Even with the use of current off-line programming software packages, the time required can still be too long. NOMAD is designed to automate the task of robot programming.
This will be achieved by development in two areas.

First, welding information, including information on weld joint location and weld size, will be merged with the CAD model and will be imported into the robot simulation software along with the geometric information. Secondly, custom routines will be created in the robot simulation software that will read welding information and properly create welding motion and process programmes. Not only will the simulation software be used for programming, it will also be used to monitor and control events during the operation.

Automated programming of robot arc welding is not possible if the simulation system does not have intelligence on the welding process itself. In this project, a database of welding procedures will be created for relevant weld joints in various positions. The robot simulation software will, in turn, retrieve welding intelligence from this database after information on the welding joint and its welding position is retrieved from other systems.

Welding consumables

Development of welding consumables capable of producing high quality welds in all positions will also be undertaken within the NOMAD project. Consumables development will concentrate on producing flexible products that can accommodate a variety of joint types, in all welding positions. Consumables development is closely linked to the welding process development to achieve an optimum welding quality. The results of welding procedure and consumable development will be used to populate the welding database.

Many challenges

The ultimate goal of the project is to build a demonstration cell into which unique pre-assembled structures can be welded as efficiently as with today's robots for large volume production.

One of the major challenges is the development of a vision system that precisely records the location and orientation of a structure, to facilitate automated RTV path planning, robot weld programming, and finally, welding of the structure. The system must be insensitive to the fume emission of the arc welding process.

The RTV will also be critical, because its performance affects the capabilities of the entire system. To provide maximum flexibility, the RTV will incorporate the controller for the 6-axis robot as well as all the arc welding equipment needed. This includes the power source, shielding gas supply, welding consumable, and auxiliary equipment.

The RTV will navigate via three independantly operating wheels that drive and steer it into position. Castors in the front and rear of the platform will provide balance while manouvring. Figure 3 shows the RTV while positioning the robot arm on one of the components used in the NOMAD project.

However, the greatest overall challenge of NOMAD is to merge the many subsystems into one single reliable system.

Figure 3. The RTV positioning the robot arm for welding.

About the author

Lars-Erik Stridh, EWE, graduated from Bergsskolan in 1982. He worked three years as a welding engineer at a repair and maintenance company in Gothenburg and after that 13 years as product manager for flux cored wires at Elga. Lars-Erik Stridh joined ESAB in 1999, is based in Gothenburg but works on ESAB's total market.

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The mechanised FCAW of high strength steel fender piles for the new Rio Paraná bridge

An innovative, integral and productive solution using ESAB Railtrac equipment for assembly welding on site.

By Eduardo Asta, ESAB-CONARCO Industrial Applications, Buenos Aires, Argentina.

ESAB-CONARCO gave valuable application support to its customer Puentes del Litoral SA., underlining ESAB's corporate slogan "Your partner in welding and cutting.

Introduction

The main concrete suspension bridge over the river Paraná is an important link in the motorway between the provinces of Santa Fe and Entre Rios, in Argentina. The bridge is 608m long and has two pylons that are protected against ship collisions by huge fender piles with a high strength steel shell. Each of the piles was constructed, on site, by joining four 9-10m long and 2m diameter pipe segments, lowered into the 37m deep river, driven into the river bed, and filled with reinforced concrete. ESAB-CONARCO Argentina provided an integral solution for the high productivity welding of the girth welds in horizontal-vertical (PC) position. This solution comprises the mechanised FCAW with ESAB Railtrac equipment, the welding procedure specification (WPS) and qualification tests (PQR), as well as welder training and qualification. ESAB –CONARCO welding technicians welded the first three piles, at the request of the main contractor Puentes del Litoral S.A.

Steel grade and filler metals

The steel used for the pile shells is 25mm thick Q&T HSLA according to ASTM A514 Grade B. Table 1 gives a typical chemical composition, the CE (IIW) and the Pcm value, as well as the mechanical properties. To ensure optimum productivity, all welding was performed with the FCAW process, manually on a steel backing strip for the root and mechanised with Railtrac equipment for filling and capping. The consumable chosen for all welding was ESAB-CONARCO TUBULARC 117 – 1.6mm, a low-hydrogen basic cored wire according to AWS 5.23: E110T5-K4 produced by ESAB in Argentina for the South American market*. It is welded under CO_2 shielding gas, which gives good protection outdoors. Table 2 gives the typical chemical composition and mechanical properties.

Figure 1. Railtrac equipment in operation.

Figure 2. Set-up during welding procedure qualification.

* Comparable ESAB basic cored wire types are:
Europe: OK Tubrod 15.27 or FILARC PZ6148
US and Asia Pacific: Dual Shield T-115

Welding procedure

Table 3 shows the approved welding procedure specification, qualified according to structural welding code AWS D1.1. The procedure offers the best possible combination of quality and productivity, taking into account the difficulties of welding HSLA steel on site, as well as the fact that each joint had to be finished within 4 hours to remain within the total project planning. Two Railtrac tractors with FCAW torches moved simultaneously in opposite directions along the aluminium rail attached to the shell, each completing half of the circumference (Figures 1 and 2).

Cracking control in HAZ and weld metal

The Q&T HSLA steel used has a characteristic microstructure consisting of tempered martensite. Its classification indicates that it is a weldable, low-carbon quality. Hydrogen induced cold cracking in the HAZ (heat affected zone) can be avoided by applying sufficient preheating and by selecting low-hydrogen welding consumables (<5mlH_2/100g). The main risk of hydrogen

Chemical composition %									
C	Mn	P	S	Si	Cr	Mo	V	CE_{IIW}	Pcm
0.18	0.91	0.002	0.004	0.28	0.54	0.20	0.4	0.49	0.29

Mechanical Properties			
Tensile Strength MPa	Yield Strength MPa	Elongation lo=50mm %	Impact (Charpy-V)-18°C J
837	773	20	Max. 152/Min. 134/ Prom. 143

Table 1. Chemical composition and mechanical properties of A 514 Grade B steel.

Chemical composition % in CO_2					
C	Mn	Si	Cr	Mo	Ni
0.07	1.90	0.45	0.50	0.45	2.30

Mechanical Properties			
Tensile Strength MPa	Yield Strength MPa	Elongation lo=50mm %	Impact (Charpy-V)-18°C J
760-900	> 680	> 18	> 35

Table 2. Chemical composition and mechanical properties of Tubularc117 (E 110 T5K4).

cracking, however, lies in the weld metal, since high strength consumables are used.

Unfortunately, there are no relationships or graphics that provide reliable guidelines to avoid weld metal hydrogen cracking.

In this case, ESAB-CONARCO used the qualification test set-up, under full restraint, to define the minimum preheat temperature, using the actual welding procedure and corresponding heat input. Ultrasonic testing revealed that a minimum preheating temperature of 150°C was required to avoid weld metal cracking. Additional Tekken, Slot and WIC tests confirmed that this was a safe preheating temperature for the weld metal.

To avoid cracks in the HAZ, three different methods were used to calculate preheating temperatures: BSI 5135; Ito y Bessyo; and Appendix XI of AWS D1.1 (see Figure 3). Aware of the fact that the calculation according to Ito and Bessyo tends to overestimate preheating temperatures for Q&T HSLA steels, an additional test was carried out using the qualification set-up and the actual steel quality, while applying the preheat temperature calculated according to AWS D1.1 (~80°C). Metallographic examination and 100% UT revealed no evidence of cracks in the heat affected zone.
It could now be concluded that 150°C was a safe preheating temperature for both weld metal and HAZ.
Figure 4 shows a macrograph of a cross section of the welded joint and the hardness traverses in the root, cap and HAZ's. An acceptable limit for HAZ and weld metal is 380HV5. No hardnesses beyond this level are recorded.

Welding equipment

Two ESAB LAW 520 heavy duty power sources with MEK 4SP wire feeders were used for FCAW, throughout the project. Mechanisation of the welding process was achieved with the flexible Railtrac FWR 1000 system, used with two tractors, digital programming boxes and remote controls. The aluminium guiding rails were attached to the shells with magnets.

Application and results

The welding of the piles, three of which were carried out by ESAB-CONARCO, took place on a circular platform placed on a pontoon. The platform was equipped with fixing gear to position the pipe segments to be joined, and all

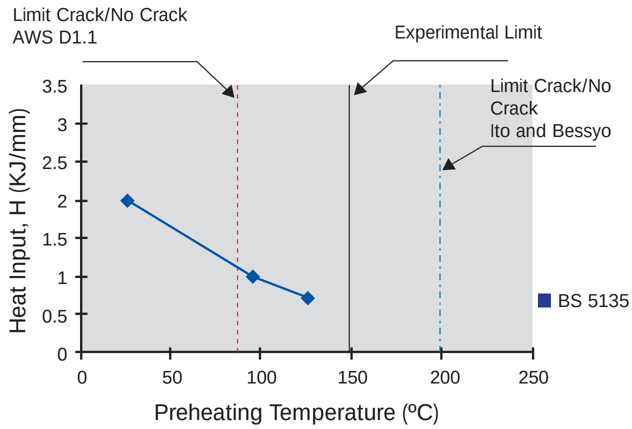
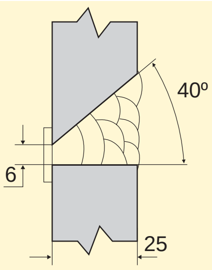


Figure 3. Preheating temperature analyses



Pass	Process	Filler Metal Class	Ø mm	Current Polarity	A	Voltage V	Weld.Speed mm/min
Root(1)	FCAW (SA*)	E110T5K4	1,6	CC+	250-300	28	150-170
Filling (2-5)	FCAW (M)	E110T5K4	1,6	CC+	300-370	28-30	280-300
Capping (6-9)	FCAW (M)	E110T5K4	1,6	CC+	220-280	23-26	300-500

SA- semi-automatic M-mechanised.

Table 3. Welding procedure of steel casing A514 Gr.B, thickness 25mm and outside diameter 2000mm.

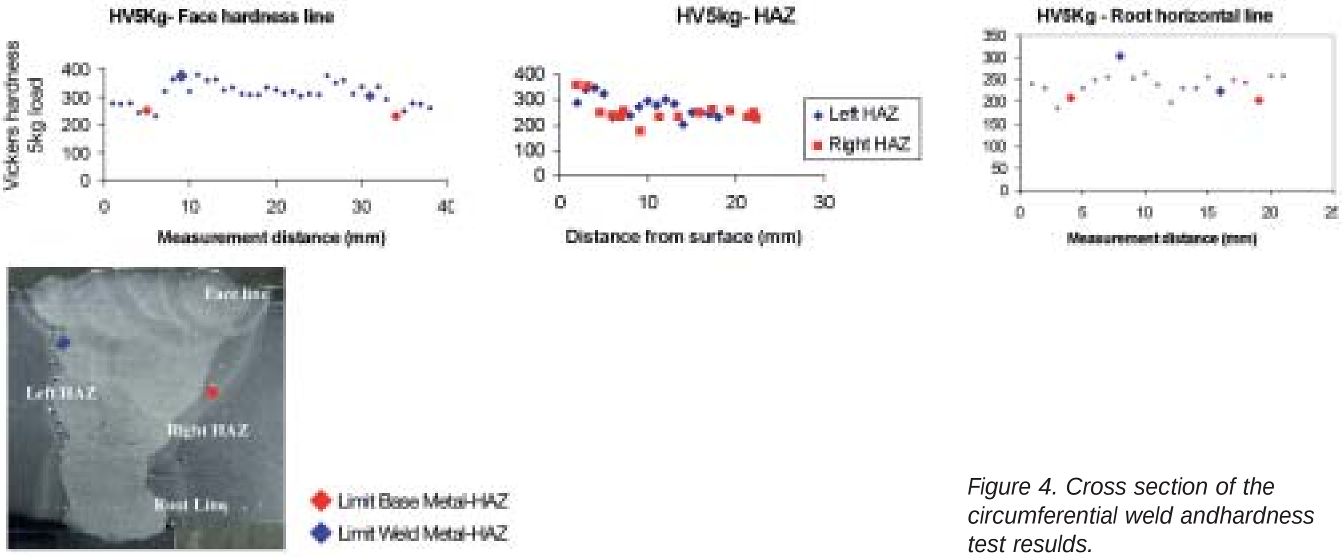


Figure 4. Cross section of the circumferential weld andhardness test resulds.

the necessary welding equipment. A tent, placed over the welding station, protected the FCAW process against adverse weather conditions (see Figure 5).

The welding solution provided the highest possible productivity for the on site welding of this structure. All joints have 9 beads deposited in four layers and, in total, 24kg of weld metal was consumed per joint; 12 kg per Railtrac. It took approximately three hours to complete one joint, so the average deposition rate was 4kg/h. All joints were visually inspected and 100% US tested. The welds were of a high quality and the defect rate was exceptionally low.

Acknowledgement

The author would like to thank Puentes del Litoral S.A, the Welding Group of Applied Mechanics Department of the Comahue National University of Argentina, La Fundación Latinoamericana de Soldadura(FLS) and ESAB-CONARCO Commercial management.

Figure 5. Welding station on site.

About the author

Eduardo Asta graduated from the National Technological University, Buenos Aires in 1982 as an Aeronautical engineer. He holds degrees in metallurgy and materials technology and in the science and technology of welding. He joined CONARCO in 1993 and is currently responsible for the ESAB-CONARCO industrial application department. He is also associated with the National Technological University as Director of the R&D Group on structural integrity and welding, and Professor at the Mechanical Department. He has published more than 60 publications in national and international magazines, including conference papers.

Figure 6. Construction overview.

ESAB welding solutions and support aid revived shipbuilding on the River Tyne in England

By: Dave Godfrey, ESAB UK.

Key role for ESAB metal-cored wires in the combat of distortion

When the Wallsend, Newcastle, yard of Swan Hunter Ltd closed in 1994, it appeared to be the end of shipbuilding on the river Tyne. The yard stood empty for a few years, before it was bought by Jaap Kroese, former owner of THC Fabricators.

Under its new ownership, the yard initially carried out a few small offshore related contracts, before being awarded a £200 million contract by Allseas BV to complete the conversion of a bulk carrier into a state of the art pipelay vessel, "The Solitaire".

Throughout this period ESAB personnel worked closely with the yards welding department, ensuring that ESAB consumables were used almost exclusively.

Against this background, when the yard returned to Naval Shipbuilding in 2001, ESAB were directly involved in qualification of a complete suite of new welding procedures.

Heavy plate fabrication and assembly of ring sections is carried out at the Wallsend yard.
Completed ring sections are moved from the main fabrication hall into a floating dry dock, where they are joined to form the hull of the ship
Thin plate fabrication and assembly of the entire superstructure takes place at Swan Hunter's newly opened Port Clarence yard 40 miles down the coast on Teeside. The completed superstructure is transported by barge to Wallsend, where it is lifted onto the hull as a fully welded unit.
Both yards have been comprehensively re-equipped with new welding sets, with 92 ESAB & Murex MIG sets installed since 1996, along with A6 tractor units, and a fully refurbished ESAB equipped panel line at the Wallsend yard.

Wallsend Panel Production.

Fully welded stiffened panels are produced on a Wenzlaff panel line, refurbished in 1999 and fitted with ESAB submerged arc equipment. Panel line procedures were qualified on plates of 6mm up to 15mm, welded using a square edge, no gap, double sided tandem arc procedure. Lead wire is OK Autrod 12.32 3.2mm and trail wire is OK Tubrod 15.00S, 3.0mm.

Running under ESAB OK Flux 10.47 (fused basic flux), a good appearance is achieved, at high welding speeds. Normal practice is to weld 5 plates to form a part welded panel, prior to turning for welding of side 2. The balanced bead sequence coupled with fast welding speeds keeps distortion at a minimum. The panel is then moved along by conveyor chains to the fillet welding station, which is equipped with 4 ESAB A6/LAE 800 units. Two heads are positioned each side of the stiffener, each pair of heads travelling half the panel width. Stiffeners are positioned and hydraulically clamped before being welded with 3.0mm OK Tubrod 15.00S/10.47. A 6mm leg length fillet can be made at 800mm/min, with primer being removed only from the bottom edge of the stiffener.

While these procedures produced very satisfactory results with plates of 8mm and above, distortion of the 6mm plates was recognised as a problem.

Port Clarence Fabrication.

Initial attempts at controlling thin plate distortion used a single 2.4mm wire (OK Autrod 12.32) SAW double sided procedure for butt joints, with OK Tubrod 15.14 in use for fillet welds, however distortion of the butt joints was still unacceptable, and difficulties were encountered in producing consistent 4mm leg length fillet welds with the 1.2mm rutile wire. At this point a more radical approach was taken, and two metal cored wires were introduced to the yard. Tubrod 14.12, 1.0mm diameter, has been in use at a South Coast U.K. shipbuilder for over ten years and is used for manual fillet welding in flat and vertical down positions.

At Swan Hunter, the 1.0mm OK Tubrod 14.12 was mounted on a tractor, and used to produce double sided butt joints in 6mm plate.

The joint preparation is still square edge –zero gap, but a very slight bevel is made to a depth of about 1mm, to aid alignment of the wire as it travels the 12 meter wide panel. The balanced procedure, with a heat input of 0.6KJ/mm, has resulted in a significant reduction in distortion, cutting down the time spent in rework and rectification.

OK Tubrod 14.11, 1.4mm diameter, was introduced for welding of bulb flats to panels, and fabrication of 'T' stiffeners, where a 4 – 5mm leg length was required.
Originally developed for robotic use in the automotive industry, 14.11 works on a high current – low voltage principle, resulting in a short, concentrated arc that can weld through shipyard primer without suffering porosity while producing neat double sided mitre shaped fillet welds at speeds of 800 mm/min, over primer.

A further benefit of 14.11's robotic capability is a very high level of reliability on restriking. This is important in shipbuilding, where spaced stitch welding is often used for welding of stiffeners to panels. Failure of the wire to reignite the arc leads not only to missed welds, but to stray arc strikes causing further rectification.

At both yards all positional welding is carried out with OK Tubrod 15.14 rutile flux cored wire. This wire is used inside the fabrication halls, and also in the dry dock for final assembly of the hull sections, and superstructure to hull welds.

For the few areas where cored wire welding is not practical, FILARC 56S and 88S electrodes are used.

Ever since the reopening of the yard ESAB's Salesmen, Process Specialists, and Welding Engineer have co-operated closely with Swan Hunter, and the benefits of this joint approach can be seen in the advanced processes and procedures in use. When a problem has arisen, both parties have worked together to find a solution, the most recent example being the successful introduction of 14.12 and 14.11 metal cored wires to combat distortion.

Finally, it is fitting to mention that July 2003 saw the launch of the Largs Bay, the first ship to be built on the River Tyne for ten years.

About the author

Dave Godfrey E.W.E. is Welding Engineering Manager for ESAB Group UK, Ltd. He joined ESAB in 1989 after having worked as a welding engineer for a UK pressure vessel fabricator. He is Senior Member of The Welding Institute.

Figure 1. Bow section of second ship ready for transfer to dry dock.

Figure 2. Primed bulk flats being welded with ESAB Tubrod 14.11.

Figure 3. Tee stiffeners being assembled onto panel at Pt Clarence yard

Figure 4. Equal leg length, no porosity, low distortion fillet with Tubrod 14.11.

Advances in Aluminum Welding within the Automotive Industry

By Tony Anderson, AlcoTec Wire Corporation

Aluminum's unique characteristics of light weight, strength, extrusion versatility, corrosion resistance, and recycling capabilities, make it the obvious choice of engineers and designers for a variety of welding fabrication applications.

Perhaps the most dynamic advance in aluminum welding fabrication is found in today's automotive industry. Promoted primarily through environmental issues such as increased fuel efficiency, corrosion resistance and recycling, more and more aluminium components are being seen in the average automobile. The high strength-to-weight ratio of aluminum allows strong, yet lightweight body structures to be built. It also allows larger crush zones that serve to reduce forces on vehicle occupants in a crash. Aluminum's use in light trucks, sports utility vehicles and minivans has tripled since 1991 mainly due to its environmental, safety and driving performance advantages.

This growth can be attributed in part to recent developments of major structural components – fabricated entirely from aluminum – such as frames, bumper beams, side impact beams, chassis components, engine cradles, front and rear suspension frames, drive shafts and wheels. These applications complement the more traditional non-structural components such as heat exchangers, radiators, body trim, and air conditioning units. Many of these welded structural components are manufactured using 6xxx series (Aluminum-Magnesium-Silicon) heat-treatable base alloys, making use of this material's ability to produce complex extruded shapes and they are often welded with the GMAW (MIG) welding process.

The use of aluminum can cut a vehicle's weight by 10% and boost its fuel economy up to 8% – or as much as 2.5 extra miles per gallon. A vehicle that uses less fuel (by lowering its weight with aluminum) produces fewer greenhouse gas emissions. Over the average lifetime of a vehicle, every pound of aluminum that replaces two pounds of steel can save the emission of 20 pounds of CO_2.

Safety is another issue associated with the use of aluminum within the automotive industry. In recent years, great strides have been made in creating leading-edge designs and using advanced materials to provide maximum safety. Most cars and trucks today are designed with a "safety cage" surrounding the passengers. To best protect the people inside, a cage should be strong, maintain its shape in a crash and prevent intrusion into the passengers' survival space. To help make this happen, safety engineers design crumple zones into the front and rear of a vehicle to absorb the energy of an impact.

The challenge is to provide protection while giving consumers the ride, handling and performance characteristics they demand. Pound for pound, aluminum is up to two-and-a-half times stronger than steel and can absorb crash energy without shattering. In the event of a crash, vehicle structure - not the vehicle passengers – should absorb the crash energy. Aluminum is ideal for this purpose.
Auto aluminum use is at an all time high and there is no disputing that today's cars and trucks are safer than ever before.

What happens when an aluminum-intensive vehicle is crashed?

Aluminum structures can be designed to fold during a crash in a predictable manner, absorbing maximum energy to protect passengers from destructive crash forces. The best example to date is Audi's A8 luxury flagship sedan, which features a revolutionary aluminum space frame, integrated with aluminum panels to enhance rigidity and crash resistance. After it was tested by the National Highway Traffic Safety Administration in a head-on collision at 35 miles per hour, the A8 received the federal government's highest safety rating - five stars for the driver and five for the front passenger.

Aluminum's basic physical characteristics lend themselves to the design of automobiles that not only perform better in a collision, but can actually help to prevent crashes altogether! Aluminum's strength-to-weight ratio allows engineers to construct larger vehicle crash zones for better energy absorption. Aluminum structures can be designed to absorb the same energy as steel – at just 55% of the weight! This weight saving relates to less kinetic energy to be absorbed in a collision.

Aluminum-intensive vehicles provide better handling and braking capability, improving their crash-avoidance ability. A vehicle made of conventional material weighing 3,300 lbs. traveling at 60 mph requires 213 feet to stop.
Given the same drivetrain, an aluminum-intensive vehicle of equal size would weigh 2,000 lbs. and could stop in 135 feet. Similar improvements are seen in acceleration ability, when a little extra speed could make the difference in avoiding a collision.

The increasing use of aluminum in the automotive industry has necessitated the development of specialized welding equipment and the need for technical training and support for manufacturers. The most common challenges encountered when moving from steel to aluminum welding – feedability, porosity, solidification cracking, and filler alloy selection – have been overcome by the automotive aluminum welding fabricators through education. The successful conversion from steel to aluminum welding techniques is often achieved through an understanding of the fundamental differences between these two materials, through specialized training, and the development of new procedures and working practices.

Welding procedures for thin wall heat exchanger fabrication make use of filler alloy ER4047, which contains 11.0 to 13.0% silicon and provides exceptional fluidity that helps reduce leakage rates during the manufacturing process, thereby improving productivity. The thicker material structural applications within this industry are often able to make use of filler alloy ER5356 (Aluminum- 5% Magnesium), taking advantage of this alloy's improved strength, ductility and impact properties. Components subjected to elevated temperatures during service are often welded with filler alloy ER5554, which has less than 3% magnesium (2.4 to 3.0%Mg) and is designed for that specific application, maintaining good strength and low susceptibility to stress corrosion cracking. Welding procedures vary but, wherever possible, make use of robotics and automation.

The use of aluminum continues to grow within the automotive industry and, with it, grow the need for suitable aluminum filler alloys, the further development of welding equipment specifically designed for welding aluminum, and the requirement for resources to provide the industry with training and technical support.

The Ferrari 360 Modena uses aluminum for the body and space frame, and several other components. In the future, all Ferrari vehicles will be aluminum-intensive. The reason? Taking weight out improves driving performance related to acceleration, braking and handling.

The aluminum-bodied Honda Insight was designed from the ground up to achieve world-class fuel economy and ultra low emissions

Just look at a sample of aluminum-bodied sports cars and winning race cars of past years. It reads like a Who's Who of motor sports:

- The stylish Mercedes-Benz 300 SL Gullwing (pictured below)
- The fire-breathing AC Cobra
- The sleek Jaguar D-Type
- The four-time LeMans-winning Ford GT40

At the 2003 North American International Auto Show, finalists for the Car and Truck of the Year awards all had at least one thing in common - the strategic use of advanced aluminum technologies.

Acknowledgment:

Much of the information within this article was acquired from the Aluminum Association, Washington DC. USA.

About The Author:

Tony Anderson is Technical Services Manager of AlcoTec Wire Corporation, MI, USA, Chairman of the Aluminum Association Technical Advisory Committee on Welding and Joining, Chairman of the American Welding Society (AWS) Committee for D10.7 Gas Shielded Arc Welding of Aluminum Pipe, Chairman of the AWS B8.14 Committee for Automotive and Light Truck Components Weld Quality - Aluminum Arc Welding and Vice Chairman of the AWS Committee for D1.2 Structural Welding Code - Aluminum.

ESAB Achievements within the aluminum automotive industry

AlcoTec Wire Corporation is the ESAB Center of Excellence for aluminum welding.

AlcoTec has worked closely with automotive component manufacturers on the development of welding procedures for many aluminum-fabricated components.

Aluminum Drive Shafts - Major improvements to welding efficiency were achieved through procedures designed to increase welding speed and reduce overall heat input on welded aluminum drive shafts.

Aluminum Wheels – Direct involvement with the development of specialized welding procedures used for the fabrication of automotive wheels. These developments involved particular attention to ramp-up and ramp-down parameters necessary to achieve acceptable stop/start characteristics. Also, the evaluation of various shielding gas mixtures in order to establish the most effective mixtures of argon and helium capable of producing improved weld profiles and consequently superior weld performance characteristics.

Heat Treated Sport Car Components – Provided assistance to the manufacturers of specialized sports cars. Helped develop welding procedures for the 6xxx series (Al-Mg-Si) base alloys that are to be post weld heat-treated. Providing specialized heat treatable filler alloy that will respond fully to thermal treatment and ensure maximum welded joint strength necessary for these high performance applications.

Engine Cradles – Helped with the development of welding procedures for the manufacturers of aluminum engine cradles, providing advice on alternate filler alloys capable of producing improved strength and ductility and being suitable for elevated temperature services.

Heat Exchangers – Assisted with the development of welding procedures capable of improving weld quality and increasing productivity. This being primarily achieved through changing from 5% silicon to 12% silicon filler alloy. The improved fluidity of the higher silicon filler material provided the opportunity for producing welds that require far fewer repairs after leak testing.

Aluminum Drum Pack – One of the most significant developments was the introduction of the AlumaPak 300 pound drum pack. This bulk wire delivery system is ideal for robotic welding applications. Many large automotive component manufacturers are now taking advantage of this packaging in order to reduce down time and improve productivity.

Shielding gases for welding and backing of stainless steels

By: Th. Ammann, Linde Gas, Unterschleissheim

Published in "Jahrbuch Schweißtechnik 2001", DVS-Verlag, Düsseldorf

Introduction

According to [1], the following distinctions are drawn between austenitic chromium- nickel steels:

austenitic steels with/without molybdenum,

austenitic steels with especially low carbon content to avoid intercrystalline corrosion, stabilised austenitic steels, also with improved resistance to intercrystalline corrosion, fully austenitic steels, which have very good corrosion resistance as a result of a completely austenitic structure, and austenitic-ferritic (duplex) steels. With their two-phase, ferrite and austenite structure, these steel grades feature good resistance to stress corrosion cracking and pitting corrosion with simultaneously improved strength and toughness.
The ideal ferrite/austenite ratio is 50:50.

The weldability of austenitic steels is generally very good. It should be noted that tarnish forms on the workpiece surfaces as a result of oxidation processes caused by the heat input in conjunction with atmospheric oxygen. Since this tarnish can seriously impair the corrosion resistance of stainless steels, it should be avoided, by proper forming, or removed after welding by pickling, sandblasting or a similar process. Best results are achieved by a combination of both processes, i.e. by forming or sandblasting followed by pickling treatment.

Stainless steels differ from unalloyed steels, not only in their corrosion resistance, but also in their considerably lower thermal conductivity and higher thermal expansion, which can result in strong distortion. Moreover, the melt is significantly more viscous in welding.

Shielding gases for all shielding-gas welding processes are standardised in [2] for both welding shielding gases as well as root shielding gases. The characterisation is not definite, but performed on the basis of concentration ranges, with the result that an EN designation alone does not suffice to describe a certain shielding gas mixture. This must be noted, for example, when ordering shielding gases.

Shielding gases for MIG

MIG welding under pure argon is not often used on stainless steels. Without active shielding gas components like CO_2 or oxygen, the arc is unstable. The thermal conductivity and ionisation energy of argon are low, the heat input in the workpiece correspondingly poor. As a result, the melt is very viscous, the metal transfer and the wetting characteristics are poor. This leads to an irregular seam with unsatisfactory penetration. Therefore shielding gases for high-alloy steels usually contain active gas components, i.e. additives of oxygen or carbon dioxide, which stabilise the arc, improve wetting characteristics and increase heat input into the workpiece.

Argon/oxygen mixtures for gas metal arc welding of chrome nickel materials contain between 1 and 3% O_2. They produce a stable arc and a low-spatter welding process. Compared to Argon/CO_2 mixes, however, disadvantages are the high degree of oxidation, low heat input and susceptibility to pore formation. Although heat input can be improved by using higher oxygen contents, this increases oxidation on the seam surface to the same extent. Further, an increase in adherent faults on the weld seam is likely, which have to be removed before pickling by grinding or hammering.

Argon-based shielding gases with a CO_2 content of around 2.5% have, therefore, largely won through for MIG welding of chromium-nickel steels. As a result of dissociation and recombination processes of the CO_2 molecules in the arc, higher heat input is attained with simultaneously improved oxidation and pore characteristics. Compared to Ar/O_2 mixtures, the seam is wider and melting on to the base material safer because of the higher heat input.

Shielding gases with additional contents of helium can be used to further improve the wetting characteristics and to increase welding speed. The helium content is usually between 20% and 50%. Compared to argon, the ionisation energy and thermal conductivity of the helium are considerably higher, which results in stronger heat input into the workpiece. As a result the melt is heated more strongly and becomes more fluid. The high thermal conductivity of the helium provides improved heat transmission in the base material, and in the cross-section it can clearly be seen that with a little larger root penetration, the welding bead is wider (figure 1). The gases with heli-

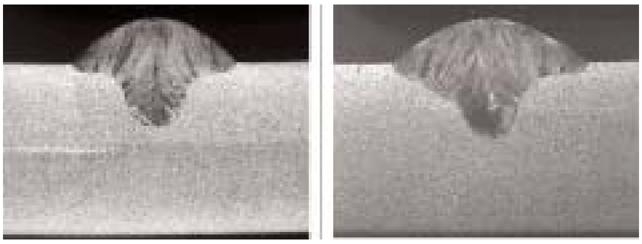


Figure 1. MAG welding on 1.4301/304, fully mechanised, wire Ø 1.2 mm, v_{Wire} = 9.4 m/min, PA position. Ar + 2.5% CO_2, left side, compared to Ar+2% CO_2 + 20% He, right side

um also have a positive influence on welding of very viscous molybdenum-alloyed chrome nickel materials. These steels tend, especially when welding at higher powers, to form deposits on the surface, which are difficult to remove. This tendency can be reduced by using gases containing helium.

Shielding gases for TIG welding

Argon is still the standard shielding gas for TIG welding of high-alloy steels. Welding speed can be increased with shielding gases containing hydrogen – normal hydrogen content between 2% and 20% depending on the application – in addition to the argon. In the case of manual welding, however, the welder should gradually be accustomed to the increased hydrogen content in the shielding gas and the resultant increase in the welding speed. Contents of more than 6% hydrogen can no longer be controlled by hand in the case of most welding jobs. Such gases remain the preserve of semi- or fully mechanised TIG processes.

Due to their high ferrite content, duplex steels should not be welded with hydrogenous gases in order to prevent the risk of hydrogen-induced cracking. In addition, pore formation can occur on some high-alloyed materials as the hydrogen content in the welding shielding gas rises. One of the main rules when welding with hydrogenous shielding gases is the elimination of oxygen or oxygen carriers from the area of the arc. The prime oxygen carriers in this regard are tarnish, rolling skin, etc. For example, in TIG orbital welding of chrome nickel tubes with hydrogenous shielding gases, pores often form when welding over the start area again at the end of the welding process. Tarnish, i.e. oxides, forms there at the start of welding and is then reintroduced into the welding process when finishing the weld.

The simultaneous presence of oxygen or carbon dioxide in a hydrogenous shielding gas can also lead to increased pore formation, e.g. in MAG welding.
The suitability of hydrogenous gases should always be checked in test welds.

Nitrogenous gas mixtures are a further consideration with TIG shielding gases. Due to the strong austenitising effect of the nitrogen, they enable a reduction in the ferrite content in the welding deposit and are already being used successfully on non ferrite-free full austenites and duplex steels. However, it must also be said that the lifetime of the TIG electrode is reduced when welding with nitrogenous shielding gases, i.e. it must be reground more frequently than is the case with argon.

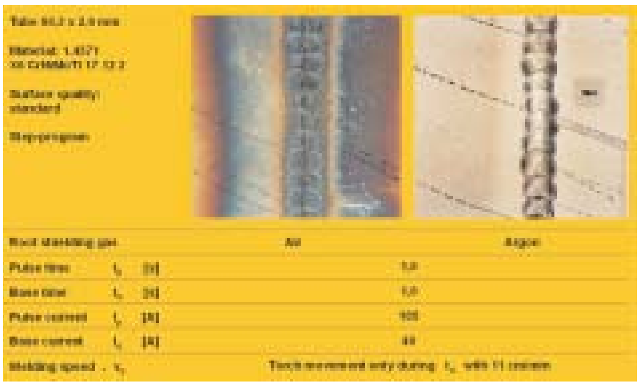


Figure 2: Formation of the weld seam root without and with root shielding

Shielding gas	Material
Argon	All materials
Ar/H_2 mixtures	Austenitic chrome nickel steels, nickel and nickel-based materials
N_2/H_2 mixtures	Steels with the exception of high-tensile fine grain steels, austenitic steels (not titanium-stabilised)
N_2	Ar/N_2 mixtures Austenitic chrome nickel steels, duplex and superduplex materials

Table 1: Root shielding gases for various materials

Gases for root shielding

The aim and object of root shielding is firstly to prevent the formation of tarnish or oxidation and, secondly, a safe root penetration guaranteed by the root shielding gas, due to reduced oxidation of the seam edges. Figure 2 shows how such oxidation can impair the formation of a root. While the seam on the right was formed properly, in the case of the seam on the left, no root was able to form because of the contact with air. Due to strong oxidation, the workpiece edges did not join, recognisable by the black line in the middle of the seam.

A distinction is drawn between three types of purging:
displacement purging, in which the specific weight of the root shielding gas is used to displace the air from a volume and replace it with shielding gas (figure 3),
dilution purging, in which the flowing shielding gas gradually reduces the residual oxygen content at the seam,
evacuation purging, in which the volume being purged is first pumped empty of air and then filled with shielding gas.
Table 1 gives an overview of the shielding gases for root shielding.

Various criteria must be considered in selecting the correct root shielding gas:

a. Metallurgical viewpoints: can the material be damaged by the root shielding gas?
b. Relative density: which type of purging is used?
c. Availability: can the welding shielding gas also be used as root shielding gas?

Re a): Ferritic and ferritic-austenitic (duplex) materials should not be formed with hydrogenous gases to prevent the risk of hydrogen-induced cracking.
A further restriction applies to the root shielding of titanium-stabilised steels (e.g. 1.4571) with nitrogenous root shielding gases. In this case the titanium in the material and the nitrogen in the shielding gas combine to form titanium nitride, which is deposited on the seam root and causes noticeable yellowing. This yellowing is easy to distinguish from tarnish because it only occurs on the remelted seam areas and not in the heat-influenced base material (figure 4).

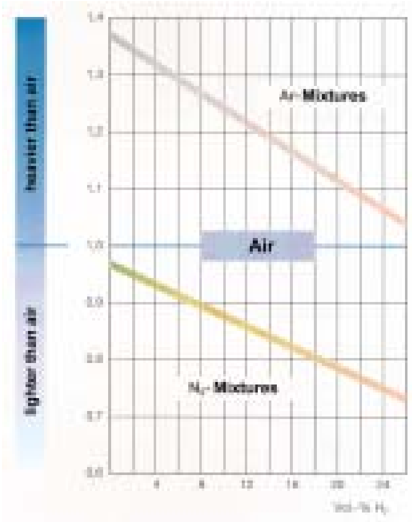


Figure 3: Relative density of root shielding gases compared to air.

Re b): For example, displacement purging in a tank. N_2/H_2 mixtures (lighter than air) should be introduced from above, argon or Ar/H_2 mixtures (heavier than air) from below.

Re c): If, for example, an Ar/H_2 mixture is used as welding shielding gas for mechanised TIG welding, in most cases there is nothing against using the same gas as root shielding gas as well (cf. chap. 3).

The most important parameter for determining an adequate purge time is the residual oxygen content in the area of the seam root. A residual oxygen content of approx. 50 vpm can be seen as suitably low. This value should, however, only be used as a guide because the thickness of the tarnish also depends on the surface quality of the material and on the section energy introduced.

Due to the many different possible welding projects and workpiece geometries, it is virtually impossible to predict exact purge times, permissible residual oxygen quantities and the thickness of tarnishing. An aid for the calculation of pre-purge times is given in [3]. First guide values for the necessary pre-purge time can be calculated with the help of the diagram – but they should still be checked in tests. A number of basic rules, however, apply to the use of root shielding gases:

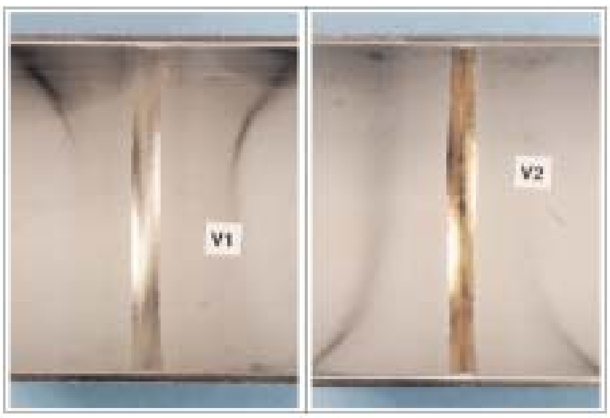


Figure 4: Yellowing of the root by titanium nitride. Left formed with argon, right with N2/H2 90/10, Material 1.4571/316Ti, TIG orbital

The volume that is to be purged should be kept as small as possible, e.g. through forming devices adapted specially to the workpiece.
The root shielding gas should flow out slowly, over as large an area as possible and steadily in order to avoid turbulence with the air. This is especially important in the case of displacement purging. Higher purge gas flow rate does not necessarily cause a reduced purging time. Here, less is often more.

Application example

For the piping of a chemical tanker, pipes of duplex steel 1.4462 were to be welded with the TIG orbital process. The following method was proposed:

Material 1.4462 (X2 CrNiMoN 22-5-3) Pipe dimensions Ø 54 mm x 2 mm Welding method TIG orbital, pulsed current, without filler metal Welding speed 4.5 cm/min Pulse frequency 2.2 Hz Base current / Pulse current 30A / 60A .

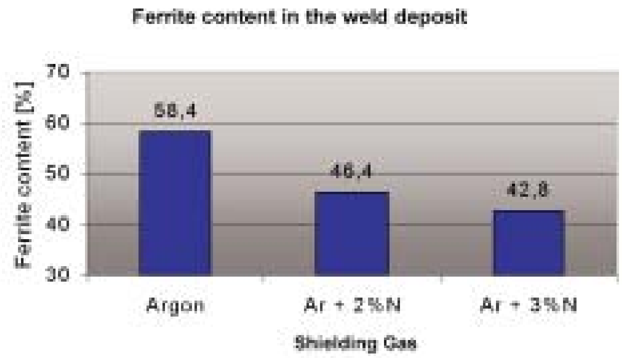


Figure 5: Ferrite contents in the welding deposit depending on the nitrogen content in the welding shielding gas

Various nitrogenous shielding gases were used for the preliminary tests to investigate their influence on the ferrite content in the welding deposit. The ferrite content was measured using a magneto-inductive measuring device. The mean value of 20 measurements on the girth of the top of the weld seam was formed in each case. The results are summarised in figure 5. The influence of the different nitrogen contents in the welding shielding gas can clearly be seen. The ferrite content in the welding deposit drops as the nitrogen content increases. In this case, in order to better visualize the trend, the mean ferrite content is given in percent, whereas in practice usually the Ferrite Number (FN) is used.
In this particular case, the use of a shielding gas mixture $Ar+2\%N_2$ would be recommended. This shielding gas comes closest to producing a result with the ideal ferrite content of 50%, while the electrode consumption remains within bounds. Dispensing with the otherwise necessary welding filler, results in significant saving in costs.

References

[1] N.N.: DIN EN 10088 T1 ”Nichtrostende Stähle. Teil 1: Verzeichnis der nichtrostenden Stähle”, Issue August 1995, Beuth-Verlag, Berlin.
[2] N.N.: DIN EN 439 ”Schutzgase zum Lichtbogenschweißen und Schneiden”, Issue May 1995, Beuth-Verlag, Berlin.
[3] N.N.: DVS Leaflet 0937 ”Wurzelschutz beim Schutzgasschweißen”, DVS-Verlag Düsseldorf, 2001.

The ESAB Process Center

By: Lars-Erik Stridh, ESAB AB, Gothenburg, Sweden.

Valuable application support for our clients

ESAB's Process and Application Center

in Gothenburg, Sweden, is a welding technology center that supports the company's sales organisations with practical application research for customers. It also supports the education and training of client's, distributors and ESAB personnel. As part of the compay's global Process & Application facility, the center is equipped with most ESAB welding equipment and automation product ranges, including the latest power sources.

This article highlights a typical application research project for a customer in the automotive industry. It deals with robotic welding of car components on production lines. For productivity reasons, fabricators are reluctant to stop production lines, for instance to allow the testing of new welding consumables. In such cases, the Process Center can undertake useful research on its own robot installations, using the same components that are being welded on the customer's production line. The results, including productivity data, are reported back to the customer so that he can verify the quality of the component welded with the new consumable. Since parameters are already known, implementation of the new solution on the production line is relatively easy and downtime is minimised.

Lower suspension link arm

The link arms (Photo) are components of the front suspension of a passenger car. One arm has a total weld length of 940mm. They are welded in one installation, with one robot, one torch cleaning station, and two welding stations; one for the left suspension arm and one for the right suspension arm.

In the previous situation, The welding consumable was an SG2 type solid wire, diameter 1.2mm, welded under 92/18 Ar/CO_2 shielding gas. The parameters were 290A/26V at an average speed of 84cm/min. The plate thickness is 2.3mm and it involved mainly overlap joints, except the fillet welds for the plate-tube connection.

The main problem was the high amount of spatter, resulting in substantial post weld cleaning work, as well as very frequent torch cleaning. The electronic records of the robot cell gave a total cycle time of 260s: 115s for welding the left arm, 15s for torch cleaning, 115s for welding the right arm, and another 15s for torch cleaning.

Results of the Process Center

ESAB has previous, experience in a typical automotive application using 4-5mm thin metal sheet – using large diameter metal-cored OK Tubrod 14.11 or FILARC PZ6105R. Both of these ESAB products – specially developed for robotic welding – have dependable feedability and an extremely stable arc. Benefits compared to solid wire are higher productivity, better penetration, wider arc, better ability to cope with gaps, and reduced spatter.

Shielded gas is also desirable with these wires. For thinner material, the amount of argon in the mixed gas is increased to a maximum level of 98% for 1mm sheet metal.

In this application case, ESAB preferred to use Ar/8%CO_2 shielding gas, but this was not possible. It was necessary to stay with the gas supplied by the customer's ring system, Ar/18%CO_2.

Successful Process Centre tests with OK 14.12 yielded the following optimal parameters: 300A/24V and a travel speed of 150cm/min., indicating substantial productivity gains. After programming and fine-tuning all parameters in the customer's robot cell (figure 4), a first series of suspension links were welded with the new consumable. It soon became clear that frequent torch cleaning sessions were no longer needed, and 9 out of 10 were removed.

Now, the final production cycle is 94s for the left arm and 94s for the right arm, to which were added only 1.5s for torch cleaning. The cycle time was reduced from 260s to 189s, a reduction of 27%. In addition, the amount of rejects to be repaired or cleaned has been dramatically reduced.

About the author

Lars-Erik Stridh, EWE, graduated from Bergsskolan in 1982. He worked three years as a welding engineer at a repair and maintenance company in Gothenburg and after that 13 years as product manager for flux cored wires at Elga. Lars-Erik Stridh joined ESAB in 1999, is based in Gothenburg but works on ESAB's total market.

Stub-ends & Spatter

ESAB joint venture in China

ESAB recently acquired the minority shares in its joint venture Shanghai ESAB Cutting Systems Co. Limited in China. Under its new name, ESAB Welding & Cutting Systems China Limited (EWCSC), it will become ESAB's centre for automated welding and cutting solutions in North East Asia.

ESAB currently supplies CNC cutting machines to the Chinese and Asia Pacific markets and has already established itself as a leader in design, quality and process control integration.

As well as the opportunities for automated cutting in the region the welding automation market is expected to show a high growth rate over the coming decade. Through EWCSC, with its dedicated sales and after sales force, and by establishing a nationwide distributor network, ESAB is planning to be the dominant player in the market for automated welding and cutting systems in the region.

ESAB is planning to relocate from its current location in the Jangpu district to larger facilities within Shanghai.

New ESAB submerged arc flux plant in USA

ESAB's newest submerged arc flux plant began operation in Hanover, Pennsylvania, USA, in April 2003, complementing ESAB flux production facilities in Sweden, Poland, Hungary, Brazil, Indonesia, and the Czech Republic. Initially, the Hanover plant is producing OK Flux 429 to serve the North American Market. However, it has been designed with the capability to produce the full ESAB range of agglomerated fluxes for welding carbon and low-allow steels. The capability of the new plant – coupled with capital improvements at our wire plant in Ashtabula, Ohio, and the U.S. expansion of the ESAB Automation Group – enhances our ability to provide customers with process solutions that improve their productivity and reduce manufacturing costs. All ESAB plant facilities in North America are ISO9000 Registered, ensuring that quality is 'built in' to every product, from design to manufacturing.

ESAB lands contract for automated welding equipment for a Russian pipe mill

ESAB Welding & Cutting Automation has won a contract from Vyksa Steel Works in Russia for the supply of the latest automated line pipe welding equipment. The contract includes the supply of OK Flux 10.74 in 1000kg BigBags for the production of pipe for the Sakhalin I project.

Svetsaren Extra on the net

This issue of Svetsaren – including additional articles – is available on our web site esab.com as Svetsaren Extra.

The Wall

The newly opened TWI building in Cambridge, UK, features a spectacular wall construction made from friction stir welded aluminium panels. The panels, joined together to form a series of plates, give a unique architectural appearance to the impressive entrance hall.

The benefits of using friction stir welded wall panels include:

light weight for easy mounting
corrosion resistant
straight, flat surfaces
ability to 'decorate' panels using the welding tool
good looks with attractive, modern appearance

Steel profiles beware! This is the first time that friction stir panels have been used as wall panels in buildings – but it will certainly not be the last!

Product News

Wake up, it is time to catch the bus!

ESAB Welding Equipment AB, Laxå has received an order from Goffi of Villanuova sul Clisi, Italy for 44 Profibus equipped U8 control boxes. Goffi will use the products to integrate AristoMig welding packages into welding lines for the production of scaffoldings.

In the 1980s, ESAB introduced the microcomputer controlled LUB 315 – a simple compact inverter. The LUC 500, with pulse welding capability, followed. The need to handle the increasing number of pulse welding parameters led to the need for better communication between the setting panel and the power unit than could be achieved with electrical wiring. At the time, a serial communication link was used as the solution. It was obvious that this was not the best solution since the feeder was left with conventional wired communication for each function. This greatly reduced the flexibility of the welding system, in that it could only use a dedicated feeder and not take advantage of the complete ESAB feeder line.

ESAB later sold its welding robot division to ABB (1992) and the companies co-operated on the development of an integrated welding system within the robot cabinet. ABB named the product Arcitec. This development was the breakthrough for bus communication in welding equipment. Now, all elements of the system communicated with CAN based DeviceNet bus system and the setting panel was integrated into the pendant of the robot controller. When the Aristo-2000 (LUD450) was developed in the mid-1990s, the CAN based communication structure was established for volume production.

Realising the business potential from volume-produced, standard equipment, an ESAB market study, during 1999, visited more than a dozen robot manufacturers and system integrators.
The study concluded that:

- Robot manufacturers were not interested in complete integration with just one welding equipment manufacturer.
- System integrators wanted direct bus communication for welding equipment.
- Welding manufacturers would not succeed in establishing a 'communication standard'.

The conclusion was clear. ESAB must offer all common field bus communication standards with its welding systems.

This product is supplied by Aristo-products, and the products are assembled on a line in Laxå with the flexibility to switch between different variants. Components are added to standard products from the line to produce direct field bus connection possible.

Today, ESAB offers three field bus systems: DeviceNet, Profibus and CANopen. We also have the ability to supply any field bus in the future.

Peter Budai, R&D Manager ESAB Welding Equipment AB. Laxå.

AristoMig U500

ESAB's new AristoMig U500 inverter is an advanced, user-friendly, multi-process power source for the (pulsed) MIG/MAG, (pulsed) DC-TIG and MMA welding of practically all weldable materials.

The power source can be equipped with AristoFeed 30-4 or 48-4 wire feeders and an optional water cooling unit for MIG/MAG guns and TIG torches. Customers can specify the new U6 control panel or the AristoPendant U8 control box. Both are highly advanced units on which up to 99 sets of welding parameters can be stored. They come with a number of pre-programmed synergic lines for easy start-up. The AristoPendant U8 allows quick transfer of welding parameters to other AristoMig U500 units by means of a memory card.

In addition, ESAB has also developed ESAT (ESAB Software Administration Tool), a special PC program for the up and down-loading of synergic data.
Custom-made synergic lines can be uploaded from AristoPendant U8 and down-loaded to the U6 control panel, or the standard synergic lines can be replaced by newly developed synergic lines.

The AristoMig U500 is user-friendly and even inexperienced welders can achieve good results with help of the preprogrammed synergic lines. At the same time, it is sophisticated enough for skilled welders to achieve an exceptional performance in a wide variety of applications.

The new 500A power module is also used for two other new members of the Aristo family:

- AristoArc 500 (MMA) equipped with A2 or A4 control panels
- AristoMig 500 with AristoFeed 30-4 or AristoFeed 48-4 and with the control panels M2, MA4 or MA6.

Parameter documentation printer

ESAB's welding parameter documentation printer can be used with Prowelder 160, 250, 320 and PROTIG 450 power sources for mechanised TIG welding.
Both programmed welding parameters and the measured values for speed, current, voltage, wire and power, are printed for each sector of the programme.
The print-out also records the power source used, date, time, run number, and total weld time.

Two new fluxes for welding on rust and mill scale.

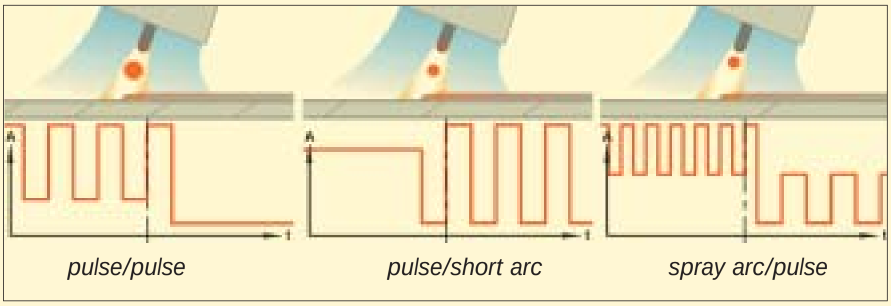
OK Flux 10.78 and OK Flux 10.88 are two new fluxes with a high tolerance for rust and mill scale. OK 10.78 is an agglomerated aluminate-basic type and OK 10.88 is agglomerated aluminate-rutile. Both are welded with OK Autrod 12.10, 12.20 or 12.22 solid wires.

ESAB still recommends that rust and mill scale be removed from the weld area. These fluxes are an option when the weld zone cannot be adequately cleaned. They are available in 15kg paper bags, 600kg BigBag and 1000kg BigBag.

New flux for low-temperature applications

OK Flux 10.72 is a new agglomerated aluminate basic flux for welds that require good CVN toughness down to –50°C. It has an extremely high current carrying capacity and is suitable for multi-wire applications (Tandem, Twin-arc). It is intended for single and multi-layer welding in an unlimited plate thickness. Slag release is excellent, also in narrow joints. Typical applications are windmill towers, pressure vessels and general construction.

Classification:
EN 760 SA AB 1 58 AC
Basicity Index 1.9



Full control over heat input with new Aristo SuperPulse™

Aristo SuperPulse is a further development of the pulse/pulse concept, giving full control over the heat input and thereby expanding the scope of application of the MIG process.
In addition to pulse/pulse, the following arc mode combinations and applications are possible:

- Pulse/short arc. Enables the welding of very thin sheet metal. Productive welding of root passes replacing the TIG process.
- Spray arc/pulse. A very efficient arc mode for positional welding of thick materials. Aluminium can be welded straight upwards, without weaving.
- MIG brazing of very thin sheet material.

Aristo SuperPulse brings the following general benefits:

- Easier positional welding
- Uniform penetration
- Less sensitive for root gap variations
- Less sensitive for unequal heat transfer
- TIG weld appearance with the MIG process
- Suitable for mechanisation, e.g. with Railtrac and Miggytrac
- Extends the working range for larger wire sizes

A complete Aristo SuperPulse package consists of an AristoMig 500w power source with AristoFeed 30-4w wire feeder, a PSF 410w welding torch and the AristoPendant U8 control box.

ESAB Marking Options

Various marking options are available with ESAB cutting machines. For maximum productivity, the marking function is managed and monitored by the ESAB control unit, together with most of the other cutting process functions. All parameters are directly programmed via integrated databases avoiding unnecessary manual settings and enabling a very high productivity by automatically mastering the marking and cutting sequences, by CNC.

Felt pen marking

Used on small machines. Particularly suitable for stainless steel, because it does not damage the material surface and can be removed. Constant distance and pressure of a classic felt pen, magnetically clamped onto its bracket, is ensured by a capacitive height control. The ideal solution for drawing folding lines or assembly marks, with speeds up to 12m/min.

Powder marking

When a mixture of zinc powder and oxygen is ignited in the nozzle, the melted zinc creates a visible line. Used for continuous or dotted line marking, lettering, and assembly marks. The line thickness depends on the nozzle type and marking speed.

Air scribe

The pneumatic Scribe Marker is ideal for high-speed, high accuracy marking. It uses an HF vibrating tool with a hardened steel tip, floating on a vertical bearing slide, to create single point marks or scribed lines on any metal. It operates on standard compressed air. It is usually added in tandem with a cutting station and can be supplied with automatic height control and motorised lifter. Makes a thinner, more accurate line than the pneumatic Punch Marker.

Punch marking system

The pneumatic Punch Marker is primarily installed on medium size and large machines. It is highly efficient when the plate must be drilled, because it creates the drilling spot to be tooled on later.
The marking frequency and punching power are adjustable and allow the NC-controlled marking of dots, lines or letters. A marking speed of about 3m/min. is recommended to prolong tip life time.

Pin Stamp Marker

The best option for high speed marking of high quality text strings of different sizes at multiple locations, leaving sharp, deep characters that remain visible after painting. Ideal for part-, heat-, or serial numbers. The printer head is placed inside a protective enclosure, which mounts the height control sensors, and is suspended from a breakaway crash protection device. The entire assembly is mounted on a heavy duty vertical lifter for accurate positioning.

Plasma marking tool “Arc Marker”

Plasma marking is an excellent method to produce dots, letters, lines and assembly marks with a speed of 3 up to 18 m/min., on mild and stainless steel and other electrically conductive materials. A major advantage is the ability to mark on wet, oily or rusty surfaces. Two types of Arc Marker system are available, both guaranteeing exceptional marking accuracy and longer consumable life than conventional plasma: standard (8-10A), for a line width between 1 – 1.5mm; and variable, for a line width from 0.6-3mm (6-20A directly controlled and monitored by the control box).
The plasma torch is protected from damage by an anti-collision protection device. Moreover, by adjusting the parameters the plasma mark can be shown or hidden after galvanization, depending on customer requirements.

Inkjet Marking

Inkjet is the ideal tool for surfaces that must not be damaged by the marking process (e.g. stainless steel). It is also one of the fastest methods of marking bar codes, references and assembly signs on the plate surface within one pass. Six font types, with a height of 10 or 20mm, can be programmed.

The marking speed is up to 20 m/min and in order to mark in all directions, the tool can be installed on a rotating head +/- 90°. The marking sequence is automatically synchronized to all the machine movements which guarantees a perfect, clean result.

“Lettering” software option

To facilitate full, easy integration into the programming software, ESAB controllers can feature the “lettering buge software option”. This software inserts an auxiliary function into the machine programme, followed by the text to be marked. The marking system provides fully automated marking which can be combined with any cutting process in the same part programme. This ensures accurate and user-friendly text positioning. Furthermore, the text is programmed in plain ASCII text. It can easily be read and edited by the machine operator.

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