11. Mechanisation of Welding and Cutting

Welding and cutting can be considered as processes involving moving a tool (the welding or cutting torch) along a line. The travel speed along the line is kept as steady as possible to ensure the weld pool size remains constant. Deviation from the intended line should be to a minimum to ensure the edge is followed accurately, or the cut face is as smooth as possible. In the case of welding, filler material is usually added.

These processes, like several of other manufacturing processes can be mechanised or automated. Depending on the process, different degrees of mechanisation and automation are possible. Some processes, such as laser cutting, waterjet cutting and submerged arc welding are always (or nearly always) mechanised. Others, such as manual metal arc welding are difficult to mechanise effectively.

Mechanisation and automation of welding involves consideration of all some of the following factors.

- Filler wire feed mechanisation
- Removal of slag and surplus flux
- Travel speed mechanisation
- Arc or flame parameter control (current and voltage) and sequence control
- Arc or flame starting and stopping parameters
- Ancillary processes, such as shielding gas start and stop, gun cleaning
- The tolerance required for each weld run, and whether manual control is more effective

The terms used for the degree of mechanisation are illustrated by considering the GTAW process used with filler, which is capable of a wide range of mechanisation.

11.1. Advantages of Mechanisation

Mechanisation is undertaken usually to improve productivity, however there are other important benefits.

Table 9 Levels of Mechanisation of GTAW

Process	Degree of mechanisation	Degree of automation
Manual GTAW	Filler and arc travel independently manually controlled.	Manual welding
Cold wire GTAW	Filler metal feed mechanised, travel manually controlled.	Semi-automatic welding
Cold wire GTAW	Filler feed and travel mechanised. Manual start and stop. Usually requires to be continuously adjusted.	Mechanised or machine welding
Orbital GTAW	As above, plus arc parameters and sequence pre-programmed. Push button start. Automatic stopping at end of sequence.	Automatic welding

11.1.1. Reduced Operator Fatigue

Productivity improvements are mostly due to an improved duty cycle, although mechanisation may allow higher arc power and travel speeds. A manual welding or cutting torch has a weight of 0.5kg to 2kg and requires considerable physical strength to keep the process going, particularly if the position is restricted so the welder is working awkwardly or cramped. Unfortunately the faster GMAW and FCAW welding guns are also heavier (1kg or more), and although it is not necessary to continually change electrodes, the duty cycle seldom exceeds 35% with these processes.

Mechanisation of GMAW and FCAW takes the weight of the gun from the welder, and therefore reduces fatigue and raises the duty cycle.

Mechanisation can also improve the work environment for the welder. Depending on the degree of mechanisation, the welder may be removed from mundane or hazardous work. As well as a reduced risk from repetitive strain injury or other muscular-skeletal problems from carrying a heavy torch in often a cramped position, the welder is often less exposed to fume, noise and heat. One argument against mechanisation is that the work becomes less fulfilling, because it does not rely on the welder's art.

11.1.2. Improved Quality

Mechanisation allows much closer tracking of a line because it does not rely on a steady hand. Mechanised welds have a more even shape than manual ones. Arc energy is more regular and is preset, so that there is greater confidence the allowable arc energy range has been achieved. There are fewer starts and stops, and consequently there are fewer defects. However, it can be easier to misplace a mechanised weld run because the process is less closely observed. This usually results in long defects that are expensive to repair. Mechanised cutting produces smoother cuts than manual thermal cutting. Less clean up of the cut surface is required.

Automation can allow measurement and recording of the process, to provide documented evidence that it was properly performed, or to interrupt the process if errors occur. Programs are only learned once and are available at any future time for re-use (provided they were logically organised and not discarded). Automated welds therefore are repeatable.

11.2. Application of Mechanisation to Welding

The application of mechanisation to welding demonstrates important principles that can be used to assess mechanising any process.

It is important to consider the intention of mechanisation. Whereas mechanisation should reduce the man-hours needed to complete a task, it may not reduce the task time. This is important if the real intention is to reduce schedule times, and so reduce the overall costs, including overheads, equipment hire and in the case of a shutdown the production outage time. It may be far more cost-effective to use many welders to complete a task manually in the shortest time than to use an automatic machine that will only do one weld at a time.

11.2.1. Manual welding.

Manual welding is flexible and portable, requires little establishment cost and is quick to set up. It will always be suitable for one-off jobs, short runs and maintenance work. Manual control allows welding of less accurate fit-up, particularly of root runs where precise control is required. It can work in confined spaces or where access is limited.

11.2.2. Semi-automatic welding

Semi-automatic welding (filler feed is mechanised, travel is manual) is usually more productive than manual welding. The down time to replace consumable electrodes or pick up another piece of filler wire is significantly reduced. However the welding gun for semi-automatic processes is heavier and is less flexible, and the wire feed mechanism must be close to where welding is being performed (within five metres). The process is still quite flexible and has many of the advantages of manual welding.

11.2.3. Mechanised welding

Mechanised welding involves the mechanising the filler feed and travel, but starting and stopping the process is manual. Constant supervision is necessary and it is often necessary to manually adjust parameters or gun position during welding. Mechanised welding is called machine welding in American publications.

Expensive equipment is required for mechanised welding. Some time is required to set it up for each weld and mechanisation is not productive for short welds. Submerged arc welding is not economic for welds less than a metre long. However is well worth considering for long continuous runs, such as multipass circumferential welds.

Mechanised welding is less flexible. Depending on the welding process, a much higher accuracy is required for weld joint preparation. For example, pipe welds can be made using manual GTAW with vee joints prepared to an accuracy of ±0.5mm. Orbital GTAW can only be done with joints machined to an accuracy of± 0.05mm. 'U' preparations have to be used, because it is impossible to achieve the tolerances consistently with a joint gap, and 'U' preparations are more tolerant of errors in locating the gun.

The tolerances required depend on process, joint and procedures. High energy and high penetration processes, such as submerged arc are more forgiving. Root runs cannot be welded by mechanised processes unless the fit-up tolerances are very tight.

Mechanisation may enable welds to be made that cannot be undertaken manually, because hand steadiness is no longer important. This is particularly the case for small assemblies, such as small bore tubes, containers for electronic devices, and prosthetic hearing devices such as heart pacemakers and bionic ears. Mechanisation allows fine welds to be made at current that is too low to be controlled manually.

Processes such as SAW, GMAW and GTAW are easily mechanised. Mechanisation of FCAW is more difficult because of the need to remove flux after each weld pass.

11.2.4. Automatic sequenced welding

Automation requires that some or all of the functions or steps of an operation are performed in sequence by mechanical or electronic means. It implies that as well as being mechanised; the process has sequence controls to enable preset parameter changes during the process and an automatic stop at completion. Starting the process may be manual or automatic. It may include loading or unloading the assemblies.

As well as the additional capital cost; there are program establishment costs, which are repeated for each different component type. It is impractical to do this unless the set-up cost can be offset by cost savings elsewhere. For this reason, a number of identical components are required. The best example of automation is orbital GTAW of butt welds in tubes and pipes.

Process automation reduces flexibility and dedicates the equipment to a more limited range of activities.

11.3. Barriers to Automation and Mechanisation

Automation and mechanisation is only being accepted slowly despite the stated advantages. The reason for non-acceptance or reversion to manual methods is due to one or more of the following factors.

- High effort to establish mechanisation. Lack of lead-time in project-oriented work.
- High and often difficult to determine capital investment. Special jigs and fixtures are often required, which require detailed design and fabrication.
- High risk, because of inexperience.
- High set up time and cost – dependent on the number of identical jobs.
- Need for precise repeatable fit-up, particularly for root runs.
- Lack of motivated people, trained with appropriate skills.
- Luddite attitudes.
- Dedication and therefore reduced flexibility of assets.
- Need to consider automating the whole manufacturing process, not just welding and cutting.

It is a major error to consider automating one process, such as welding without considering the effect on the rest of the manufacturing process. Productivity improvements can only be realised if an automatic welding station can be efficiently fed with components, which can be removed and passed on to the next stage of fabrication as quickly as possible. Material movement will become a major issue.

11.4. Filler Feed Mechanisation

Most of the welding processes described in detail in this book have a mechanised consumable feed. In the case of submerged arc welding, the feed of flux to the weld and the removal of surplus flux and slag from the weld can also be mechanised.

The major exception is MMAW, for which only limited mechanisation is possible. This is by the gravity welding system, where long E4824 electrodes are used in a sliding frame arrangement. The electrode holder slides down the frame as the arc travels along the

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