Aluminium

Years ago 'aluminium' was considered a difficult material to weld, since when using oxy-acetylene there was no change in colour to indicate the metal's temperature and suddenly it could melt and collapse! With the introduction of TIG and MIG welding processes, these 'welder fears' have been put to one side, providing that the properties of aluminium are understood. This article is intended to give a general overview.

Aluminium and its alloys have special properties of lightness, strength, conductivity, malleability etc, which make it a particularly useful material in a variety of industries. The metal can be either in 'cast' form or extruded (wrought), which then divides into non-heat treatable and heat treatable. Generally, it is readily weldable, but it is important to understand some of its characteristics:

Oxidation: in air aluminium immediately forms an oxide layer on its surface, which will increase in thickness with time. This oxide layer must be controlled during the welding process, by chemically and mechanically cleaning the metal, using an aggressive flux or ensure the arc has reverse polarity (electrode positive). Correct gas shielding (argon) will prevent oxides reforming in the weld.

Thermal: as aluminium is a very good thermal conductor, it will rapidly disperse heat. Care must be taken to avoid distortion and possibly cracking.

Colour: unlike steel, there is no change in colour as it is being heated. Look out for a 'wet' appearance. For gas brazing, melting of flux powder is a temperature indicator.

Preparation: smooth all edges of workpiece to minimise trapped dirt. Use a commercial degreaser and stainless steel brush to remove dirt, oil, paint. Dry surface thoroughly. If TIG welding, wipe filler rod clean of any surface oil.

Application: support the joint to be welded, preferably with a jig, but spot tacking can be used. Keep the arc travelling at the right speed to build up a bead of the right proportions. Do not stop/start on one weld, as this can lead to oxidation/porosity. Carry out the weld quickly to minimise distortion.

Typical welding consumables:

Arc welding electrodes - HILCO Aluminil Si5 & Si12 (important for welder to get into a comfortable position, as weld run must be deposited very quickly)

Brazing - Sifalumin No 16 and Aluminium Flux

Soldering - SIF 555 Aluminium Solder (separate data sheet available)

Gas welding - Sifalumin No 14 or No 15 and Aluminium Flux.

MIG & TIG welding -

SIFMIG 1050	Sifalumin No 14	for pure aluminium
SIFMIG 4043	Sifalumin No 15	ccontains 5% silicon, for castings and heat treatable alloys 6063, 6061 & 6083. Weld will discolour if anodised.
SIFMIG 4047	Sifalumin No 16	contains 12% silicon, for castings and automotive applications.
SIFMIG 5356	Sifalumin No 27	contains 5% magnesium, for similar 5xxx alloys and heat treatable alloys 6063, 6061 & 6083.
SIFMIG 5183	Sifalumin No 28	contains 5% magnesium with 0.75% manganese for improved weld strength.
SIFMIG 5556	Sifalumin No 37	contains 5.3% magnesium and other closely controlled elements for 5083 military and aerospace applications.

Conclusion: it is hoped that these comments will lead to sound welds being produced. However, provided the right filler wire has been used, defects are usually due to inadequate cleaning/preparation or poor technique (shielding gas not effective, too long an arc, incorrect torch angle).

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Aluminium Soldering and Brazing

Soldering – SIF 555 Aluminium Solder

Historically, engineers have considered that welding aluminium presents a range of problems, due to its surface oxide and that it does not change colour when heated. With the advent of MIG and TIG welding, it is now regularly welded with great success. Certain alloys can be gas welded or brazed, but the removal of flux residue is most important, as its corrosive action will continue after the joint has been completed.

There is another 'low temperature' process, which is called soldering, although the workpiece is melted. The parts to be joined are heated (even by a small propane burner) and the rod rubbed on the work surface. At the correct temperature (370ºC), the rod is seen to melt and creates an exothermic reaction generating sufficient heat to locally melt the aluminium. An advantage of this process is that flux is NOT required. We refer to the material as SIF 555 Aluminium Solder. The product gives high strength deposits that do not have the problem of galvanic corrosion between base metal and solder. The low working temperature keeps distortion and discoloration of the work to a minimum.

This process is commonly used by manufacturers of aluminium windows and doors. It is ideal for repairing and sealing defects in aluminium boats, gutters, engine parts, castings and sheets, being especially recommended for applications where flux residue removal is a problem.

The correct procedure is as follows; cracks and joints should be bevelled to a 60º to 90º Vee. Remove all dirt, grease and foreign material from the surface to be bonded. For a higher strength bond, roughen the surface before applying the alloy. Using a carburizing flame, heat the part broadly. As the temperature approaches 370ºC, rub the rod on the surface to be soldered. Continue heating base metal until enough heat is present to cause the rod to melt off when it is rubbed on the joint. Do not overheat, but be sure the entire joint surface is tinned before adding additional alloy to make a build-up. Tinning action may be improved by using a clean, stainless steel wire brush to brush through the molten metal to the base metal surface. Allow part to cool slowly.

Brazing – Sifalumin No16 & Aluminium Flux

Traditionally Sifbronze referred to the technique as "Process 36", but recently Sifalumin No 36 and Aluminium No 36 flux have been replaced by Sifalumin No 16 which melts approx. 80ºC lower than pure aluminium and Aluminium Flux.

The process is applicable to pure aluminium and alloys with up to 2% magnesium. Other alloys will prove difficult, especially if containing high % of silicon. The joint design should be lap type with a good mechanical fit. Parts must be thoroughly cleaned and if magnesium bearing wire brushing is essential. The brazing operation should be carried out as soon as possible after cleaning .

The SIF Aluminium flux is used as a temperature indicator and can be applied via the rod or applied direct to the workpiece as a paste, made by mixing the flux with water. The whole workpiece should be pre-heated with the blowpipe moving backwards and forwards along the joint line. As the flux melts, the rod is applied to flow freely along and through the joint. It is important to avoid overheating which can destroy the properties of Sifalumin No 16.

Aluminium flux is highly corrosive and the residue must be removed within 30 minutes of the brazing operation. Where joints are accessible, wire brush with very hot water or even a steam jet, alternatively treatment with 5% nitric acid solution may be required.

MIG Brazing 'Manganese Boron Steel'

(in the automotive / vehicle production & repair industries)

Why 'Manganese Boron Steel'

In the automotive industry the need to save weight, while at the same time meeting increasingly severe crash test standards, has led to the use of high strength steels that conserve good ductility and formability. The high yield strength makes this material particularly suited for anti-intrusion functions i.e. fender beams, door reinforcements, middle posts etc. This sheet steel is pre-aluminised to protect the metal from oxidation and decarburisation, during heat treatment; this also enhances the corrosion resistance after painting, avoiding the need for any subsequent corrosion protection treatment.

MIG Brazing of pre-aluminsed (galvanised) sheet

Zinc, in the galvanised coating, melts at temperatures of around 420ºC and vaporises at 906ºC. This causes unfavourable effects on the welding process as unalloyed SG2 MIG welding wire melts around 1450ºC. The zinc starts to vaporise as soon as the arc is struck; zinc vapours and oxides can lead to pores and inadequate fusion. An alternative is to use MIG Braze process, using a copper silicon alloy wire SIFMIG 968 (CuSi3). SIFMIG 968 has a relatively low melting point approx 980ºC.

The reduced heat input results in the following advantages:

- low coating burn off
- no corrosion to the joint seam
- low distortion
- dissimilar joints (any combination of material, except aluminium)
- easy after joint machining
- fast deposition saving labour costs
- minimal spatter

Since there is no fusion of the base metal, it therefore has more in common with a brazed joint than a welded one.

The Product - SIFMIG 968

SIFMIG 968 is produced to conform to BS2901 C9 and also Din CuSi3, having a typical composition of 3% Silicon, 1% Manganese and balance Copper.

Diameters available:	0.8mm, 1.0mm and 1.2mm
Spool sizes:	D100 - 0.7kg (in 0.8 and 1.0mm) D200 - 4.0kg (spool bore is 50mm, so fits standard MIG set spindle) D300 - 12.5kg

General Hints

Copper alloy MIG wires require 'soft' or formed wire feed drive rollers and a soft or Teflon type wire liner in the torch cable. If the welding machine has been used with steel MIG wire, ensure any steel particles are removed from the wire feed system. This is to avoid carbon contamination on the copper alloy wire.

Procedure Tips

On thin sheet steel and galvanised sheet use 0.8mm / 1.0mm SIFMIG 968, keeping heat input to a minimum (approx 45-65 amps). Select a shielding gas, which will maintain a stable arc, such as pure Argon or Argon 2% CO2 mix. Pushing MIG torch (as conventional MIG welding) will ensure not too deep penetration, avoiding burn through on thin sheet. If galvanised coating is thick, use dip transfer with a short arc.

For best results, use a programmable synergic MIG machine. This type of system will produce a neat, clean brazed joint, requiring a minimal amount of joint dressing and preparation prior to painting. low coating burn off no corrosion to the joint seam low distortion dissimilar joints (any combination of material, except aluminium) easy after joint machining fast deposition saving labour costs minimal spatter

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TIG Brazing

(Comments and a few Applications)

'TIG Brazing' can cover a wide range of applications, from the point of view of materials to be joined, joint design, one off special repair job to quantity production. Perhaps the title is a confusion of terms. Initial reaction is that TIG is a fusion welding process and brazing gets obscured with the thought of oxy-acetylene torches, flux powder etc. In practice, the heat source is the TIG arc but run on a low current so as not to melt the material with a suitable filler rod fed into the arc. This filler rod is quite different from conventional oxy-acetylene 'silicon bronze' brazing rod. As the TIG torch provides a protective gas shroud, there is no need for the addition of flux, as with the long established brazing process.

There are typically three different copper alloys filler rods to be considered for TIG Brazing:

Sifsilcopper No 968 (C9)

Sifsilcopper No 968 conforms to BS2901 C9 and Din CuSi3, having a typical composition of 3% Silicon, 1% Manganese and balance Copper. It is available in diameters: 1.2, 1.6, 2.4 & 3.2mm and pack sizes 1.0, 2.5 & 7.5 kgs.

A customer was using Sifsteel A15 to complete TIG welds on sheet steel ducting, which was being joined to a square section frame. The initial problem was distortion due to heat build up and subsequent costs for heat treatment to remove stresses and dress the weld. TIG brazing with Sifsilcopper No 968 was suggested. The speed of operation is nearly twice as fast as welding, as the TIG arc has a temperature of approx 1400ºC and Sifsilcopper No 968 melting point is around 1000ºC, some 450ºC lower than Sifsteel A15. The speed of operation is very rapid.

Not only did the customer nearly halve his 'joining' time, but found there was only minimal 'after brazing' work to bring the components into an acceptable final condition for painting.

Procedure tips

TIG brazing is relatively straightforward. The TIG torch needs a thoriated tungsten and dc current (torch +). Whereas TIG welding with say 1.6mm Sifsteel A15 would require 80-95 amps, TIG brazing will only require less than half that current, more in the order of 35-45 amps. As you can imagine, it is important for the welder to be comfortably positioned with regards to the parts being joined, so that the whole procedure can flow at a relatively fast rate. Maintaining torch and filler rod angles with respect to the workpiece is key, to prevent breakdown of the inert gas envelope to avoid atmospheric contamination of the joint.

Sifphosphor Bronze No 8 (C11)

Sifphosphor Bronze No 8 conforms to BS 2901 C11 and Din CuSn6, having a typical composition of 7% Tin, balance Copper It is available in diameters: 1.2, 1.6, 2.4 & 3.2mm and pack sizes 1.0, 2.5 & 7.5 kgs.

This filler rod is particularly useful where copper alloys are involved, if the joint is between dissimilar metals (e.g. copper/stainless), if the metal cannot be completely identified or if it is known to be difficult to weld but can be brazed.

As an example, a welder was required to repair an old exhaust manifold, which had been previously welded on a number of occasions where cracks had developed in and around the heat affected zone. Further efforts to TIG weld the material only led to burn through and further cracks. The exact composition of the metal was not known.

The solution was for the welder to try Sifphosphor Bronze No 8, working on ground out cracks and suitably reducing the current. The job was successful and the manifold went back into service.

Sifalbronze No 32

Sifalbronze No 32 conforms to BS 2901 C13 and Din CuAl9Fe, having a typical composition of 10% Aluminium, 1% Iron, balance Copper. It is available in diameters: 1.6, 2.4 and 3.2mm and in 1.0, 2.5 and 7.5 kg packs.

This filler rod alloy has free flowing characteristics making it ideal for close fitting joints which one would expect to find in brazing operations.

An example here would be the fabrication of special bicycle frames from T45 (0.2% C, 0.2% Si, 1.5% Mn) Steel material. If the joints are of the type where tube fits into sockets or lugs, Sifalbronze No 32 is particularly ideal, as it has excellent 'wetting out' characteristics compared with the other alloys.

As Sifalbronze No 32 contains 10% aluminium, ac current is recommended with zirconiated tungsten.

General Hints

Irrespective of the filler rod used, argon is the recommended shielding gas. Always remember that cleanliness of the workpiece is a priority for first class results: remove any oxide or grease from the joint area.

Bronze Welding and Brazing

Sifbronzing

For successful 'bronze welding' or'sifbronzing', parts must be clean and for optimum strength a 60º - 90º vee preparation is required. Using leftward welding technique, the parts should be heated with an oxidising flame to a 'dull red', before introducing the Sifbronze rod and flux. Overheating must be avoided, as this will lead to porosity and inferior work.

It is essential that the joint faces are tinned. A drop of Sifbronze appears to collapse and spread across the metal face. If the drop stays as a globule, the metal is either too hot, too cold or dirty. The gap between the tinned faces is now filled with a weave action. It may be necessary to carry out further 'weld runs', building up the joint.

Sifbronze flux plays an important role not just cleaning the metal, but it covers the weld pool surface, preventing further oxidation of the molten bronze.

Bronze welding cast iron

Prior to 'welded fabrications', engineers would use cast iron to produce a whole range of products from small domestic items (mangles, mincers, mowers) to large industrial parts (agricultural equipment, civil engineering brackets and fixings, cylinder blocks, machine tool frames etc). Cast iron is a very hard, but brittle material, which can be easily machined.

Since it is brittle, there is a tendency for it to fracture, especially if a part is subjected to a sudden impact, such as a casting being dropped on a protruding fixing lug or bracket. A repair of this nature does not require a colour match, so oxy-acetylene sifbronzing (or bronze welding) will be considered. The joint must be prepared by grinding back the surface and producing a 'vee' preparation if the material is thick.

The first task is to seal the carbon into the cast iron, by 'buttering' both faces of the joint. This is done by using brazing rod (Sifbronze No 1) and standard Sifbronze flux, to cover each face with a layer of brazing material. Next, the two parts are positioned so that the joint can be completed by bronze welding between the two 'buttered' faces.

This produces a strong joint, which is very visible, unless dressed and painted. The process does not require the parts to be pre-heated, as necessary when full fusion welding cast iron.

Brazing copper to copper

Copper to copper joints produced with SIFCUPRON, do not require the addition of flux, as the phosphorus provides a self-fluxing action. It is necessary for the parts to overlap with a joint gap of 0.05 to 0.12mm. The gap should not exceed 0.4mm

As copper is a very good thermal conductor, the heat must be applied quickly, taking great care not to overheat and cause embrittlement. If joint strength and ductility are important, Sifcupron No 17-2Ag or 17-5Ag should be used in preference to No 17. Sifcupron No 17-15Ag is more tolerant if joints are not close fitting.

On occasions, there is the need to braze copper to brass (perhaps a brass flange to a copper pipe). Provided it is a suitably designed joint, a copper/phos alloy with an inclusion of silver (such as Sifcupron No 17-2Ag) will be ideal. However in order to get the alloy to bond with the brass, it is necessary to use a flux, such as Sifsilcopper or Sifbronze.

Sifcupron is not suitable for brazing nickel alloys, ferrous metals or where the joint is subject to hot sulphurous gases or oxidising atmosphere above 200ºC.

Silver Soldering

As with all brazed joints, preparation and cleaning of the workpiece is essential to produce a successful joint. When silver soldering, lap type joints (rather than butt) are preferred and the recommended clearance is 0.04 to 0.15mm.

Apply SIF Silver Solder flux to both joint faces before assembling the parts. Using a neutral flame, heat assembly quickly and evenly, avoiding overheating the silver solder (wipe rod on joint rather than melting it directly in the flame). Use in a well ventilated area and be aware of health and safety procedures.

To silver solder stainless, a high silver content alloy is required (such as SIF Silver Solder No 43 — 55% Ag Cd free) and a suitable flux (SIF Flux - Silver Solder). Alternatively, a 'nickel bronze' brazing rod such as Sifbronze No 2 together with 'Tool Tipping/Brazing Stainless' flux (note: do NOT use Stainless flux as it is for gas welding of stainless).

GasFlux Process

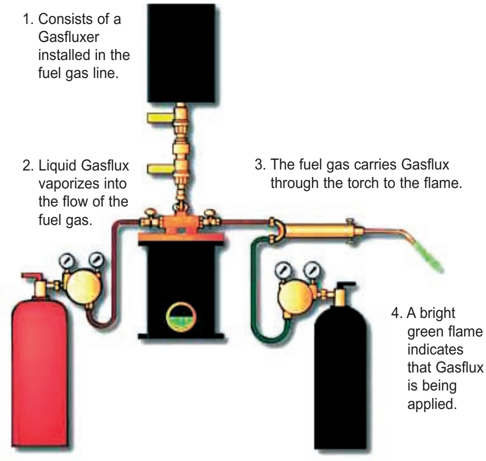
With changing technology, the 'old' established methods of joining metals by gas welding or brazing are being converted to TIG or MIG processes. However, there is still a place for the 'old' processes for either production of parts designed for brazing and also for repair and maintenance work, which is dependent on welder skill and technique.

The Process

The 'GasFlux' process is a very attractive alternative to using powder flux or flux coated rods. It literally puts flux into the fuel gas and it is delivered to wherever the flame is directed, resulting in superior fluxing and wetting action, which encourages the brazing alloy to flow evenly and follow the flame smoothly giving optimum strength and outstanding appearance.

As shown in the diagram, a GasFluxer unit is installed in the fuel gas line (usually acetylene). The Reserve Tank is detachable, so that it can be removed from the welding area and any possible source of ignition, when it is topped up with GasFlux Liquid, which is flammable; an important health and safety point.

The Gasfluxer unit can control the gas flow rate and also the amount of liquid flux being collected, thereby ensuring that just the right amount of flux is delivered to the joint, ensuring a sound braze with a minimum of flux residue removal work. The flame with Gasflux burns with a green hue and ideally blue goggle lenses should be used to clearly view the joint area during the brazing process.



Applications

Immediate thoughts turn to tubular applications, where a smooth fillet joint is required, which is then possibly painted or plated to look attractive. Such items might be bicycles, wheelchairs, hospital furniture, go-karts, automotive assemblies. The list could go on and on. These are all predominantly produced from steel, but GasFluxers are also used on copper and brass components to aid the brazing process and reduce subsequent cleaning operations. Many assemblies are suitable for automatic brazing and the GasFlux system is an ideal method for delivering flux to the joint area.

For steel applications, the ideal rods to use are Sifbronze No 1 (EN 1044 CU 302) and also our Special bronze 'Sifbronze No 101', which is ideal for production work with the GasFlux process. For work on copper and brass, filler rods such as Sifcupron No 17 (EN 1044 CP201) and No 17-2Ag (EN 1044 CP105) and a range of silver solders would be considered.

Benefits

The GasFlux process improves brazing quality and reduces costs by:
Optimum joint strength
Reduced filler rod consumption
Minimising post joint cleaning operations
Quicker brazing times.

General

The flux is only delivered where the flame is directed. With a complicated design where the flame cannot access a blind side or where deep penetration is required, it maybe necessary to mix a powder flux to paste and add to the 'blind' areas prior or during assembly.

Welding Copper and Brass

Copper

Pure copper has characteristics of high thermal and electrical conductivity and, because the metal requires about six times more heat (melting point is 1,083ºC) for fusion welding than steel, particular care must be taken during welding and brazing.

Tough pitch copper, which includes most varieties of high conductivity copper, contains up to 0.5% oxygen (cuprous oxide) and is not suitable for fusion welding since it has a tendency to embrittlement and cracking, though it can be brazed.

Deoxidised copper, where the oxygen has been removed during manufacture by the use of deoxidising agents, can be fusion welded.

For MIG and TIG welding, It will be necessary to preheat workpiece if it is over 6mm thick. The usual shielding gas is argon, but with thicker material an argon/helium mixture can beneficially increase the arc temperature. Consumables to be used are SIFMIG 985 and Sifsilcopper No 985, although Sifsilcopper No 7 can be used for TIG welding sheet up to 3mm thick.

Gas welding of copper, such as whiskey stills, tanks etc, requires the parts to be preheated to 600ºC and slowly cooled on completion of the joint. Sifsilcopper No 7 together with Sifsilcopper flux will produce a joint with excellent colour match.

Copper is not generally joined using arc welding electrodes. But in circumstances where there is no other welding equipment other than a transformer, Hilco Bronsil proves ideal.

Brass

Brass is a generic term covering a wide range of copper alloys containing additions of zinc. All brasses, which includes Gilding Metal, can be silver soldered, MIG and TIG welded successfully. However, the addition of lead for free cutting brass and in gunmetal (LG1 & LG2) causes porosity and fume problems with gas shielded arc welding. Phosphor Bronze, copper/tin alloys such as PB2, can be readily brazed or welded.

Gas welding of brass is not recommended as the zinc will tend to vaporise causing fumes (zinc oxide) and porosity. However, PB2 phosphor bronze can be joined with oxy-acetylene and Sifphosphor Bronze No 8, as sometimes used by sculptors.

For MIG and TIG welding a shielding gas of argon or argon/carbon dioxide mixture is used. If it is felt necessary to use preheat, this must be limited to less than 80ºC, otherwise the structure of the brass may become altered.

The choice of filler wire or rod will depend on the composition of the alloy being joined. As a general comment, SIFMIG 8 or Sifphosphor Bronze No8 is recommended as first consideration. However, SIFMIG 328 and 968 or Sifalbronze No 32 and Sifsilcopper No 968 may also be suitable. If colour match with brass is important, Sifphosphor Bronze No 82 is recommended.

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Stainless

Stainless steel is a generic term for a range of steels that contain a minimum of 12% chromium, although other elements such as nickel and molybdenum are added to improve corrosion resistance, which is their primary feature and use. They sub-divide into five groups, but our main interest is with austenitic, which is the most popular and weldable range of stainless used in chemical plants, food processing equipment etc.

TIG welding is ideal for high quality work or root runs, prior to filling with an alternative process. Whereas the main advantage of MIG is speed. Shielding gas is typically argon or a mix of argon, helium and CO_2 There is a range of matching consumables in 2. SIFMIG and Sifsteel Stainless, covering 347, 308, 316, 309 and 312 grades. Whilst talking MIG and TIG process, stainless can be TIG or MIG brazed using say Sifphosphor Bronze No 8 or SIFMIG 8, which can be very useful if the material needs to be joined to copper or steel.

It is possible to gas welding the common grades of stainless (18/8), but it is important to use Stainless flux and also apply the flux in paste form (mix powder with water) to the reverse side of the joint. Also, stainless can be silver soldered or brazed, which is again a benefit for dissimilar metal applications. To silver solder stainless, a high silver content alloy is required (such as SIF Silver Solder No 43 55% Ag Cd free) and a suitable flux (SIF Flux Silver Solder). Alternatively, a 'nickel bronze' brazing rod such as Sifbronze No 2 together with 'Tool Tipping/Brazing Stainless' flux (note: do NOT use Stainless flux as it is for gas welding of stainless).

A widely used process is arc welding. Our range of Hilchrome electrodes are ideal in the flat and vertical up positions and produce a concave bead from which the slag will easily lift.

Procedure Tips:

Cleanliness of the workpiece and working area is most important. Only use stainless wire brushes for cleaning. As stainless is considered a poor thermal conductor, preheat is not normally required and a high heat input should be avoided. Avoid striking the arc outside the joint, as this can lead to pitting and cracks.

With TIG, use a thoriated tungsten and do not allow it to contact the workpiece, which can lead to contamination. After welding, clean thoroughly using a stainless brush. Use SIF Pickling Paste to clean discoloration from surface and restore chrome oxide layer on the stainless.

The weld can become contaminated and 'rust' spots appear on the stainless if ferrous particles have inadvertently been allowed to enter the weld area. This can be caused by poor housekeeping (stainless brush being used on steel) or other operations in the welding area which produce air borne metal particles, such as grinding.

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Steel

As a general statement, steel is readily weldable by the majority of welding processes. With alloy steels, it is necessary to select an appropriate filler metal for the material and service situation that the weld will be subjected to. As a guide, carbon content is the first consideration, followed by silicon and manganese. If there are other elements such as chromium, molybdenum etc, then these will usually take priority over carbon.

In today's world, the first thought for welding steel is to use the MIG process and SIFMIG SG2 wire, or perhaps if a higher UTS is required SIFMIG SG3. In fact, welding is symbolised by a MIG welder and a 'shower of sparks'!

Having touched on the MIG process, if deposition rate is important, then Sifcored E71T-1 flux cored wire should be considered. It should also be borne in mind that steel can be MIG brazed, as in the automotive industry on manganese boron steel with SIFMIG 968. Our other copper alloy wires SIFMIG 8 and 328 are also suitable for MIG brazing.

TIG filler rods are available for a range of mild and alloy steels. A frequently asked question is 'what do we use on 4130 (0.3C, 0.3Si, 0.5Mn, 1.0Cr, 0.2Mo)'; the answer is Sifsteel A32. With spring and high carbon steels, Sifsteel Stainless 312 is often the answer. For joining steel to stainless, consider Sifsteel Stainless 309LSi.

It is also worth remembering that TIG brazing with Sifphosphor Bronze No 8, Sifalbronze No 32 or Sifsilcopper No 968 can be very useful with difficult steel applications, dissimilar joints or where heat must be kept to a minimum.

The Sifbronze business developed due the ability of Sifbronze No 1, No 101 and No 2 to 'bronze weld' and braze steel, with minimum of distortion and producing a neat fillet joint, especially on tubular structures. Perhaps we should also add silver solder for those steel to brass/copper joints. From a gas welding point of view, the filler rod is Sifsteel No 11, which is also referred to as CCMS.

Now to arc welding electrodes, which come with three different types of coating. The most common and popular electrode, such as Hilco Red Extra, Velveta and Velora have a 'rutile' coating, which is predominantly titanium oxide to decrease spatter and improve slag removal. Cracking in steels is often due to the formation of minute quantities of steam from hydrogen in the electrode combing with oxygen from the air. This can be overcome by using 'basic' coated electrodes (Hilco Basic Super and Basic 55), also known as 'low hydrogen'. Finally, for high deposition rates, iron powder is added to the coating to substantially increase the amount of material deposited compared with a rutile type electrode. They are referred to as 'high recovery', such as Hilco Regina 160.

Cast Iron and Super SG Cast Iron

Oxy-Acetylene Welding with Super Silicon No. 9

Broken castings should be aligned and tack-welded into position before pre-heating. All castings must be carefully supported on firebricks with a space of at least three inches beneath and preheated in a muffle to between 600ºC and 800ºC.

An oxy-acetylene flame, of ample capacity for the thickness of metal to be welded, is adjusted to a neutral condition. The edges of the fracture, or the sides of the vee groove, are melted by flame application; a little SIF Cast Iron Flux sprinkled in the weld area assists in forming a fluid pool of metal.

It is recommended that, on completion of welding, the casting should be brought once again to a uniform temperature of 600ºC-800ºC and then allowed to cool very slowly inside the muffle. Cast iron welds correctly made by the oxy-acetylene process using Super Silicon No. 9 rods can be relied upon to provide a soft and easily machinable deposit with full physical properties similar to those of the parent metal.

For spheroidal graphite cast iron, follow the above procedure and ensure you are using Sif Super SG Cast Iron.