Enclosures

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The metallic alloys we use today have evolved through decades of research and many represent the pinnacle of achievement in terms of strength and corrosion resistance. Without these materials, the remarkable advances that have taken place in nuclear energy, medicine, pharmaceuticals, power generation and petrochemicals could not have been realised.

One of the most significant early breakthoughs occurred in 1912 in Sheffield when chromium/iron alloys were found to be corrosion resistant. Since then we have witnessed the introduction of low alloy creep-resistant steels, nickel-based alloys with elevated temperature properties and, more recently, the development of lightweight titanium alloys offering high strength-to-weight characteristics.

Optimum properties of all these materials is only achieved by precisely controlling the balance of elements. The ideal composition for every application has only been realised thanks to intensive research work by metallurgists but if elements are lost during subsequent manufacturing processes such as welding or other elevated temperature excursions, the corrosion and mechanical properties can be affected significantly.

Fusion welding of stainless steels provides a good example where loss of corrosion resistance can be significant. If welding is carried out in air and even where oxygen levels are as low as 50 ppm, the effective chromium content can be reduced and since this is the principle element added for corrosion resistance, it is a major consideration.

Another consequence of chromium loss during welding is the effect on mechanical properties. In the chromium/molybdenum/vanadium materials for example, developed for their high temperature creep resistance, enhanced hardenability, wear resistance, impact resistance and machinability, any reduction in chromium content can affect these properties. Furthermore, the sensitivity of these materials to contaminating products such as hydrogen in the shield gases needs to be considered. Care needs to be taken in selection of consumables and it is essential that any shield gases are of high purity

The thermal cycles along with any local contamination involved in fusion welding titanium alloys can give rise to embrittlement of the alloy. Their reactive nature makes it essential to address the requirement for thorough pre-cleaning and particularly oxidation at the high temperatures involved in arc welding.

All in all, then, there is a strong material case for eliminating oxygen and other contaminants from the locality of the weld by purging with inert gas such as argon. A wide variety of purging solutions have been developed to combat the problem, including pipe welding systems and trailing shields but there is increasing demand for complex three dimensional components using alloys that are sensitive to oxidation and contamination. These are best fabricated in sealed enclosures where the entire welding operation is carried out in an inert atmosphere where contamination can be eliminated and oxygen levels reduced to well below 10 ppm.

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White Papers

Where quality and freedom from oxidation and contamination is crucial, total protection is afforded by using weld enclosures. Metal chambers and glove boxes have been in use for decades, and these are effective in providing a totally inert atmosphere during fusion welding.

Fig 1. Multi-tube junctions are difficult to protect efectively without the use of an inert gas enclosure. For safety critical applications such as competitive pedal and motor cycling and in motor car racing where this type of joint is commonplace, total protection is essential.

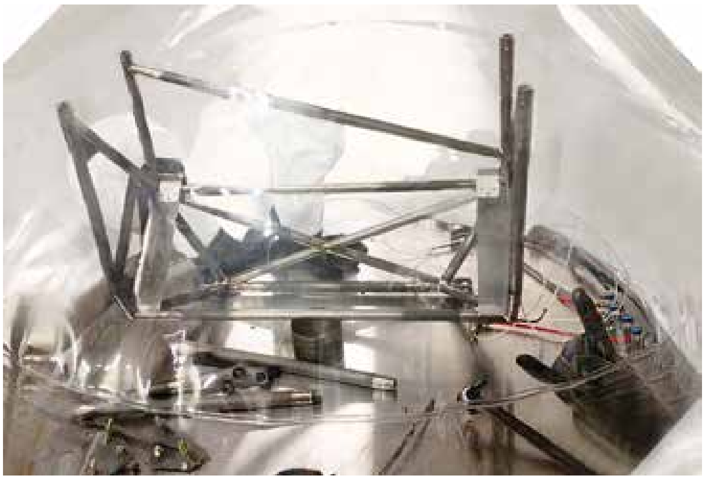

Fig 2. The accident involving Formula 1 racing driver Romain Grosjean at the Bahrain circuit in 2020 could have been fatal were it not for the head protection provided by the 'Halo' structure. This typifies an application where structural integrity is vital. Complete protection of the titanium alloy fusion zone during welding is essential and is provided by using an inert gas enclosure.

Although a traditional metal glove box can provide adequate protection it has a series of limitations. These have now been addressed successfully with currently available flexible alternatives.

- There is a major cost difference. Typically, metal enclosures cost ten times more than flexible alternatives, size for size. As the size increases, this ratio increases.
- The difference in weight means shipment and movement is much easier – typically a metal enclosure weighs significantly more than of a flexible alternative.
- Flexible enclosures can be deflated and stored when not required. Without inflation a 1.25 metre diameter model occupies a mere 0.2 cubic metres and weighs only 8 kg.
- Manufacturing times for metal glove boxes can be very lengthy, extending into weeks. Some flexible enclosures are available from stock: bespoke versions can be produced in less than 8 weeks.

- There are no sharp corners in flexible enclosures and consequently no likelyhood of trapping air pockets.

Fig. 3. Flexible Welding Enclosure® showing excellent access and all-round visibility coupled with low weight.

Fig. 4. Conventional metal glove box offers limited visibility and access. Manoeuvrability whilst welding is restricted.

There have been considerable advances in enclosure development since the concept was introduced over two decades ago. For example, Huntingdon Fusion Techniques in the UK has spearheaded a drive to design systems specifically for the welding industry. The company has been at the forefront in developing these enclosures and has exploited the opportunities offered by advanced engineering polymers.

These innovative products offer significant attractions over metal glove box alternatives; a significant reduction in cost, very small floor footprint and availability of a very wide range of sizes. The HFT® product has rapidly become the preferred alternative enclosure globally. The flexible option has played a significant part in 3-D production and additive manufacture using arc welding is now being undertaken with CNC or robot systems, together with welding plant, all accommodated inside enclosures, some the size of small rooms.

A commercial spin-off from Cranfield University in the UK uses flexible enclosures to produce aerospace parts with the Wire Arc Additive Manufacturing (WAAM) process.

Technical Specification of Flexible Enclosures

A combination of translucent pvc material and optically clear sheet is used depending on the viewing requirements of the customer. Ultra-violet stabilized engineering polymers are used throughout during manufacture. Material thickness is nominally 0.5 mm (480 microns).

Principle large access zips are fitted and additional entry points can be provided for operators' gloves. A service panel incorporates access ports for welding torches and for electrical leads. A purge gas entry port and an exhaust valve to vent displaced gas to atmosphere are incorporated into each enclosure.

Large Viewing Area

Large sections can be manufactured using optically transparent engineering polymers. This offers the opportunity for use by several operators at the same time – ideal for training purposes.

Multiple Access Points

Systems can be manufactured with numerous glove ports and gas/electrical entries. Large leak-tight zips afford easy access for components.

Fig. 5. Multi-access enclosure manufactured to allow for several smaller fabrications to be welded in the same gas cycle. Alternatively, it can also be used for a single large item requiring access to several joints. Simultaneous multiple training can be undertaken.

Monitoring the purge gas oxygen content

The fact that even very small amounts of oxygen in the purge gas can cause discolouration around the weld underbead makes it desirable that sensitive instruments be employed to measure residual oxygen.

Two essential characteristics of a suitable instrument are that it must have an adequate measuring range and it must sample the gas for oxygen content inside the purge volume.

Although many commercial monitoring systems are available these are generally not sensitive enough to meet the requirements for quality welding of alloys such as some stainless steels and most titanium alloys where the presence of oxygen levels as low as 20 ppm are essential if loss of corrosion resistance and reduction in mechanical properties are to be avoided.

Typical of advanced monitoring systems is the PurgEye® family of instruments from Huntingdon Fusion Techniques Ltd in the UK of which the recently introduced Argweld® PurgEye® 500 Desk is totally compatible with the requirements to continuously monitor oxygen levels in flexible enclosures

Fig. 6. The protective gas needs to be continuously monitored to ensure that a low oxygen content is maintained. An advanced instrument such as the PurgEye 500® meets these requirements with a measuring range accurate to 10 ppm.

The instrument is fitted with an integral pump to deliver a regular flow of exhausting weld purge gas to the oxygen sensor to ensure consistent measurements and readings. Advanced software is used for control and communication purposes.

- PurgeLog™ is employed for computer interfacing, data acquisition, storage and printing of results and graphs for quality control purposes.
- PurgeNet™ is used for communicating the current oxygen reading to another piece of equipment such as a Dew Point Monitor with additional inter-pass temperature monitoring.
- PurgeAlarm™ is an IP66 Rated visual alarm that displays a red indicator when the oxygen level is reading a greater value than the alarm threshold set by the user. An optional green indicator can be fitted above the standard red indicator and will illuminate only if the alarm is active and reading a value lower than the alarm threshold set by the user. A sounder is available as a further option to provide an audible alarm instead of a light.

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