Automation in sheet metal cutting and welding

The paper examines welding and cutting process trends in the sheet metal and plates used in various industries like automobiles, infrastructure, ship building, aerospace industries, wind tower manufacturing etc. Productivity gains in arc welding are reviewed, and the increasing use of laser cutting and welding, as well as laser-arc hybrid welding, particularly in Europe, is discussed and explained. Some friction technologies are already widely adopted, but they could make more impact with further development. Electron beam welding could also be used with economic benefit in some situations, but as with all non-arc processes, it will only be adopted if significant gains in productivity and cost reduction can be created to justify the more specialist welding equipment required. Many productivity improvements can come from non-welding activities in the fabrication process.

1. INTRODUCTION

Leadership in manufacturing (welding and Cutting) can come from addressing the factors of QUALITY, COST, PRODUCTIVITY, SAFETY and CONTINUAL UPGRADATION OF TECHNOLOGY. Inflection in Metal Fabrication Technology has taken place in the Manual / Semi-Automatic Welding Power Sources - (Digital control inverters), Welding Automation - (Developments in HNG SAW, HNG MIG, Tandem MIG / SAW, Friction Stir, Electron Beam, Saddle Welding Automation, Robotics, Laser spot welding, Hot wire TIG, Orbital systems, automation with hybrid welding systems like Plasma – MIG, Laser - MIG) and major advances in the cutting processes (Precision Plasma, Laser Cutting, Water-jet cutting etc.).

This paper reviews current trends in arc welding and cutting processes used for Sheet metal processing and will discuss some of the newer processes which are beginning to replace arc welding for such steels, or have potential to do so in the next 10 years.

2. ADVANTAGES OF AUTOMATION

a. Consistency in weld result - Error Proofing: A welding supervisor can limit the amount of changes an operator can make during a program, preventing him from accessing the override screen through the use of a key switch or password.
b. Multiple parameters for multiple weld-run: In addition to the ability to adjust parameters between weld passes, operators of microprocessor-based welding machines can also program changes to weld parameters during each pass, which offers distinct advantages for certain applications.
c. Store parameter for sharing on other machines with same applications: A microprocessor-based power source can store programmed welding procedures on data cards. This allows the operator to easily transfer programs developed on one machine to other machines being used either in the same facility doing the same type of work.
d. Quality control: Microprocessor-based machines can immediately alert the operator if weld parameters fall outside pre-selected limits. Parameters can be directly to a quality-control computer program for storage or statistical analysis. This eliminates time-consuming radiography in many applications.
e. Date storage and records: It is now very easy to display a set of welding parameters and operator or supervisor can observe the welding procedure. Moreover, the data can be printed in the form of reports, which can be presented to the customer as quality assurance procedure.
f. Quicker Weld-Fault diagnostics lower repair time: The system can be stopped if the measured values cross a certain preset variation limit. It is possible to stop the machine in out-of-tolerance conditions. This enables the operator to perform timely functions and take necessary steps to prevent the deposit of faulty welds.

3. TANDEM MIG AND ROBOTIC WELDING

Significant improvements in productivity are nowadays hard to gain in this mature process. In gas-shielded MIG/MAG processes, the growth of tubular wire over solid wire is still slow despite the deposition and bead shape benefits of the former although tubular wire usage is higher in the USA and Japan compared to other parts of the world. The lower price of solid filler wire, particularly in Europe, is still a dominant factor that continues to favour their use. Self-shielded cored wires are still widely used in the USA but less so in Europe because of the fall-off in fabrication of large offshore installations. Care is always needed in selecting self-shielded wires if weld metal toughness is a critical design factor.

Schematic of Equipment for TANDEM MIG

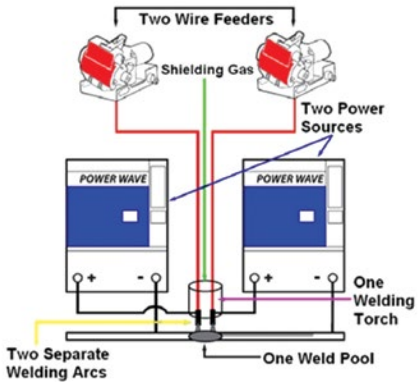


Fig. 1: TANDEM MIG

Advantages of TANDEM MIG:

- Exceptional welding speeds
- High weld metal deposition rate
- Superior weld quality:
  - ◊ Reduced heat input
  - ◊ Resists burn-through on thin materials
  - ◊ Maintains low spatter levels
  - ◊ Produces good penetration on thick materials
  - ◊ Improves bead wetting at weld toes
  - ◊ Resists undercut
- Bead profile control
- Lowers production costs
- Increases productivity

The greatest potential for productivity improvements comes from using robots. Japan still leads the work in new robot installations per annum, but generally robot take-up for welding is still majorly for the automobile sectors. Robots are being employed in situations where product repetition and/or tonnage throughput are high, combined with relatively standardised designs. Robot profile cutting is increasing in usage and in Japan, some building frames are now being welded on robot lines and agile robots are also used for site welding building column joints at height. The applications most suited to robot use involve butt and fillet welds in the fabrication of beams, welding of stiffeners to beams, welding of end plates and the assembly of panels or decking.

A likely trend is to 'take robots to the work' and use them for large part and sub-assembly manufacture in cells which house autonomous vehicular robots. These robots, mounted on moving platforms are manoeuvred around the parts to be welded and are capable of all-positional welding using the MAG process with tubular wires, **(Fig.2).**

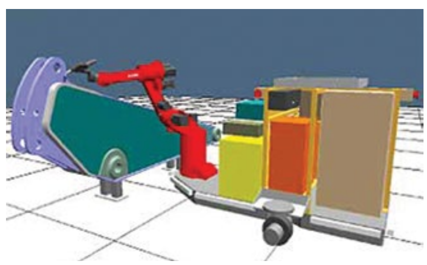


Fig.2. Schematic diagram showing autonomous robot vehicle navigated by vision system, being used for all positional MIG / MAG welding

4.NARROW GAP SAW

In submerged arc welding, multi-wire, iron powder additions and narrow gaps are common ways to increase productivity. However, the use of tubular wires is increasing in popularity and can offer better weld quality compared to solid wires in some situations, e.g. when submerged arc welding of primed plate. In building and bridge construction MIG/MAG welding is more suited to automation and is now beginning to replace submerged arc welding, reducing costs and distortion significantly.

5 . LASER – IN CUTTING AND WELDING

Low power CO_2 lasers were originally developed in the late 60s for cutting and welding operations, while Nd: YAG lasers entered the market only in the early 1980s. In the shipbuilding and off-road vehicle sectors, higher power lasers (3-10kW CO_2 and 2-4kW Nd:YAG) have become popular in the last decade because their use brings more precision in dimensional control, and greater accuracy in assembly, as well as the additional advantages of high cutting and welding speeds, and cleaner working.

Laser cutting is now an essential route to accurate assembly in steel fabrication. Parts can be cut to a precision of ±0.3mm in 10 metres compared to ±1-2mm for conventional plasma cutting. Sub assemblies can then be arc welded to tolerances of a few millimetres in 15 metres, with the same lasers being used for marking and hole drilling on the cutting table. Even though arc welding is still regularly used for assembly of laser cut parts, cost reductions can be dramatic because of the improved accuracy of assembly and the potential for eliminating distortion correction and other processing operations downstream from welding. Direct costs have been cut by up to 50% using lasers for cutting in many shipyards, and this shows the extent of benefit which could follow from more widespread use of laser cutting in building, bridge and public infrastructure construction.

Fig.3. A typical laser welded sandwich panel and advantages over conventionally stiffened panels

6. LASER-ARC HYBRID WELDING

There is tremendous interest in the use of CO_2 laser-arc or Nd: YAG laser-arc for steel construction at the present time. The concept has been around since 1978 and was actively developed in Aachen in the late 90s using high power CO_2

Fig.4a. Nd:YAG laser - MAG hybrid process being developed for land pipeline girth welding. Picture of the welding head

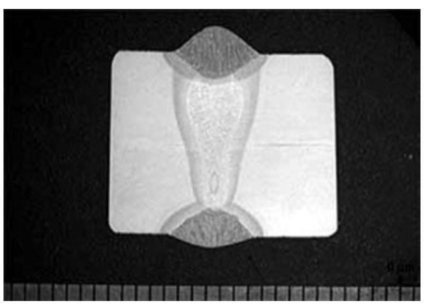


Fig.4b. macro section showing MAG root and cap beads & central hybrid weld bead

lasers in combination with one or two MAG torches directed into the same weld pool in series with the laser. Already one shipyard in Germany has such a system in production on a panel line, the process replacing submerged arc welding. The advantages of moving from simple arc processes to a hybrid laser-arc system include higher joint completion rates and associated control of distortion. As noted above, laser systems alone are usually not sufficient to cope with variations in joint gap in large structures. However, where plates are thin, it is possible to produce stiffened panels successfully by laser welding.

7. FRICTION TECHNOLOGIES

There have been many exciting developments in friction welding and probably more process innovation in the last decade than in the previous 40 years when friction welding first came on the scene. In the context of metal joining and construction, friction stud, radial friction and friction stir welding are good examples of more recent approaches, with friction stud already being used in the production of sandwich structures comprising steel skins and a concrete core and for welding attachments in high volume such as shear connectors and reinforcing bars to end plates. Attachment of anodes under water to offshore installations using steel studs and electrical connections to railway lines are other applications of friction stud welding.

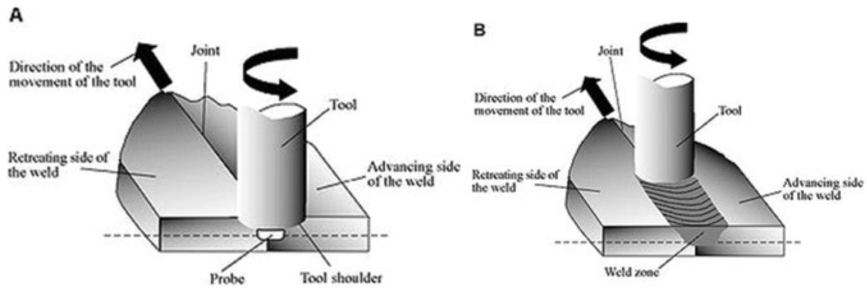


Fig. 5.Schematic diagram of the FSW process: (A) Two discrete metal work-pieces butted together, along with the tool (with a probe). (B) The progress of the tool through the joint, also showing the weld zone and the region affected by the tool shoulder.

APPLICATIONS

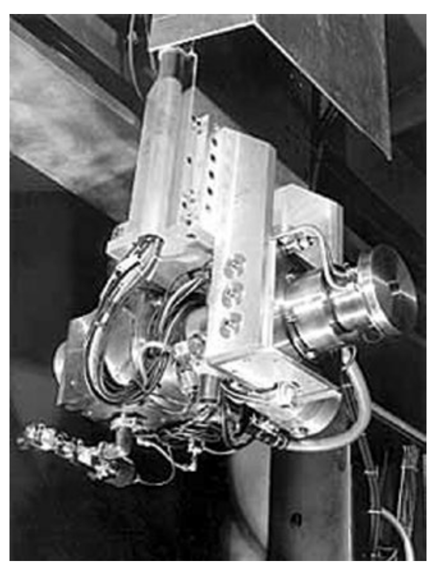
Shipbuilding and Offshore, Aerospace, Automotive, Railway Rolling Stock, Fabrication

8. ELECTRON BEAM TECHNOLOGY

There have been several key improvements in this process in the last decade which have made EB welding increasingly attractive for large-scale fabrication of steel structures such as buildings and bridges. The two main areas of improvement are in gun development and reduced pressure technology.

Reduced pressure electron beam welding system

Reduced pressure EB welding using chamber pressures of around 1mbar has been another major step forward in simplifying EB welding operations. The beam shape and beam penetration at, say 5mbar, is identical to that at the

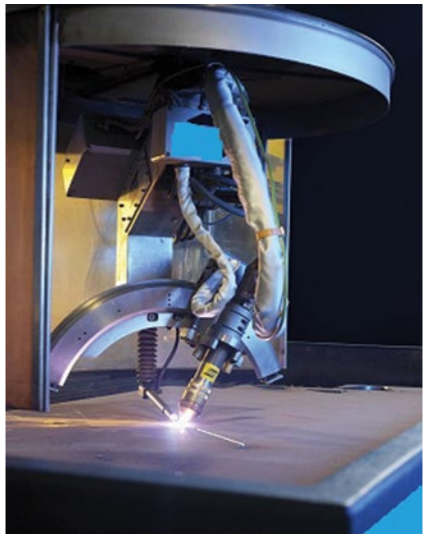


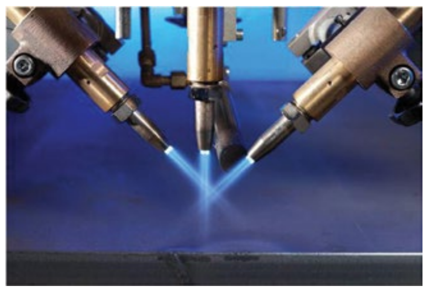
more conventional pressure for EB welding of 5 x 10 -3 mbar. This reduced pressure option does away with the need for large vacuum chambers and worries about leaks and seals. Simple mechanical pumps and local seals are sufficient to achieve ~1 mbar. These systems are also more tolerant to fluctuations in working vacuum pressure, gun to work distance and work-piece cleanliness.

9. WIND TOWER MANUFACTURING – SPECIALIZED CUTTING AND WELDING PROCESS APPLICATIONS

Wind Tower fabrication employs extremely precision applications of metal cutting and welding processes like gas cutting triple torch, with Single pass three torch cutting Automatic setup which provides High accuracy, Capacitive height adjustment, Infinite rotation of cutting head, Automatic angle adjustment 20 - 50° (Option for 30 - 60°). In addition, plasma cutting system is used with Automatic Setup, Highest Accuracy, and Bevel angle adjustment: +/- 52°, Initial height setting with tactile sensor, Cutting height adjustment via automatic arc voltage sensing process.

Precision High end CNC Plasma cutting process is utilized with high degree of automation needed to guarantee consistent quality. Programming software, Numerical control and Automatic rotating bevel tools are used to dispense with manual tasks. Automated SAW systems with





Twin Wire, Tandem, Tandem – Twin and Multi – wire systems are used along with customized welding heads, wire feed systems, joint tracking systems, Column and Booms, TELBO systems, Rotators and Positioners. In addition, Tractors and Fit – up units are all used for this application and also for many other welding applications.

10. CONCLUDING REMARKS

Where will engineering construction be in five years time? Productivity improvements can come from many different areas in the total fabrication process, e.g. general design, detailed design, contract drawings, CNC instructions, cutting and profiling, welding, inspection, finishing etc. It needs to be realised that optimising the welding process and procedure in isolation may have only a small effect on overall productivity. As an example, fabricators in the bridge and building sector continue to make big improvements in reducing the cost per tonne of steel fabricated by focussing on efficiency improvements in non-welding operations.

These non-welding areas will continue to receive much attention in the next few years. For example, 3D solid modelling is expected to be at the heart of the improvement process enabling virtual assembly, direct instruction of cutting and welding machines, computer modelling of metal processing and welding operations and optimising of welding sequences. In addition automated inspection and data gathering will increase in usage to give more comprehensive Quality Assurance. Productivity improvements could also come from greater standardisation in steel specifications and in joint details and from modularisation of large structures to reduce the time spent on site fabrication and erection.

Use of new welding processes and an increased use of automation and robots will take place slowly and gradually, only being justified where the introduction creates significant gains in productivity or cost reduction. As such, these changes can be expected particularly in situations where skilled labour is short, where welding cells can be kept fully occupied or where customised, made to order components are needed.

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