International Journal of Advanced Multidisciplinary Research
ISSN: 2393-8870
www.ijarm.com
DOI: 10.22192/ijamr Volume 4, Issue 6 -2017

Research Article

DOI: http://dx.doi.org/10.22192/ijamr.2017.04.06.007

Effect of Shielding gas mixture on Welding of Stainless Welding in Gas metal Arc Welding process

*Subramanian.S[1], Senthil kumar.T[2]
[1] PG student, Department of Mechanical Engineering, BIT Campus, Anna University, Trichy, Tamil Nadu, India
[2] Dean, University College of Engineering, University, BIT Campus, Trichy, Tamil Nadu, India
*Corresponding Author

Keywords

Shielding Gas,
Weld pool
Stainless steel SS 309
Welding process

Abstract

Shielding gases are inert or semi-inert gases that are commonly used in several welding processes, most notably gas metal arc welding and gas tungsten arc welding (GMAW and GTAW, more popularly known as MIG and TIG, respectively). Their purpose is to protect the weld area from oxygen, and water vapour. Depending on the materials being welded, these atmospheric gases can reduce the quality of the weld or make the welding more difficult.

1. Introduction

In chemical and petrochemical industries, it is difficult to resist the effect of highly corrosive atmosphere of hydrocarbons on the low alloy steel pressure vessels or heat exchangers. Stainless steel is a corrosion resistant material, but it is very costly. So, by applying SS-Lining/cladding on the inner surface of Carbon/ Low alloy steel vessels economically serve both the purpose – required mechanical properties and good corrosion resistance properties. The internal surfaces of the high pressure heat exchangers are given a surface treatment using austenitic stainless steel in order to surfacing is carried out in the flat position using a high deposition rate process. Complex shapes and difficult access will likewise restrict the choice of process to the single arc systems, like GMAW.

Stainless steels are high-alloy steels which have higher corrosion resistance compared to other steels due to the presence of large amounts of chromium. Based on their crystalline structure, they are further divided into ferritic, austenitic, and martensitic steels.

Grade 309 stainless steel has high corrosion resistance and strength compared to 304 stainless steel. The following datasheet gives an overview of grade 309 stainless steel FCAW.

Flux cored wires are aimed to combine the advantages of the flux of manual metal arc electrodes with the continuous welding capability of solid wires. FCAW employs a tubular wire electrode whose core contains: a) Alloying materials which can be tailored to meet the deposit chemistry and corrosion/ wear requirements, b) Fluxing agents to improve wetting and deposit appearance c) Fluxes to generate gas shield. Since the fluxes can even generate a protective gas shielding, one of the variations of the process is Self shielded FCAW process, well known as FCAW-S, where S stands for self-shield property. FCAW- S is often used for onsite welding purpose like in ship building, repairs of railway tracks etc.

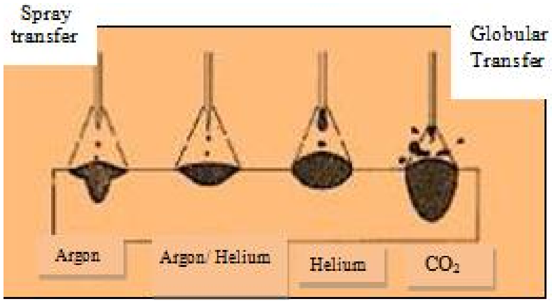
[1]. However, for the corrosion resistant overlay purpose the gas shielded FCAW process, which is well known as FCAW-G, is preferred. The shielding gases used for carbon manganese flux cored wires are either CO_2 or argon based mixtures containing CO_2, O_2 or both. Argon based or helium rich mixtures may be used with stainless steel wires, but in all case, if the optimum performance and weld metal properties are required, the gas chosen should comply with the recommendations of the wire manufacturer

[2]. The main features of the FCAW Process are: high deposition rates, alloying addition from the flux core, slag shielding and support and improved arc stabilization and gas shielding [2]. The shielding gas and flow rate have a pronounced effect on the following: arc characteristics, mode of metal transfer, penetration and weld bead profile, speed of welding, undercutting tendency, cleaning action, weld metal mechanical properties [

3]. There are two basic requirements for the overlay: minimum dilution of the substrate material to attain the correct chemistry, 3 mm from the top of the bead, and the flat profile of the weld bead, for 50% overlap with the adjacent beads. The two main variables which affect the properties of the deposited metal when FCAW process is employed are the flux

2. Effect of thermal conductivity

Argon atoms are easily ionized at the arc, which results in a highly charged path between the electrode and work piece. This concentration of energy constricts the droplet size of the weld metal, thus keeping transfer well within the spray mode. Pure Ar due to the low thermal conductivity and higher surface tension has low penetration compared to pure CO_2 and produces an arc transfer which is difficult to control. CO_2 has higher thermal conductivity and low surface tension has dipper and wider penetration than 100% Ar. It is also reported that there is higher base metal dilution with the filler metal, in the CO_2 containing shielding gas atmosphere as compared to pure Ar, (The effect from process parameters on dilution is restricted by maintaining the same parameters for both the types of gases/mixtures). Figure 1, illustrates the effect of thermal conductivity and surface tension on the weld bead profile.



3. Effect of oxidation potential in the shielding gas

Oxidation potential of the shielding gas is equal to the % O_2 + ½ % CO_2 [6] .It is reported that the use of carbon dioxide containing shielding gases may result in the change in carbon content of the weld metal. During the welding of stainless steel using CO_2 containing shielding gases, two different types of reactions may take place, depending on the % C in the weld molten metal at the time of welding. These reactions are as under, In the heat of the arc CO_2 breaks down into oxygen and carbon monoxide which prevents some alloying elements from being transferred into the weld pool resulting in loss of alloying elements.

$2 CO_2 \leftrightarrow 2CO + O_2$ ---------- {Eq.1}

Now due to the presence of the oxygen in the weld metal during weld, some of the elements like Si, Mn, and Cr etc will be easily oxidized. Thus their levels in the deposit may be reduced. It is seen that with the decrease in Si and Mn levels, the strength and toughness of the metal gets reduced and the loss of alloying elements like Cr affects the ferrite number (decrease in ferrite number) of the weld metal. Now molten iron reacts with CO_2 and produces iron oxide and carbon monoxide in a reversible reaction:

$Fe + CO_2 \leftrightarrow FeO + CO$ .... {Eq.2}

At red heat temperatures, some of the carbon monoxide dissociates to carbon and oxygen, as follows:

$2 CO \leftrightarrow 2C + O_2$ .... {Eq.3}

The effect of CO_2 shielding on the carbon content of mild, low-alloy steel and stainless steel weld metal is unique (as also referred earlier). Depending on the original carbon content of the base metal and the electrode, the CO_2 atmosphere can behave either as a carburizing or decarburizing medium. Whether the carbon content of the weld metal will be increased or decreased depends on the carbon present in the electrode and the base metal. If the carbon content of the weld metal is below approximately 0.05%, the weld pool will tend to pick up carbon from the CO_2 shielding atmosphere and this carburization reaction may raise the weld metal carbon level to about 0.08 to 0.1 %.Conversely, if the carbon content of the weld metal is greater than approximately 0.10% the weld pool may lose carbon.It is also reported that the increase in Cr and Si content there is increase in Carbon content. It is reported that the above explained phenomenon is more prominent with solid wire welding. Now in solid wire welding (GMAW) using shielding gases, namely, 100% Ar and Ar – CO_2 gas blends, if the % C in the weld metal achieved by using each gas is measured and compared. Then the value of % C so measured for the weld metal achieved in the pure Ar atmosphere, which is an inert atmosphere, can become the basis or the reference value for comparing the weld metal % C achieved in the CO_2 containing shielding gas atmosphere (for % C content study). Since in the present study, flux cored wire is employed, the sole effect of shielding gas, on the % C in the weld metal, cannot be achieved even with 100% Ar shielding gas(which is an inert gas.). So it becomes necessary to know the contents of the flux, which will also have some effect on the weld metal composition. The rutile type FCAW wire was employed for the overlay. (Presence of High amount of TiO_2, Ca oxide, and SiO_2 reported during chemical analysis of flux). The flux contains mainly stable oxides, smooth arc promoters like TiO_2 and calcium oxides, Ferro alloys and some metallic powders.

*"During the analysis of the chemical compositions, particularly % C, of the overlay metal achieved by the experiment, the results of % C in 100% Ar atmosphere were discussed with **Dr. D. J. Kotecki**. In those regards it wassuggested by **Dr. D. J. Kotecki** that "the slag system of E309LT0-1 and of E347T0-1 is high in SiO_2 in all of the commercial embodiments with which I am familiar. The SiO_2 can cause some oxidation of carbon, which may explain loss". Thus through this valuable guide lines, it was known that the flux contains high amount of SiO_2"*

The present study mainly deals with the effect of use of CO_2 containing shielding gas/ mixtures for the overlay of low carbon containing austenitic stainless steel on low alloy steel and also comparing these results when the overlay is carried out with pure Ar as shielding gas.

3.1 GMAW of stainless steels

Stainless steels are defined as iron base alloys which contain at least 10.5% chromium. The thin but dense chromium oxide film which forms on the surface of a stainless steel provides corrosion resistance and prevents further oxidation. There are five types of stainless steels depending on the other alloying additions present, and they range from fully austenitic to fully ferritic types. Type of Stainless Steels Austenitic stainless steels include the 200 and 300 series of which type 304 is the most common. The primary alloying additions are chromium and nickel. Ferritic stainless steels are non-hardenable Fe-Cr alloys. Types 405, 409, 430, 422 and 446 are representative of this group. Martensitic stainless steels are similar in composition to the ferritic group but contain higher carbon and lower chromium to permit hardening by heat treatment. Types 403, 410, 416 and 420 are representative of this group. Duplex stainless steels are supplied with a microstructure of approximately equal amounts of ferrite and austenite. They contain roughly 24% chromium and 5% nickel. Their numbering system is not included in the 200, 300 or 400 groups.

Precipitation hardening stainless steels contain alloying additions such as aluminum which allow them to be hardened by a solution and aging heat treatment. They are further classified into sub groups as martensitic, semiaustenitic and austenitic precipitation hardening stainless steels. They are identified as the 600-series of stainless steels (e.g., 630, 631, 660). Special Alloying Elements The alloying elements which appear in stainless steels are classed as ferrite promoters and austenite promoters and are listed below: Ferrite Promoters Chromium – provides basic corrosion resistance. Molybdenum – provides high temperature strength and increases corrosion resistance. Niobium (Columbium), Titanium – strong carbide formers. Austenite Promoters Nickel – provides high temperature strength and ductility. Carbon – carbide former, strengthener. Nitrogen – increases strength, reduces toughness. Neutral Effect Regarding Austenite & Ferrite. Manganese – sulfide former. Silicon – wetting agent. Sulfur and Selenium –

improve machinability, but may cause hot cracking in welds.

Weldability of Stainless Steels Most stainless steels are considered to have good weldability and may be welded by several welding processes including the arc welding processes, resistance welding, electron and laser beam welding, friction welding and brazing. For any of these processes, joint surfaces and any filler metal must be clean. The coefficient of thermal expansion for the austenitic types is 50% greater than that of carbon steel and this must be considered to minimize distortion. The low thermal and electrical conductivity of austenitic stainless steel is generally helpful. Less welding heat is required to make a weld because the heat is not conducted away from a joint as rapidly as in carbon steel.

In resistance welding, lower current can be used because resistivity is higher. Stainless steels which require special welding procedures are discussed in later sections. Ferritic Stainless Steels The ferritic stainless steels contain 10.5 to 30% Cr, up to 0.20% C and sometimes ferrite promoters Al, Nb (Cb), Ti and Mo. They are ferritic at all temperatures and, therefore, do not transform to austenite and are not hardenable by heat treatment.

This group includes the more common types 405, 409, 430, 442 and 446. Table 7 lists the nominal composition of a number of standard and several non-standard ferritic stainless steels. They are characterized by weld and heat affected zoned (HAZ) grain growth which can result in low toughness of welds. To weld the ferritic stainless steels, filler metals should be used which match or exceed the chromium level of the base alloy. Type 409 is available as metal cored wire and Type 430 is available in all forms. Austenitic Types 309 and 312 may be used for dissimilar joints. To minimize grain growth, weld heat input should be minimized, preheat should be limited to 300 - 450°F (149 - 232°C) and used only for the higher carbon ferritic stainless steels (e.g., 430, 434, 442 and 446). Many of the highly alloyed ferritic stainless steels are only available in sheet and tube forms and are usually welded by GTAW (Gas Tungsten Arc Welding) or TIG welding without filler metal. Martensitic Stainless Steels.

The martensitic stainless steels contain 11 to 18% Cr, up to 1.20% C and small amounts of Mn and Ni and, sometimes, Mo. These steels will transform to austenite on heating and, therefore, can be hardened by formation of martensite on cooling. This group includes Types 403, 410, 414, 416, 420, 422, 431 and 440. Both standard and non-standard martensitic stainless steels are listed in Table 8. They have a tendency toward weld cracking on cooling when hard brittle martensite is formed. Chromium and carbon content of the filler metal should generally match these elements in the base metal. Type 410 filler is available as covered electrode, solid wire and cored wire and can be used to weld types 402, 410, 414 and 420 steels. Type 410 NiMo filler metal can also be used. When it is necessary to match the carbon in Type 420 steel, Type 420 filler, which is available as solid wire and cored wire, should be used. Types 308, 309 and 310 austenitic filler metals can be used to weld the martensitic steels to themselves or to other steels where as-deposited toughness is required. Preheating and inter pass temperatures in the 400 - 600°F (204 - 316°C) range is recommended for most martensitic stainless steels. Steels with over 0.20% carbon often require a post weld heat treatment to soften and toughen the weld. GMAW of Stainless Steels.

4 Welding process

Welding process mostly used in tube to header joint configurations are,

a) Shielded metal arc welding (SMAW)
b) Gas metal arc welding (GMAW)
c) Tungsten inert gas welding (TIG) for root pass.

4.1Shielded metal arc welding

This process employs coated or covered electrode for producing an arc to act as a heat source; the covering on burning provides the necessary shield to protect the molten metal from ill effects of oxygen and nitrogen from the surrounding atmosphere. This process is more popularly known as stick electrode welding or manual arc welding process in the world. Both AC and DC power source can be used equally and effectively. The weld pool produced depends up on the size of the covered electrode and the welding current used. This process is an all-position welding process and is used for all types of jobs. All metals for which covered electrodes are available can be welded by this process. Because this is a very versatile process so it is still extensively used in the fabrication of ships, pressure vessels and structural; however it is used in its manual mode only.

4.2 Tungsten inert gas (tig) welding

TIG welding employs a non-consumable tungsten electrode with an envelope of inert shielding gas (Argon, helium etc.) to protect both the electrode and welding pool from detrimental effects of surrounding atmosphere gases. Both AC and DC power sources are used for TIG welding. The tungsten electrode employed varies in diameter from 0.5 to 6.5mm and the current carrying capacity varies accordingly between 5A to 650 A. The welding torch used for carrying current higher than 100A is normally water cooled. TIG welding is an all position welding process and gives highest quality welds amongst the commonly used arc welding process.

4.3 Gas Metal Arc Welding (GMAW)

In gas metal arc welding (GMAW) process a consumable wire of 0.8 to 2.4mm wound in spool form, fed at a preset speed through a welding torch wherein it is provided the electrical connection and the shielding gas. The arc which is struck by direct contact between the wire electrode and the work piece, is maintained at a constant length by the interaction of electrical parameters. The power source used is invariably of the rectified DC type. Both the constant voltage and constant current type power sources are in use. Depending up on the work material, the shielding gas may be argon, helium nitrogen, carbon dioxide, hydrogen and their mixtures. When inlet gas is used the process is more popularly known as metal inert gas (MIG) welding and when carbon dioxide is used as shielding gas it is referred to as carbon dioxide welding or MAG (Metal active gas) welding.

The molten metal at the electrode tip can be transferred to the weld pool by three different transfer modes: globular, spray and short circuiting.in globular transfer discrete metal drops close to or larger than the electrode diameter travel across the arc gap under influence of gravity. Globular transfer often is not smooth and produce spatter. At low welding current globular transfer occur regardless of the type of the shielding gas. Short circuit buried arc is used in carbon dioxide.

In spray transfer small discrete metal drops travel across the arc gap under the influence of the electromagnetic force at much higher frequency and speed than in the globular mode. Metal transfer is almost stable and spatter free. The critical current level depends up on the material and size of the electrode and composition of the shielding gas.

In short circuit transfer molten at the electrode tip is transferred from the electrode to the weld pool when it touches the weld pool surface, that is, when short circuit occurs. Short circuit transfer encompasses the lowest range of welding currents and electrode diameter. It produces small and fast-freezing weld pool that is desirable for welding thin sections, out of position welding and bridging large root openings.

A weld can be made over the whole joint area in a range of section sizes and complex shapes (for example from bicycle wheel rims to railway rails), although the sections to be joined should normally be closely matching. Mitre joints can also be formed, such as in welded metal window frames. A wide range of materials can be welded including steels, stainless steel, aluminium alloys, nickel alloys and titanium. A solid phase, forge weld is made, and any molten metal and contaminants formed at the interface during heating are squeezed out into the upset. Thus, solidification cracking and porosity are not normally an issue. The process is normally automatic or semi-automatic and process monitoring can provide an indication of weld quality.

Globular transfer often is not smooth and produce spatter. At low welding current globular transfer occur regardless of the type of the shielding gas. Short circuit buried arc is used in carbon dioxide shielded GMAW of carbon and low alloy steels to minimize spatter.

5. Protecting shield flux

Gas metal arc welding (GMAW), sometimes referred to by its subtypes metal inert gas (MIG) welding or metal active gas (MAG) welding, is a welding process in which an electric arc forms between a consumable wire electrode and the workpiece metal(s), which heats the workpiece metal(s), causing them to melt and join.

It produces small and fast-freezing weld pool that is desirable for welding thin sections, out of position welding and bridging large root openings.

6. Material selection and preparation

Material selection is governed by the metal temperature limits specified by ASME boiler and pressure vessel code. Stainless steel does not readily corrode, rust or stain with water as ordinary steel does.

However, it is not fully stain-proof in low-oxygen, high-salinity, or poor air-circulation environments. There are various grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel is used where both the properties of steel and corrosion resistance are required.

Table 6.1 Comparison of standardized steels

EN – Standard Steel no k.h.s	EN – Standard Steel name	SAE grade	UNS
1.4408	G-X 6 CrNiMo 18-10	316	S31600
1.4125	X105CrMo17	440C	S44004

Table 6.2 Chemical composition of the material (plate)

Material	Composition %						
	Fe	Cr	Ni	Mn	Si	S	C
SS 309	60	23	14	2	1	0.030	0.20
E 309	0	23.5	12.3	1.70	0.52	0.021	0.08

Table 6.3. Mechanical properties of the material

Material	Temperature limit (°C)	Tensile strength (MPa)	Yield strength (MPa)
Sstainless steel.309	0-100	620	310
E 309	150	600	207

6.1 Selection of welding electrode

Depending on the process variation and base material being welded the diameters of the electrodes used in GMAW typically range from 0.7 to 2.4 mm (0.028 – 0.095 in) but can be as large as 4 mm (0.16 in).

Weding process	Elecrode specification	Electrode diameter in mm
TIG	ER 80S-B2	2.4
GMAW	ER80S-B2	1.4
SMAW	E8018-B2	3.15

6.2 Other consideration

Material selection is affecting the welding processes in following ways. The selection of optimum process or technique for a specific application is made on the basis of the following considerations.

- Size and shape of the component
- Chemical composition of the deposit
- Metallurgical effect on parent material properties
- Surface finish and distortion
- Operating economics

6.3 Selection of welding machine

In GMAW process, along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from contaminants in the air.

The process can be semi-automatic or automatic. A constant voltage direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used

7 Experimental set up

- **Gas metal arc welding** (**GMAW**), sometimes referred to by its subtypes **metal inert gas** (**MIG**) **welding** or **metal active gas** (**MAG**) **welding**, is a welding process in which an electric arc forms between a consumable wire electrode and the workpiece metal(s), which heats the workpiece metal(s), causing them to melt and join.
- Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from contaminants in the air.
- The process can be semi-automatic or automatic. A constant voltage direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used.
- Unlike welding processes that do not employ a shielding gas, such as shielded metal arc welding, it is rarely used outdoors or in other areas of air volatility.
- A related process, flux cored arc welding, often does not use a shielding gas, but instead employs an electrode wire that is hollow and filled with flux.

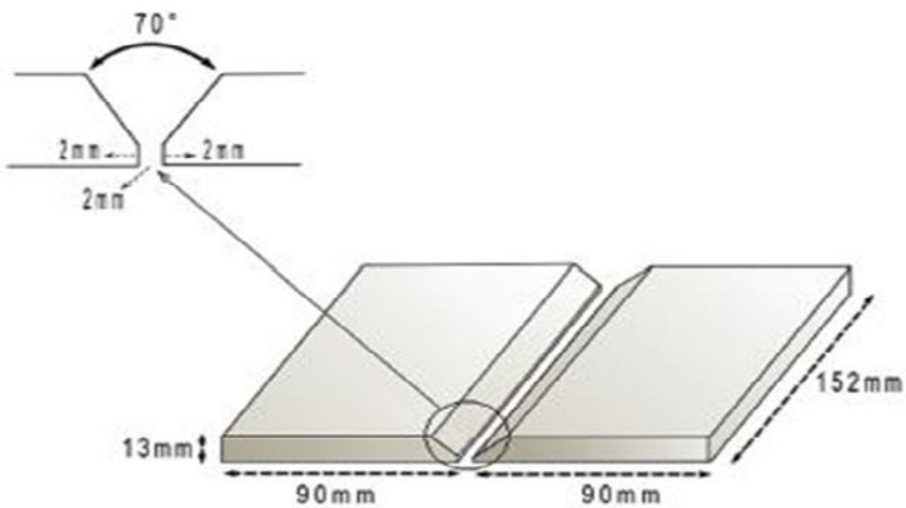


Fig. 6.1 Edge preparation of plate

7. Result and Conclusion

7.1 Room temperature bend test

The bend test is conducted to find out the ductility of the test piece. This test is conducted in UTN 60 bend testing m/c. Two types of bend test is conducted

i) Root bend - root side is bent at 180° angle

ii) Face bend - Face side is bent 180° angle

The two bend specimens of Stainless steel test pieces are prepared. The specimens are prepared as per AWS (B4:04:0M: 2000).

It is concluded from the bend test result that cracks appeared in the plates as both base metal and buffer layer are failed. It is proved that both joints have Brittle property and SS 309 has considered bonding when compared.

Table 4.2 Bend test results

Specimen	Face Bend	Angle of opening	Remarks	Root Bend	Angle of opening	Remarks
SS 309	25 mm	open	Failed	15 mm open discontinuity	90	Failed

Fig-2: Universal bending m/c

7.2 Micro hardness measurements

Hardness measurement can be defined as macro-, micro- or nano- scale according to the forces applied and displacements obtained.

Measurement of the macro-hardness of materials is a quick and simple method of obtaining mechanical property data for the bulk material from a small sample. It is also widely used for the quality control of surface treatments processes. However, when concerned with coatings and surface properties of importance to friction and wear processes for instance, the macro-indentation depth would be too large relative to the surface-scale features.
Where materials have a fine microstructure, are multi-phase, non-homogeneous or prone to cracking, macro-hardness measurements will be highly variable and will not identify individual surface features. It is here that micro-hardness measurements are appropriate.

Microhardness is the hardness of a material as determined by forcing an indenter such as a Vickers or Knoop indenter into the surface of the material under 15 to 1000 gf load; usually, the indentations are so small that they must be measured with a microscope. Capable of determining hardness of different microconstituents within a structure, or measuring steep hardness gradients such as those encountered in casehardening. Conversions from microhardness values to tensile strength and other hardness scales (e.g. Rockwell) are available for many metals and alloys.

Micro-indenters works by pressing a tip into a sample and continuously measuring: applied load, penetration depth and cycle time.

7.3 Hardness measurement methods

There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgic ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The way the three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a given load, within a specific period of time. The followings are the most common hardness test methods used in today`s technology.

Rockwell hardness test
Brinell hardness
Vickers
Knoop hardness

Vickers hardness in vertical

Test piece	At Base metal	At weld metal
SS309	565	524

Vickers hardness in horizontal

Test piece	At Base plate	At HAZ	At weld metal
SS309	556	485	528

7.4 Macro & micro structure

Micro test is conducted by optical microscope at different focal length to find out the microstructure present in the weld metal, HAZ, weld interface, Root interface and base metal. Metallography procedure is used to study the microstructure of base metals, weld metals and heat affected zone and microstructure changes The recording observed under metallurgical microscope can be the effective way to analysis the effects Of cladding layers base plate and SS309. Microstructure reveals the better bonding of SS 309 is observed with lesser dilution.

7.5 Micro-hardness testing

Joining metals together by welding is a skill which demands precision and expertise. The quality of a weld is dependent on the combination of materials used for the base and the filler material. The microstructure of the base metal is always altered by the fusion of its substance. Heat generated by the energy source, followed by the subsequent re-cooling of the material causes changes in the area surrounding the fusion zone. This changed area, also called the heat-affected zone (HAZ) can be of varying size and strength. In general, the extent and magnitude of the HAZ is inversely proportional to the diffusivity and cooling rates of the material, i.e. where thermal diffusivity is high, the material cooling rate is high and the HAZ is small; where thermal diffusivity is low, the cooling rate is slower and the HAZ is larger.

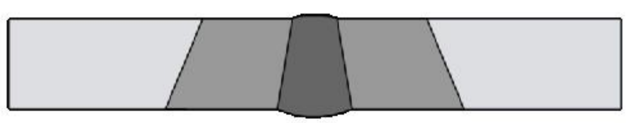


Fig. 7.1: Schematic of a weld.

In the above schematic (Fig. 1), the dark gray represents the weld or fusion zone, the light gray represents the base material, and the medium gray is the heat-affected zone. In fact, the HAZ is a portion of the base material that has not been melted, but whose mechanical properties have been altered by the heat of the welding process. Understandably, this alteration can be detrimental, causing stresses that reduce the strength of the base material, leading to catastrophic failures. That is why weld-testing is an essential part of quality control.

Weld-testing comes in two forms: non-destructive methods such as acoustic impact techniques that detect the presence of cracks, and destructive methods, where a weld specimen is subjected Weld analysis: micro-hardness measurement step The sample is scanned resulting in a macroview of the entire sample. Seeing the sample as a whole, the fusion zones and the HAZ are clearly visible and distinguishable from the base material, even with a scratched surface.

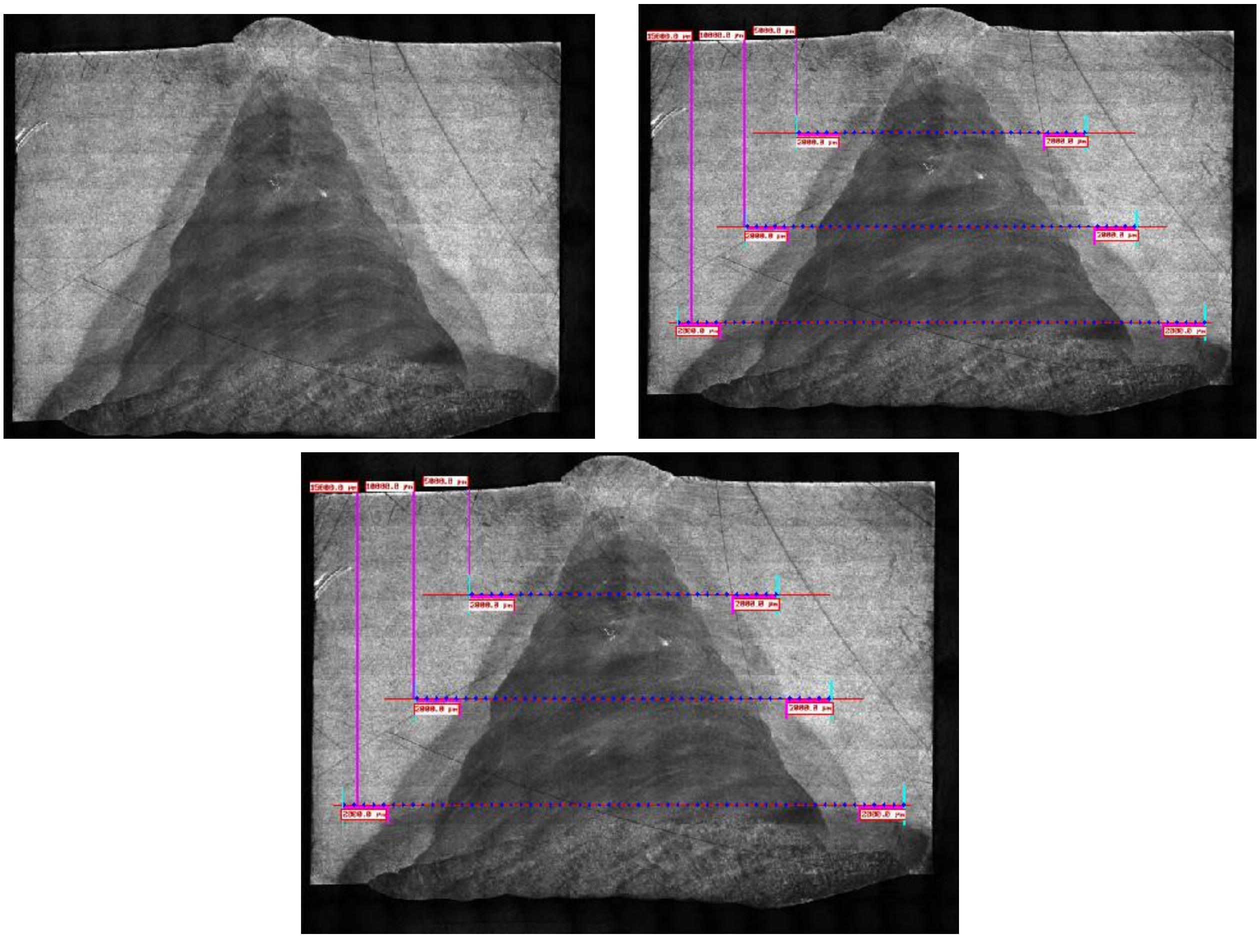


Fig 7.2 Sample figure of Micro structure

In this case, we must indent the sample at three different depths. Using the software's Annotation Tools it is easy to draw different path lines that will ultimately determine where the traverses will be positioned.

The line tool, which conveniently shows the distance in microns as the line is drawn, allows us to draw three "depth lines" starting from the exterior part of the sample, to depths of precisely 5000, 10000, and 15000 microns. From those, a series of perpendicular lines are drawn that will determine the paths of the traverses (Fig).

It is now easy to draw a traverse starting point at exactly 2000 microns from the Heat Affected Zone into the base material. No other software allows this kind of precision.

Once the layout is drawn, the image is transferred in the Stage Pattern Window. It is here that the spacing between indents is determined and the traverses correctly positioned (Fig). The automated indenter then follows the path of the traverse patterns to test the sample's material hardness (Fig).

8. Conclusion

1. There is carbon pick up from the shielding gas when 100% CO_2 is used for the low carbon containing austenitic stainless steel overlay.

2. When 100% CO_2 is used as shielding gas, chances of loss of weld metal carbon content due to oxidation and gain of weld metal carbon due to the dissociation of CO_2

3. to C and O_2, is possible depending upon the molten weld pool carbon content during the weld overlay.

4. The Ferrite number decreases as the CO_2 % in shielding gas increases.

5. Comparing both the shielding gases, 100% CO_2 gives the best bead profile only the depth of penetration is to be controlled. But there is a high alloying element loss resulting in the decrease of ferrite number. 100% Ar gives poor bead profile characteristics and also the ferrite number is too high than the required limit.

6. Thus 100% CO_2 shielding gas can be successfully used for SS347T0-1 weld overlay on 1 ¼ Cr – ½ Mo low alloy steel using Flux cored arc welding process for achieving good overlay characteristics provided if we can control the dilution. Research can be done by using CO_2 - Ar gas blends which may give better result than 100% CO_2 shielding gas.

9. References

1. Karlsson L (2012) Welding duplex stainless steels—a current review of recommendations. Weld World 56:65–76
2. van Nassau L, Meelker H, Hilkes J (1993) Welding duplex and super-duplex stainless steels. Weld World 31(5):322–343
3. Lu S, Fujii H, Nogi K (2010) Weld shape variation and electrode oxidation behavior under Ar-(Ar-CO2) double shielded GTA welding. J Mat Sci Technol 26(2):170–176
4. Pettersson C-O, Fager S-Å (1995) Welding practice for the Sandvik duplex stainless steels SAF 2304, SAF 2205 and SAF 2507. AB Sandvik Steel. Technical document S-91-57, 15
5. Westin EM, Johansson MM, Bylund L-Å, Pettersson RFA (2013) Effect on microstructure and properties of superduplex stainless steel welds when using backing gas containing nitrogen and hydrogen. IIW Commission IX Document IX-2459-13 rev.1. 9
6. EN ISO 6947:2011 (2011) Welding and allied processes—welding positions
7. How to weld duplex stainless steels (2006) Avesta Welding AB. Document 10601EN-GB, Avesta, Sweden, 20
8. Welding guidelines for duplex & superduplex stainless steels (2005) Metrode Products Limited. Chertsey, UK, 7
9. Fuji H, Lu S, Sato T, Nogi K (2008) Effect of oxygen content in He-O2 shielding gas on weld shape for ultra deep penetration TIG. Trans Jpn Weld Res Inst 37(1):19–26
10. Persson K-A (2014) Pore formation in MIG welding duplex stainless steels with super duplex filler wire. Conference “Svetsning av rostfria stål” organised by Swerea/Kimab. Stockholm
11. EN 10028: 2008 (2008) Flat products made of steels for pressure purposes, part 7: stainless steels
12. NORSOK STANDARD M-601 (2008) Welding and inspection of piping
13. Welding consumables technical handbook (2009) Metrode Products Limited. Revision 10, Chertsey, UK, 384
14. Vitek JM, Iskander YS, Oblow EM (2000) Improved ferrite number prediction in stainless steel arc welds using artificial neural networks—part 2: neural network results. Weld J 79(2):41s–50s
15. Kotecki DJ, Siewert TA (1992) WRC-1992 constitution diagram for stainless steel weld metals: a modification of the WRC-1988 diagram. Weld J 71(5):171s–178s
16. Valiente-Bermejo MA (2012) A mathematical model to predict δ-ferrite content in austenitic stainless steel weld metals. Weld World 56(09–10):48–68.

Access this Article in Online	
Quick Response Code	Website: www.ijarm.com
	Subject: Engineering
DOI:10.22192/ijamr.2017.04.06.007	

How to cite this article:
Subramanian.S, Senthil kumar.T. (2017). Effect of Shielding gas mixture on Welding of Stainless Welding in Gas metal Arc Welding process . Int. J. Adv. Multidiscip. Res. 4(6): 53-63.
DOI: http://dx.doi.org/10.22192/ijamr.2017.04.06.007