# New Arcwelding Systems

*by*

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## INTRODUCTION

Continuous improvement and development of arc welding systems are resulting in extended applications on larger and heavier workpieces produced on-off or in small batches.

Mechanized and flexible material handling are often integrated in the welding systems, which encompass quality monitoring as an integrated part.

To reduce the set up time in a high investment simulation an offline programming systems must be introduced.

The welding process itself is also improved to realize unmanned welding.

Some examples on such improvements and applications will be described below.

## Square wave welding transformer

To reduce magnetic deflection of the arc different measures can be taken e.g. keeping earth and welding cables in parallel, close to each others, careful localization of each cable connection, using a transformer etc. While the transformers eliminates the magnetic blow effect on the arc, other less server drawbacks are introduced.

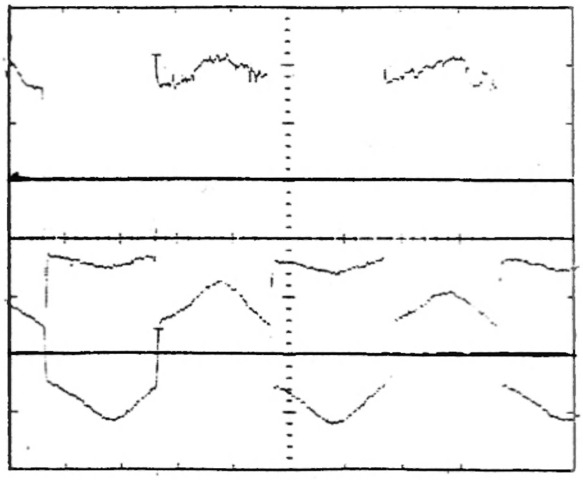

Fig. 2 : Welding with an agglomerated flux 10.62 and wire OK 12.10 = 5 mm

The striking of arc is not as reliable as with a rectifier, mainly due to limited shortcircuit current inherent in a leakage core transformer which has a constant current characteristic.

The arc stability in AC-welding is not as good as in DC-welding. At sinusoidal output current the restriking of the arc at zero line is a problem, especially when the workpiece becomes negative relative to the electrode. This effect is a result of the workpiece having lower temperature than the electrode and consequently demanding a higher reigniting voltage for emission of electrodes. The mentioned drawbacks are known since years.

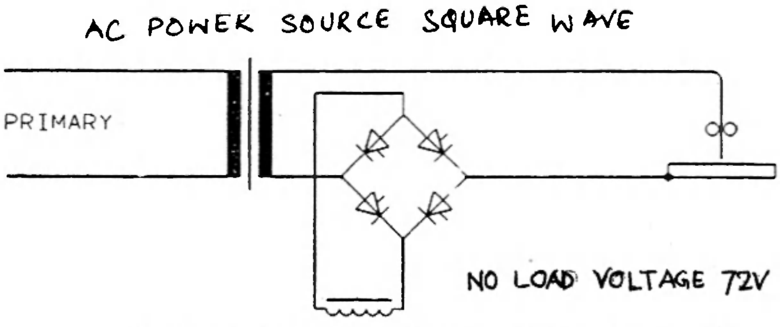


Fig. 1 : Power circuit for a square wave output transformer

To reduce this kind of problems square wave output power sources were introduced several years ago, mainly for TIG AC-welding. Hereby TIG-welding without HF has been realised of great importance from EMC (Electro Magnetic Compatibility) point of view.

The EMC-directive will force the welding industry to drastically reduce to use HF but also introduce electrical filters to reduce the radiated electromagnetic radiation and conducted electrical noise.

The EMC-directive must also be considered in a square wave transformer used for submerged arc welding. Figure 1 shows the principle power circuitry with a constant voltage output characteristic. The output current and voltage waveforms at welding are shown in figure 2.

An electronically controlled AC-power source with feed back control offers other valuable benefits compared to a regular welding transformer :

- Compensation of mains voltage fluctuation.
- Voltage compensation for long welding cables.
- High power factor ensuring low power consumption.
- Optimized open circuit voltage.
- Simple programming and presenting of the welding parameters.

A submerged arc welding installation for rear axles has been running with the parameters shown in table 1.

Material thickness : 15 mm
Wire : O=2,4 mm OK 12.22
Flux : OK 10.71

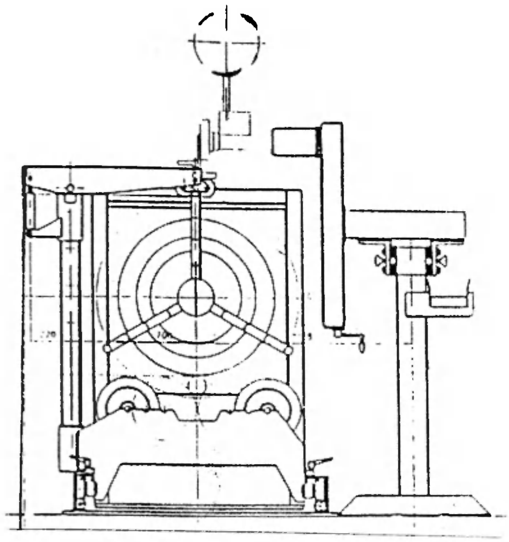

Fig. 3: Plasma Welding Installation for tubes (100-1100) mm in diameter with two roller beds and welding head movable along 30 m long separate rails.

| Position | Amp A | Voltage V | Travel speed cm/min |
|---|---|---|---|
| 1. Twin arc DC + Outside | 590<br>560 | 37<br>38 | 60 |
| 2. Single wire AC Inside | 520 | 38 | 60 |

By replacing the ordinary transformer with a square wave output transformer for the internal welding the welding defects were drastically reduced to almost 0-defects from about 3%. Such a potential saving must be of great interest for those using regular transformers to avoid arc blows.

## Plasma welding installations

For very demanding applications in the offshore industry plasma welding is used for joining of e.g. titanium tubes with diameters between 100 and 1100 mm, mainly for the achieved high quality welds and higher productivity compared to TIG-welding. The productivity difference can be as high as 6-8 times, which advantages several Norwegian offshore industries are utilizing.

The plasma method is not only used for titanium but also for stainless steel and duplex. The method is as well tested on aluminium. Excellent results on aluminium are achieved with square wave output power sources in CNC controlled installation (figure 3) with integrated material handling for long pipes. Both the roller beds and welding heads can be moved along 30 m long rails.

The welding parameters are programmed on and stored in a micro-computer based power source with a possibility to also close the key hole.

The inherent advantages, which the plasma welding process is offering are not appreciated as they ought to be.

## TIG Welding installation

Another interesting application for the offshore industry is the superduplex stainless steel tube umbilical design, developed by Alcatel Kabel in Norway over the past three years. It has resulted in major contracts for the supply and installation of umbilicals for North Sea offshore operations. The satellite fields statfjord North and East, Sleipner Loke and Sleipner East will be equipped with Alcatel umbilicals with a total length of 74 kilometres.

Subsea umbilicals, figure 4, provide the electric and hydraulic power needed to operate subsea installations remotely from offshore platforms. By tradition, umbilicals have been manufactured with hydraulic hoses made of thermoplastic materials.

The design of the new Alcatel umbilical currently on order utilizes ten superduplex stainless steel tubes surrounding a central electric core, which consists of 28 conductors for power and signal transmission. The ten 1/2" superduplex tubes are heli-

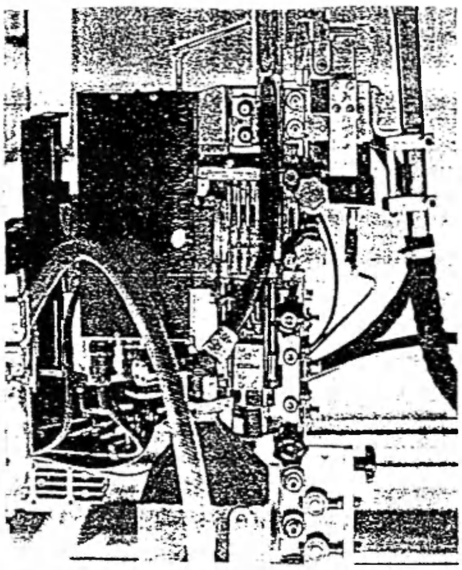

Fig. 4 : The Alcatel subsea umbilical utilizes ten superduplex tubes which surround the electrical power and transmission conduits. The superduplex tubes have been welded with automatic orbital TIG welding using the ESAB A21-system.

cally wound around the electric core element followed by conventional Alcatel Kabel sheathing and armouring.

This advanced design represents something completely new in umbilical technology. The previous plastic hoses have the disadvantages of permeation through the liner wall, hose collapse and incongruity between hose liner and liquid. Stainless steel tubes overcome these problems. In 1989, the Norwegian company AS Nymo produced 150 kilometres of steel tube with an inside diameter of 34 millimeters for the Troll field. 10,200 steel tubes were welded with an orbital automatic TIG welder in a 50- kilometres long underwater cable. The Alcatel cable is even more complicated and it took approximately three years to develop it.

An evaluation programme was carried out in order to find the best performance grade of stainless steel. the following main criteria were observed.

- Corrosion properties
- Weldability
- Mechanical properties
- Previous experience

Steel grade UNS S32750/S32760 (superduplex) was found to be the most suitable material for the following reasons.

- Higher yield strength permitting reduced wall thickness.
- Reduced weight and size of the umbilical.
- Corrosion protection in the form of zinc and/or RBFC compound is not required.
- Reduced forces during lay-up of the umbilical.
- Better weldability.

Welding duplex and superduplex does not pose any problems. However, welding accounts for a very large part of the production cost of umbilicals and it was therefore necessary to develop an efficient and safe welding procedure.

The manufacture of umbilicals calls for a special factory lay-out and production processes. Alcatel Kabel's plant in Halden in Norway is specially equipped for handling long and heavy umbilicals. Three stations for welding superduplex tubes in very long length are included. The ongoing production of 740,000 metres of superduplex tubes involves over 33,000 welds. Each weld is 100% radiographically controlled with a Real Time Radiography system. Three shots are taken of each weld and each shot is checked on a video screen and stored on a laser disk storage system.

Pressure testing is the last stage before the tube string is sent to the main plant for the lay-up and completion of the umbilical. the working pressure in the tubes is 7,500 psi, but Alcatel Kabel use a test pressure of up to 11,250 psi.

The orbital TIG welding system consists of a 315 amp computer controlled power source of the inverter type, the MECH- TIG 315, an MEI 20 feed unit for feeding filler wire and the PRB 18-40 welding head. The mechanized TIG welding of tubes offers significant benefits in terms of both quality and productivity. To obtain the optimum results, a programmable, fast response power source is needed.

A microprocessor enables a large number of functions and parameters, such as pulsed welding current, wire feed, travel speed, stepless up and downslope, pre- and post-flow of gas, to be programmed. The complete weld cycle can be divided into several sectors and the optimum parameters can be selected within each sector. The internal memory has a capacity of up 100 welding programs.

The welding head is practical and easy to work with. The unique tong principle cut setting-up time to a minimum and water cooling permits fast, intensive welding with current of up to 250 A. The welding head is quickly clamped around the tube. The radial and axial adjustment of the electrode is easily done using micrometre screws.

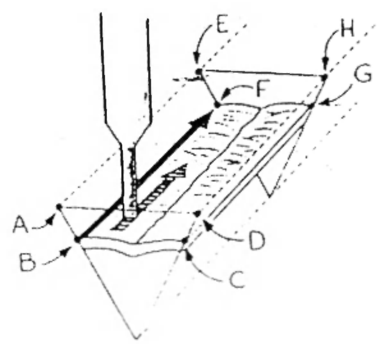


Fig. 7 : Measuring the joint profile.

This cable design is expected to be sold as well to Gulf of Mexico, South America and other subsea projects.

## Submerged arc welding installation

Back in 1980, the first fully automatic narrow gap welding system for commercial use was supplied. Close col-

Fig. 5 : Fully Automatic Butt Welding (ABW) head with measuring sensor and flux system.

laboration with manufacturers in the pressure vessel and offshore industries in particular has resulted in the development of increasingly sophisticated systems for submerged arc welding, for example.

The latest development - an adaptive welding system for butt joints called ABW - is one example of the degree of mechanised welding that can be obtained using modern computer technology and intelligent software.

Data collected from skilled welders has been turned into an intelligent software package which makes fully - automatic multilayer welding possible. In practical terms, the responsibility for the welding result is transferred from the operator when it comes to the operational aspects of the weld.

The patented ABW system is able to fill all the normal types of butt joint. Figure 5 shows a welding head with measuring sensor. When it comes to the fully-automatic filling of a gas-cut single V butt joint in which both mismatch and gap variations are possible, total adaptivity is absolutely essential.

A great deal of work has therefore been put into the development of theoritical models for the run sequence of the joint. The advanced properties of the ABW will probably set a new standard for quality welding.

The term adaptivity is often misused as it is used to describe the automatic properties of a certain welding equipment. On many occasions, this simply refers to the ability of the weld nozzle to follow the joint.

There are varying levels of adaptive control and more sophisticated equipment, such as welding robots, featuring a certain degree of adaptive control also in the deposition rate when it comes to limited-layer welding, but in no case known to the authors is the adaptivity so complete as it is in the ABW system.

Fig. 6a : shows a narrow gap joint with a relatively simple run sequence configuration and figure 6b the more complex formation in a single V butt joint.

Both joints have been procedure-welded automatically using ABW (as a result of subsequent NDT, the cap has been machined off, however). As mentioned above, the adaptive functions have been developed to the maximum level possible in ABW.

This means that all the decisions relating to the fully-automatic joint filling procedure are based on the measurement values which are obtained continuously in the joint by the welding head measuring sensor.

## Joint tracking

The measuring sensor which oscillates in front of the welding head continuously measures the joint profile at all levels during welding. This enables a large number of configuration sections (polygons) along the joint line to be defined and memorised in the co-ordinate system of the control system.

In figure 7 these sections are illustrated by A-B-C-D, E-F-G-H and so on. As the welding head positioning axis are linked to the same co-ordinate system, the tip of the electrode can be controlled with great precision with the desired offset in relation to the sections and parallel to the wall of the joint (indicated by the arrow between B-F in figure 7.

## Determining the number of runs in the different levels of the joint.

Using the continuously memorised measurement values in the configuration sections, the system recognises the position of each basic level for each new layer of runs. In figure 8 this is illustrated by points A and B.

Since the top of the outer runs is also measured during welding in the layer in question (points C and D), the space which is available between the outer runs, and which is demarcated by the polygon A-B-C-D, can be defined and the number of runs needed to fill this level can be calculated.

The position of the intermediate runs is calcualted by taking account of the position of the outer runs.

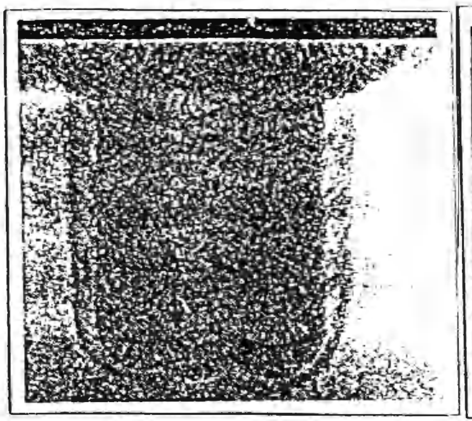

Fig. 6a : Narrow gap joint. Width 18 mm.

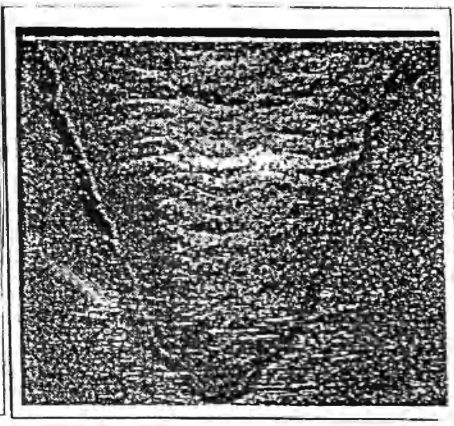

Fig. 6b · Single V butt joint Depth 55 mm.

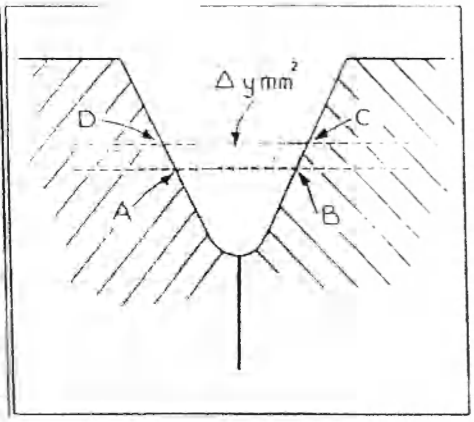


Fig. 8 : Determining the number of runs.

## Adapting the fill level of the weld runs

Using the measurement values which the ABW sensor continuously collects along the joint line during welding at the basis, a large number of configuration sections are calculated, as has already been described.

These sections are illustrated in figure 6 and represent unwelded residual areas above the base of the layer of runs in question.

The configuration sections or residual areas above the base of the layer of runs in question.

The configuration sections of residual areas are compared and based on their relationship, different references, which will govern the deposition rate of the subsequent run, are calculated. In this way, the run areas can be continuously and individually adapted to the actual joint profile along the entire line of the joint.

## Cap procedure

The collected information about the groove is stored and also used in the capping run, during which tracking and measures of the groove is not possible.

To control the welding process a computer is introduced with a specially developed Man-machine communication, which is made up of three main sections ;

¤ Editing the welding programs

¤ presentation of the welding process

¤ welding reports

The welding programs are edited on the screen of the PC. As shown in figure 9 the screen has ready-made maneus for editing the required set of parameters at three levels in the joint (single- run layer, fill layer and cap layer).

The data which is either programmed or retrived from the computer library comprises current, voltage, welding speed and tolerances, the number of single runs at the bottom of the joint, the offset for the outer runs, the required cap height and the alarm limits.

The presentation of the welding process takes place automatically when the arc is struck (as shown in figure 10). The actual values and reference values for the process data are presented both digitally and graphically on screen. Any incorrect messages are also shown.

Welding reports from each welding operation (quality monitoring) are automatically stored. These reports explain the design of the run configuration and the location of any critical parameter data in the joint vis-a-vis run position, depth and distance from the starting point.

The ABW system has been created to take over the work normally performed by the operator in submerged arc multi-run fill procedures, thereby enabling the fabricator to obtain top-class reproducibility and an unbeatable quality standard. Two systems are delivered to the well-known Kvaerner Group in Norway for welding off-shore components.

## Summary

Besides the growing market for robot solutions there are several other advanced welding installations, in which the best welding process is used,are developed for realising higher productivity and high and consistent quality as examplified above.

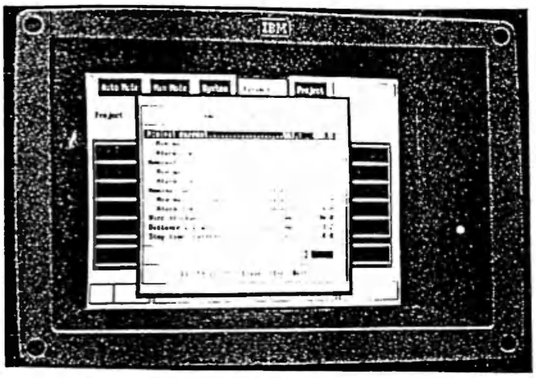


Fig. 9 : The welding programs are edited on a computer.

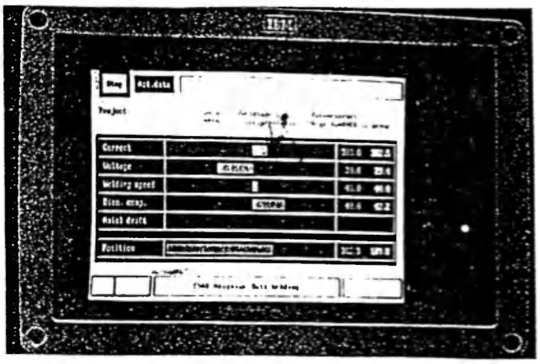


Fig. 10 : The welding process can be presented on the screen of the PC.