Improving the Joint Strength of SS2507 Using Stellite 6 as Filler Material through TIG Welding

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Abstract: **The purpose of the current study is to find the optimal setting of welding parameters in TIG welding of Super Duplex Stainless Steel (2507).Normally SS2507 is used in heavy applications such as heat exchangers and chemical tankers, so stellite 6 is used as a coating material to improve the strength of the material in those applications. The strength and the chemical properties can be analysed using some of the testing methods such as tensile test, scanning electron microscopytest, X-ray diffraction test, energy dispersion X-rays test. By using these tests the strength SS2507 can be analysed.**

Keywords: **TIG welding, SS2507, Stellite 6, Tensile strength.**

1. INTRODUCTION

Normally Super-duplex stainless steel used in various applications such as heat exchangers, chemical tankers, vessels and various mechanical components. Super-duplex stainless steel can be welded using Various traditional techniques includes submerged arc welding(SAW),friction stir welding(FSW),tungsten inert gas welding(TIG) and where as other welding process is not suitable for this material because this material has low melting characteristics and high strength. For submerged arc welding and friction stir welding includes surface preparation, edge preparation and pre-heat treatment but Tig welding can be done without these preparations for the fast development of manufacturing industries.ForTig welding process stellite-6 is used as the filler rod due its high strength and hardness.when stellite-6 is welded with super-duplex stainless steel the strength of the welded area increases and argon gas is used as the inert gas in Tig welding to increase the welding speed up to 40% and it also acts as shielding gas because this gas protects the atmospheric air which affects the welding zone. The increased globalization of industry is causing acceleration in the pace of product change. Shorter product development time with Excellency in functionality, quality cost competitiveness and aesthetics is the order of the day. This trend is forcing the Engineers and Engineering managers to respond with products that have increasingly lower costs, better quality and shorter development times.Welding is a process of joining similar or dissimilar metals by the application of heat with or without the application of pressure and addition of filler material.

1.1The GTAW (TIG) Process:

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non consumable tungsten electrode to produce the weld. The weld area and electrode is protected from oxidation or other atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used, though some welds, known as autogenous welds, do not require it. A constant current welding power supply produces electrical energy, which is conducted across the arc through a column of highly ionized gas and metal vapours known as a plasma.

GTAW is most commonly used to weld thin sections of stainless steel and non-ferrous metals such as aluminium, magnesium, and copper alloys. The process grants the operator greater control over the weld than competing processes such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher quality welds. However, GTAW is comparatively more complex and difficult to master, and furthermore, it is significantly slower than most other welding techniques. A related process, plasma arc welding, uses a slightly different welding torch to create a more focused welding arc and as a result is often automated. Similar to torch welding, GTAW normally requires two hands, since most applications require that the welder manually feed a filler metal into the weld area with one hand while manipulating the welding torch in the other. Maintaining a short arc length, while preventing contact between the electrode and the workpiece, is also important.

1.2 Advantages of the GTAW Process:

The greatest advantage of the GTAW process is that it will weld more kinds of metal alloys than any other arc welding process. TIG can be used to weld most steels including stainless steels, nickel alloys such as Monel and Inconel, titanium, aluminium, magnesium, copper, and brass, bronze, and even gold. GTAW can also weld dissimilar metals to one another such as copper to brass and stainless to mild steel.

1.3 Components of the GTAW Machine:

The main components of GTAW (TIG) machine are;

a Power Source

b GTAW Torch

c Coolers and Coolant

d Electrode

e Shielding Gas

1.3.1 Power Source:

TIG welding can be carried out using DC for Stainless Steel, Mild Steel, Copper, Titanium, Nickel Alloys etc and AC for Aluminium and its Alloys and Magnesium. Further information on the TIG Welding Process follows information on equipment used in this document. The Power Source is of a transformer design with or without a rectifier, with a drooping characteristic (constant current power source). The output is generally controlled by either a moving core within the main transformer of the power source or by using electronic control of power thyristors. DC power sources could be of 1 phase or 3 phase design, with an inductor to provide a smooth output. AC and AC / DC Power Sources are of a single phase design.

There are various types of power sources are available. They are;

* Constant Current power sources

* Square wave Silicon Controlled Rectifier (SCR) power sources

* Inverter power sources Engine driven power sources.

1.3.2 GTAW Torch:

The TIG torch can be air cooled or water cooled and of vastly different shapes and sizes dependant on access to the area to be welded and welding current required. TIG torch for use on equipment without a electric operated valve (normally scratch start systems) can have a finger operated gas valve fitted to the torch head. If the operator is using a foot control unit, the torch will not need a switch fitted. For welding in difficult to get to areas, a flexible head torch can be used and bent to the best position for welding. In water cooled torches, the current cable is a bore copper conductor within a water carrying hose, this means the conductor can be greatly reduced in size and weight. The gas shield are now invariably alumina ceramics and are available in a wide range of sizes. When access is difficult, it may be necessary to project the electrode well beyond the end of the gas nozzle, this may result in inferior gas shielding because of turbulence. This can usually be overcome by employing a Gas Lens System replacing the standard collet and collet body system, this producing improved directional and stability of the gas flow. Connection to the power source can be via a special lug if the equipment has a stud output fitting, or a universal dinse type TIG adaptor if output fittings are dinse type sockets. Electrodes for TIG welding are Pure Tungsten or a Tungsten oxide, generally 2 % Thoriated tungsten are used for DC welding and 2 % Zirconiated tungsten are recommended for AC welding. The diameter of the electrode is chosen to match the current required. For DC welding, a sharp point is required but for AC welding only, a small bevel is needed as the end of the electrode becomes rounded when the arc is operated. The power cable is contained inside a hose, and the water returning from the torch flows around the power cable providing the necessary cooling. In this way, the power cable can be relatively small making the entire cable assembly light and easily maneuverable by the welder. When using water cooled torch a lack of cooling water or no cooling water at all will cause the polyethylene or braided rubber sheath to melt or possibly burn the power cable in two. A torch manufacturers specifications will designate the required amount of cooling water for a specific torch. A safety device known as a ―fuse assembly‖ can be installed in the power cable. This assembly contains a fuse link, which is also cooled by the water. If there is no cooling water circulating, the fuse link will melt in two and prevent damage to other more expansive components. The fuse link is easily replaced. When the fuse link is replaced and water flow is maintained, welding can continue

1.3.3 SHIEDING GAS:

Other arc welding processes use other methods of protecting the weld from the atmosphere as well – shielded metal arc welding, for example, uses an electrode covered in a flux that produces carbon dioxide when consumed, a semi-inert gas that is an acceptable shielding gas for welding steel.

Shielding gases fall into two categories—inert or semi-inert. Only two of the noble gases, helium and argon, are cost effective enough to be used in welding. These inert gases are used in gas tungsten arc welding, and also in gas metal arc welding for the welding of non-ferrous metals.

Semi-inert shielding gases, or active shield gases, include carbon dioxide, oxygen, nitrogen, and hydrogen. Most of these gases, in large quantities, would damage the weld, but when used in small, controlled quantities, can improve weld characteristics

1.3.4 ELECTRODE:

Tungsten Inert Gas (TIG) welding is a popular type of welding that utilizes tungsten electrodes to join various metals. The tungsten electrode is a critical component in the process, as it channels the current required to establish the arc. The tungsten electrodes can be alloyed with a variety of metals. Different types and sizes of electrodes are used for different types of welds and materials, and welders develop preferences based on welding style and project. Certain electrode types perform better with alternating current (AC) as opposed to direct current (DC). Electrodes are shipped without a ground tip. If grinding a tip, make a tight, sharp point in order to achieve a powerful and precise arc to ensure a clean weld.

2. EXPERIMENTAL PROCEDURE

The Super Duplex Stainless Steel plates (SS2507), cut from turbine blades, with dimensions 100mm x 50mm x 3mm were chosen as parent material. The co-based stellite 6 and super duplex stainless steel (SS2507) in the form of 3.2 mm diameter rods were deposited on super duplex stainless steel plates in three sequences using GTAW method. Initially the parameters for TIG welding has been noted at below table(1) and the temperature of tungsten electrode is heated at 1285 - 1410ºC and during this time the stellite 6 starts melting. Argon gas is used as an inert gas to protect the impurities form the atmosphere to delegate the oxide formation.

TABLE (1) PROCESS PARAMETERS

CURRENT	**140A**
VOLTAGE	**50V**
GAS FLOW RATE	**(8-10) l/min**
WELDING SPEED	**3 mm/sec**
UP SLOPE	**20 degrees**
ARGON GAS	**15 pulse**
PULSE FREQUENCY	**20 hz**

The first sample of SS2507 has been welded with edge preparation and the gap is filled using stellite 6 through GTAW process. The second sample has been welded using stellite 6 without edge preparation through GTAW process and the third sample is welded by making a distance of 2mm. After welding, according to ASTM standard E8 the welded SS2507 has been cutted by means of dog bone shape for analysing the tensile strength. Then 1mm x 1mm has been cutted at welded area for Scanning Electron Microscope (SEM) test and Energy Dispersive X-ray (EDX) test to analyse the microstructure and chemical properties.

3. RESULT AND DISCSSION

3.1 SEM TEST:

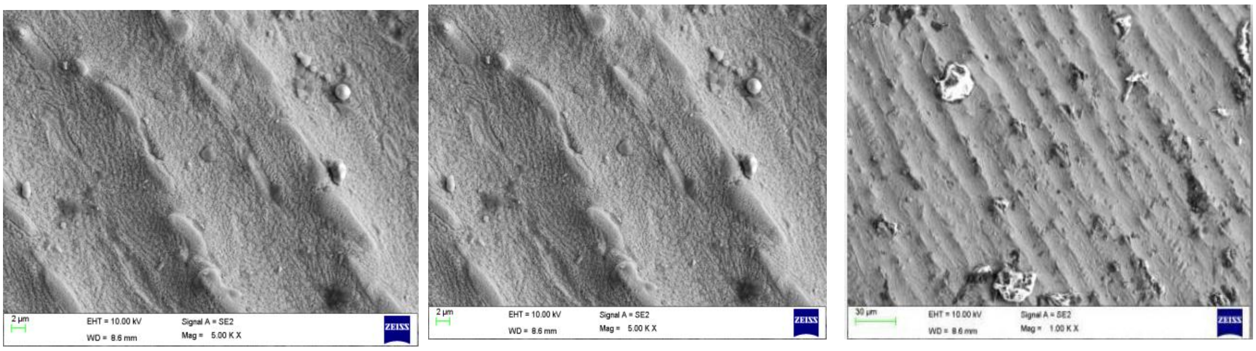

Figure (1)

The above fig(1) is tested by Scanning Electron Microscope(SEM) in the welded zone at different micrometer levels and it also commonly tested at Electron High Tension(EHT) by 10.00 KV and Working Distance by 8.6mm.From the fig(a) the SEM test is done at 2µm level and it also includes Magnification by 5.00KX.From the fig(b) the SEM test is done at 10µm level and it also includes Magnification by 3.00KX.From the fig(c) the SEM test is done at 30µm level and it also includes Magnification by 1.00KX.

The fig (1) shows the SEM imges which is done by TIG welding process. Therefore the TIG welding is homogenous throughout the joint and minimum spatter is absorbed.

3.2 ENERGY DISPERSIVE X-RAY TEST:

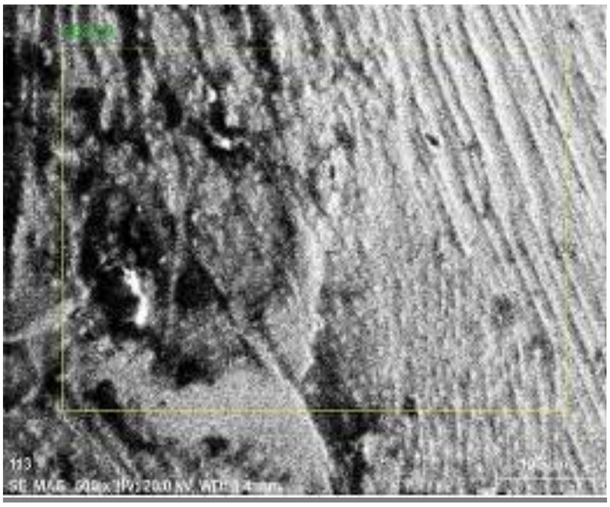

Fig (2)

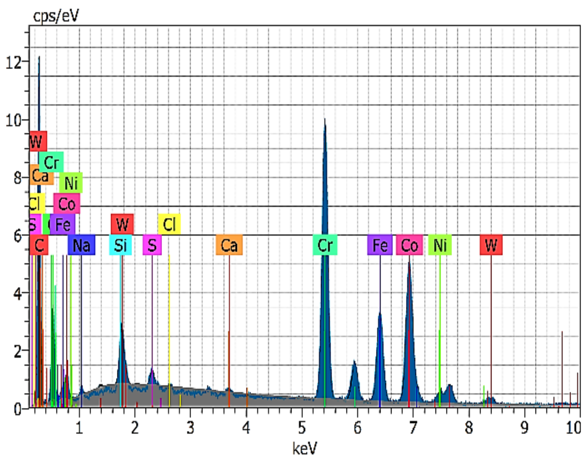

Fig (3)

This fig(2) shows that the SEM image of welded zone of SS2507 to analyse the chemical properties and it also shows that the carbon is maximum at the welded zone. When SS2507 is welded using stellite 6 through TIG welding increases carbon content increases hardness and strength and improves hardenability but carbon also increases brittleness and reduces weldability because of its tendency to form martensite and the fig(3) shows that the chemical composition of welded zone of SS2507.

TABLE (2) CHEMICAL COMPOSITION

Element	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (3 Sigma) [wt.%]
Carbon	K-series	38.68	37.91	68.39	14.94
Oxygen	K-series	8.57	8.40	11.38	4.00
Sodium	K-series	0.31	0.31	0.29	0.16
Silicon	K-series	0.48	0.47	0.36	0.15
Sulfur	K-series	0.30	0.30	0.20	0.12
Chlorine	K-series	0.02	0.02	0.01	0.08
Calcium	K-series	0.10	0.09	0.05	0.09
Chromium	K-series	18.03	17.67	7.36	1.55
Iron	K-series	9.73	9.54	3.70	0.89
Cobalt	K-series	19.74	19.35	7.11	1.70
Nickel	K-series	1.82	1.78	0.66	0.27
Tungsten	L-series	4.25	4.17	0.49	0.54
	Total:	102.04	100.00	100.00	

The Table(2) shows that the chemical composition of welded zone for super duplex stainless steel (SS2507) using stellite 6 as a filler material through TIG welding.

3.3 TENSILE TEST:

The welded base metal SS2507 is cutted in the form of dog bone shape using turbine blades according to ASTM standard E8.For tensile test initially the load is started at 200N and increases gradually.

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Pre-load	:	2	N
Test speed	:	100	mm/min
Grip to grip separation at the start position	:	50,00	mm

Test results:

No.	F_H N	ε_H %
1	32200	2,8

Series graph:

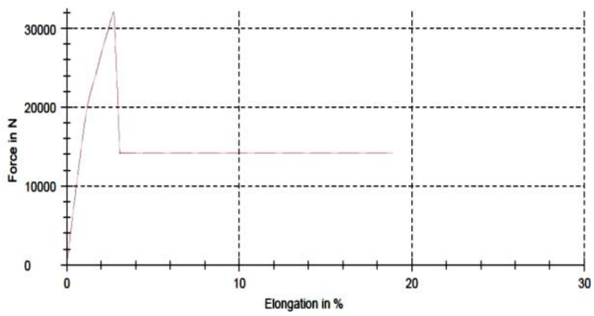

Figure (4) Tensile test

The fig (4) shows the tensile result for welded super duplex stainless steel and when the load reaches 32200N the breaking point is achieved.

4. CONCLUSION

Based on the above results, the SEM images of the super duplex stainless steel using stellite 6 through TIG welding is analysed according to different micron levels such as 2µ,10µ etc., and it is absorbed that there is no spatter is absorbed and uniform weld is achieved. From EDX test the chemical properties have been analysed and the carbon is maximum so brittleness is maximum and the strength is improved. The tensile strength of the SS2507 material welded using stellite-6 as filler material through TIG welding is also discussed by the force applied to welded zone of the material to be broken, also the breaking point of that material is 32200N and by comparing that the breaking point of welded material is less than the parent metal.

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