Study and analysis of welding of dissimilar metals 409 stainless steel and 439 stainless steel by TIG welding

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ABSTRACT

Corrosion is the main stagnation of essential mechanical properties. The corrosion occurs due to reaction with the elements in the environment. Corrosion rate is differing at different temperature and different atmosphere. To overcome this problem two different materials Stainless Steel 409 and Stainless Steel 439 are welded by TIG welding. This is to increase the effort of corrosion and to balance the cost of the material and to make it economically feasible. The corrosion resistance is done by performing welding of these two dissimilar metals by using electrode 309L. After the welding is performed properly it is forwarded to proceed further tests like tensile test, Rockwell hardness test, macro examination test, micro examination test and corrosion resistance test.

KEYWORDS: SS 409, SS 439, ER309L and TIG welding.

1. INTRODUCTION

Nowadays corrosion is the major downturn for the automotive industries and for automotive holders. The chances of corrosion are getting increased more during the warranty period, as a result it have attracted many customers and car makers. Due to the cyclic condensation and oxidation of exhaust gasses, the parts of the vehicles like mufflers of vehicles exhaust system are usually subjected to corrosion failure. That's why it is necessary and mandatory to clarify the corrosion behaviour and to improve the corrosion effecting of stainless steel which is used for exhaust systems (Han, 2014; Inoue, 2003; Douthett, 2006; Edwards, 1974). Automotive exhaust gas mostly contains CO_2, H_2O, O_2, CO, HC, NOx and SO_2 (Douthett, 1995; Heck, 2001; Engstrom, 1999). By this we came to know that so_2 is the main cause for the failure through condensation process, which mainly comes from the sulphur in the fuel. The low-temperature oxidation will enhance the condensate corrosion of 409 Stainless Steel. The chemical properties and composition Stainless steel 409.

Table.1.Chemical properties of Stainless Steel 409

Element	C	Si	Mn	P	S	Cr	Ni
Wt%	0.020	0.525	1.305	0.024	0.005	11.60	0.12

The type SS439 is known as ferritic stainless steel and this is used for moisture separator in a nuclear and steam power plant and also has wide uses in chemical industries. The most disadvantages in mechanism is the vibration induced to tube support plate wear and the fatigue cracking. The wear that has been reported occurs mainly on the outer surface diameter (EPRI, 1997; American Society for Metals, 1997). By this we came to know that the inspection can be done on stainless steel 439 for obtaining magnetic flux density of an eddy current probe. Tubing has been analysed and specific magnetic saturation probe was designed (Lee, 1997). The chemical composition of SS 439 is shown in table 2.

Table.2.Chemical properties of Stainless Steel 439

Element	C	Si	Mn	P	S	Cr	Ni	Ti	Al
Wt%	0.022	0.431	0.737	0.003	0.011	17.21	0.321	0.452	0.009

Tungsten Inert Gas welding in this process it produce coalescence when the job is heated with an electric arc struck between a non-consumable tungsten electrode and the job. Most commonly, Argon, helium and their mixture are preferred to use in welding zone because these gases will not react chemically and does not combine with each other and these gases are also known as shielding gases. The main purposes of shielding gas: i) it covers the welding area from the atmosphere, ii) the heat is transferred from electrode to metal, iii) it has a stable arc due to low ionization potential (Edels, 1951). The cooling rate; weld bead size and mechanical properties of the weld are influenced by the given heat from the electrode. TIG weld has a strong weld pool geometry because the weld pool geometry has an important role in describing the mechanical properties of weld (Funderburk, 1999).

Stainless steels are mainly used for cooking items, transportation, steel rods in construction etc .Electrode 309L is a product of titanic suitable for welding of 22.1Cr-12.0%Ni steel, dissimilar metals and to weld the joints. It is used for welding similar alloys in wrought or cast form. Occasionally the welding can be done using this process"18-8" base metals exists corrosion conditions or different metals. It has of 0.03% carbon content due to this content it has strong and it increases inter granular corrosion. It is embossed and taken from each side for easy identification after use (Degarmo, 2003). The following steps are defined over here. Retake the electrodes at 250 ~ 300°C for 1 hour and keep it at 100 ~ 150°C prior to use. We have to use stainless steel wire brush for cleaning of slag at the weld pool. We have to take care at the weld pool to obtain a good performance. We should use lower current for dissimilar-metal joint

Experimental Detail: In this work, the experiment over two different plates of dissimilar metals that is, SS 409 and SS 439. First of all two plates of SS 409 and SS439 of dimension (200 x 150 x 10) mm are taken. Then we will place one connecting to another by butt joint. Now the sides which are connected will be bevelled properly for the further process of the welding. After the sides are bevelled we will proceed for the fit up. Fit up is required to keep both the metal constant and in linear position so that welding can be done properly. For that we will place both the materials connected to each other with 0.5 mm of gap. Now when the fit up is done properly we will proceed for the welding process. Next it comes the root pass. It is done with the help of electrode 309L. In the root pass we will proceed to weld the two different metals by butt joint. Then 142 A of current is passed over it to heat up. And about 20 V of voltage will be passed on it as it is the optimum value for doing the stainless steel welding. The contact tube gap of 1.2 mm should be maintained throughout the whole root pass. Flow of gas shielding rate will be maintained about 15 L/m. welding travel speed is maintained about 92sec/200mm long. The welding will be done around 3 times with travel speed 95sec/200mm long and 94sec/200mm long respectively.

In second pass the current of 181 A is maintained to heat it up and Voltage of about 21 V will be passed on it for welding. The contact tube gap of 1.2 mm should be maintained throughout the whole second pass. Flow of gas shielding rate will be maintained about 14L/m.

Welding travel speed is maintained about 93 sec/200 long. And the other two times of about 93sec/200mm long and 98sec/200mm long respectively. In final pass the current range of 184 A is maintained to heat it up. Voltage range of about 20 V will be passed on it for welding. The contact tube gap of 1.2 mm will be maintained throughout the second pass. Flow of gas shielding rate will be maintained about 15 L/m. Welding travel speed is maintained about 91 sec/200 long. And the other two times of about 92 sec/200mm long and 91 sec/200mm long respectively.

2. RESULTS AND DISCUSSION

Tensile testing, also known as tension testing and stress testing, these are the main concepts for testing the durability in which a work piece is subjected to a controlled tension until failure. From the above result we can get the required strong material which wills suits the work, for quality control, and to know when a material is subjected to different types of forces what will be the result. Properties that are directly measured via tensile exams are ultimate tensile stress, bar maximum elongation and reduction in area. From these measurements the following properties can also be known those are Poisson's ratio, young's modulus, yield strength, and strain-hardening characteristics. By doing the test on the welded part, different values were obtained for the test parameters. Such as gage thickness came out of about 10.26 mm, gage width came out of about 19.06 mm. Original cross sectional area came out of about 195.56 mm^2. Ultimate tensile load was about 93.70 KN. Ultimate tensile strength was about 479.14 MPa, and the fracture location was the base that is SS 409. So it is noted that the overall value that came out was optimum for a normal stainless steel.

Then the Rockwell hardness test. The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test is used to determine the hardness by measuring the depth of penetration the process is done by an indenter under a heavy load compared to the penetration made by the previous load. There are different scales; those are given by a single letter (or) single word, that using different kind of loads or indenters. The result is a dimensionless number noted as HRA. When the metals are testing, indentation hardness correlates linearly with tensile strength. This important relation allow the non-destructive testing of bulk metal deliveries with lightweight, even portable testing machine, those are hand-hold Rockwell hardness testing equipment. The result came by doing this test was about (91, 92, 91) kgf which was found to be strong and optimum enough for further use.

Then macro examination test was conducted. Macro examination is done on the cross section area, longitudinal section or 'Z' direction (through thickness) it is an independent test to relevant the sub surfaces or as a subsequent step of another test to reveal the effects on the subsurface. That macro examination of the specimen revealed complete weld fusion. The figure is shown below figure.1. Then the micro examination test. It should be done to check the defined particles of the welded region to detect of a material structure and this material structure will determine the applications and properties. Here the micro examination is done by magnifying up to 200X. The etchant used here is the glycergia reagent. The examination is done on various regions. While doing the examination on SS 409 parent it was observed that micro examination of the parent region revealed grains of ferrite with particles of alloy carbides present in the ferritic matrix. The figure is given below figure.2.

On SS 439 parent region we observed that micro examination of the region grains of ferrite with particles of alloy carbides present in the ferritic matrix. The figure is given below figure 3.

The characteristic brittle behaviour of the carbide ceramic is set of by the ductile metal binder, hence raising its durability and toughness. By controlling these all parameters, including cobalt content, grain size, donation (e.g. alloy carbides) and carbon content, specific applications are a carbide manufacturer can tailor the carbide's performance. Hence 2.5 to 4.0% of carbon and 1.0 to 3.0% of silicon is used to obtain a graphitic micro structure.

Grey iron may have the content of graphite from 6 to 10%. Silicon is the most important one to make grey iron and to oppose the white cast iron, because silicon is a part of the graphite stabilizing element in cast iron, which it helps the alloy produce graphite instead of iron carbides; at if there is 3% silicon almost such that no carbon is held in chemical composition with the iron. The solidification rate is the factor affecting graphitization; it requires greater the time for the carbon to diffuse and accumulate into graphite and a slower time. Cooling rate forms pearlitic matrix is formed by the moderate cooling rate and fast a fully ferritic matrix is formed by fast cooling matrix and these finally forms a cementite and this can be also called as white iron.

On the weld pool of the material it is observed that micro examination of the weld pool revealed dendritic delta ferrite. It is shown in the figure below figure 4. A dendrite in metallurgy is a tree-like structure of crystals or other growing as molten metal freezes, the energetically favourable crystallographic directions are the shapes produced by the faster growth. This dendritic growth has huge consequences in regard to material properties. We can get dentrites in both of one-component systems as well as multi-component systems. The requirement is the molten material to be super cooled, less than the freezing point of the solid. So that, a spherical solid nucleus has formed in the super cooled melt (Dantzig, 2009). Ferrite is a magnetisable, body cantered constituent with various chemical composition. When steel is solidified ferrite is formed or by doing the transformation out of a sigma-phase. Alpha-iron and delta-iron are both centred at the cubic body. A little amount of ferrite determinable is in the microstructure of austenitic chromium-nickel and chromium-nickel-molybdenum-steels. It is dependent from the chemical combination and from the heat treatment. The magnetizability is formed by the partly conversion of austenite in to ferrite. A light magnetism is frequently possible at the molybdenum bearing steels. The stability against corrosion is not unfavourable influenced in the mechanical properties. The microstructure transformed completely in austenite when the steels get annealed and the magnetizability disappears. In austenitic welding materials the required amount of delta-ferrite is used to reduce the tendency of hot forming. A material without delta-ferrite is bad for hot cracking at increased temperatures. The formation of delta-ferrite is suppressed in the stell by nitrogen (Maranian, 2009).

It is concluded that the heat produced during the welding is about 3000°C which is shown by the red colour on the photograph. It is observed that the heat is travelling throughout the plate. Temperature of different ranges is shown here by tagging different colour. It is concluded that the lowest temperature on the metal plates are at the corners of the plates and is about 1982.6°C. Whereas this temperature will not affect the metal to change its form but it shows that its thermal conductivity is quite higher.

Total Heat flux: The total heat flux distribution is given below on both the material that is SS 409 and SS 439. Graph 6 shows heat flux distribution.

The rate of heat energy transfer through a given surface per unit surface is known as the heat flux or thermal flux. The heat rate SI unit is joule per second, or watt. The heat rate per unit area of eats flux density. In SI units, heat flux density is measured in [W/m^2]. Heat rate is a scalar quantity, while heat flux is a vector quantity. One takes the limiting case where the size of the surface becomes infinitesimally small by this we can derive the heat flux at required point in the space.

From the simulation for heat flux it is observed that the heat flux generated over the bevelled region during welding is about 8.2102e5 W/m^2 which is denoted by the red colour on the photograph. It travelled over the whole plate from the weld region and is least at the corners of the plate which is given by blue colour and is about 9906.7 W/m^2.

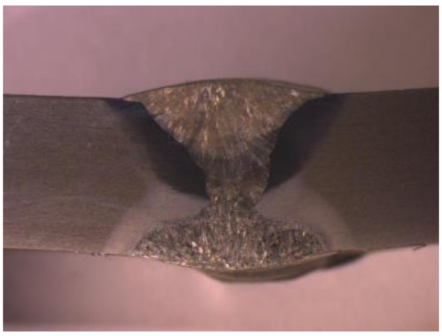
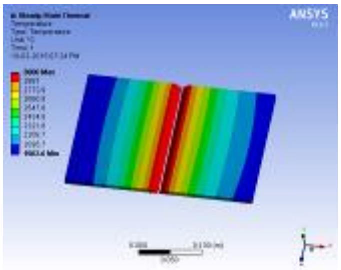


Figure.1.Macro examination of the specimen revealed complete weld fusion

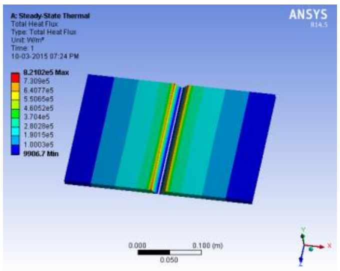
Figure.2.Micro examination of the parent region revealed grains of ferrite with particles of alloy carbides present in the ferritic matrix

Figure.3.Micro examination of the parent region grains of ferrite with particles of alloy carbides present in the ferritic matrix

Figure.4.Micro examination of weld pool revealed dendritic delta ferrite



Graph.5.Analysis of heat distribution



Graph.6.The total heat flux distribution

3. CONCLUSION

So, from here after performing different tests on the welded regions of SS 409 and SS 439 and concluded that after performing TIG welding, this dissimilar material with property of high corrosion resistant and thus this ferritic material provides better facility of corrosion resistant which gives the opportunity of using it on different fields which are highly prone to corrosion areas and so it can use on different fields like on chemical industries, to make machines, engines etc. As the SS 409 and SS 439 has high corrosion resistant property but the difference is SS 439 has better corrosion resistance than SS 409 and also the cost is high than the SS 409. So now the result have succeeded in welding both the materials by performing different test this combination can use it now in different fields by the combination of both the material with the help of TIG welding. It is concluded that the heat produced during the welding is about 3000^0C which is shown by the red colour on the photograph. It is observed that the heat is travelling throughout the plate. Whereas this temperature will not affect the metal to change its form but it shows that its thermal conductivity is quite higher. From the simulation for heat flux it is observed that the heat flux generated over the bevelled region during welding is about 8.2102e5 W/m^2 which is given by the red colour on the photograph. It travelled over the whole plate from the weld pool and is least at the corners of the plate which is given by blue colour and is about 9906.7 W/m^2.whether there is any defect or not. During microscopic examination or microstructure analysis, the structure of a material is studied under magnification. The properties

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