Welding process parameters & optimization & analysis OF SS410 with mild steel by using taguchi

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ABSTRACT

The dissimilar metal joints of have been emerged as a structural material for various industrial applications which provides good combination of mechanical properties like strength, corrosion resistance with lower cost. Selections of joining process for such a material are difficult because of their physical and chemical properties. The stainless steel and mild steel dissimilar material joints are very common structural applications joining of stainless steel and mild steel is very critical because of carbon precipitation and loss of chromium leads to increase in porosity affects the quality of joint leads deteriorate strength. Gas tungsten arc welding is a fusion welding process having wide applications in industry. In this process proper selection of input welding parameters is necessary in order to control weld distortion and subsequently increase the productivity of the process. In order to obtain a good quality weld and control weld distortion, it is therefore, necessary to control the input welding parameters. In this research work, experiments has to be carried out on SS410 stainless steel of 3 mm thick using gas metal arc welding (GMAW) process. The research will be applied Taguchi Method on an austenitic stainless steel specimen of dimensions 50 × 50 × 10 mm, which have following interested parameters: various arc current arc voltage and inert gas pressure. The main objective of the experimental factors affecting to mechanical property of SS410 with semi automatic Gas Metal Arc Welding(GMAW) through various welding parameters.

Keywords: MIG welding, mild steel, stainless steel 410, taguchi method,.

INTRODUCTION

Welding is the process of fusing two materials together using extreme heat, pressure and (or) fillers. Welding processes have developed to fit every industrial need imaginable. The two types of welding most prevalently in use are Arc welding Gas Arc welding.

1.2 TYPES OF WELDING

- Arc welding
- Gas welding
  - Mig welding
  - Tig welding

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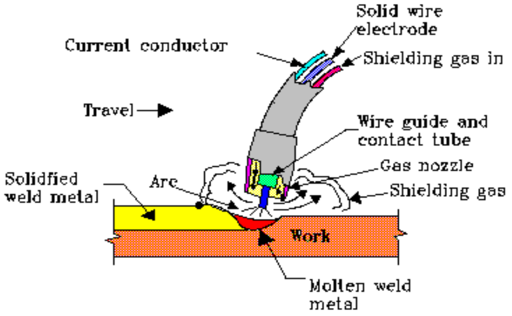


Advantage Fabricated Metals performs a number of welding processes. The two most common welding processes we use include TIG, an acronym for Tungsten Inert Gas welding and MIG, an acronym for Metal Inert Gas welding. TIG is also referred to as GTAW (Gas Tungsten Arc Welding) and Heliarc®. MIG also is referred to as GMAW (Gas Metal Arc Welding). We also provide oxy-acetylene welding.

CHARACTERISTIC OF MIG WELDING:

- Uses a consumable wire electrode during the welding process that is fed from a spool,
- Provides a uniform weld bead,
- Produces a slag-free weld bead,
- Uses a shielding gas, usually – argon, argon - 1 to 5% oxygen, argon - 3 to 25% CO_2 and a combination argon/helium gas,
- Is considered a semi-automatic welding process,
- Allows welding in all positions,
- Requires less operator skill than TIG welding,
- Allows long welds to be made without starts or stops,
- Needs little cleanup.

The illustration that follows provides a look at a typical MIG welding process showing an arc that is formed between the wire electrode and the work piece. During the MIG welding process, the electrode melts within the arc and becomes deposited as filler material. The shielding gas that is used prevents atmospheric contamination from atmospheric contamination and protects the weld during solidification. The shielding gas also assists with stabilizing the arc which provides a smooth transfer of metal from the weld wire to the molten weld pool.

WELDING DRAWBACKS ON STAINLESS STEEL

3.1 PROBLEM IDENTIFICATION AND DEFINITION

The range of applications of austenitic stainless steel includes house wares, containers, industrial piping and vessels, architectural facades and constructional structures.

When welding stainless steels it is adviaisable to follow the general welding guidelines valid for the type of steel, e.g. Austenitic Stainless steels have, due to their chemical compositions, a higher thermal elongation compared to mild steels. This may increase weld deformation. Dependent of weld metal microstructure they might also be more sensitive to hot cracking and sensitive to intermetallic precipitations compared to mild steels. Austenitic grades are those alloys which are commonly in use for stainless applications. The austenitic grades are not magnetic. The most common austenitic alloys are iron chromium- nickel steels and are widely known as the 300 series. The austenitic stainless steels, because of their high chromium and nickel content, are the most corrosion resistant of the stainless group providing unusually fine mechanical properties. They cannot be hardened by heat treatment, but can be hardened significantly by cold-working. The special material properties of stainless steels affect all four mach inability factors: in general, it can be said that the higher the alloy content of a stainless steel, the more difficult it is to machine. The special properties that make stainless steels difficult to machine occur to a greater or lesser extent in all grades of stainless steels, but are most marked in the austenitic grades. They can be summarized in five points:

1. Stainless steels work-harden considerably
2. Stainless steels have low thermal conductivity
3. Stainless steels have high toughness
4. Stainless steels tend to be sticky
5. Stainless steels have poor chip-breaking characteristics.

3.2 SCOPE OF WORK:

In this work, of first a detailed study of MIG Welding and process parameters are made. Then problems in welding of Austenitic stainless steel with ferrite and martensitic stainless steel using conventional Welding process are analyzed. In the next phase design of Experiment are done by conducting several Welding in the test specimens and the effect of each parameters and depth of penetration is analyzed.

3.3 METALLURGICAL DEFECTS

CRACKS:

Cracks are the linear ruptures of the metal under stress. Sometimes they appear large and frequently they are narrow separations. The major classification of cracks is:

- Hot cracking
- Cold cracking
- Micro fissuring
- Base metal cracking
- Crater cracking.

REASON FOR CRACKING

1. Base metal composition
2. Welding process characteristics
3. Defective welding filler materials
4. Welding environment
5. Joint design
6. Cracking may occur in:

i) Weld metal ii)Heat affected zone

HOT CRACKING:

Hot cracking occurs at elevated temperature during cooling and solidifying from the molten stage. The main causes are the restraint on the joint and the presence of higher carbon and sulphur. The other reason is segregation of weld metal due to bead shape.

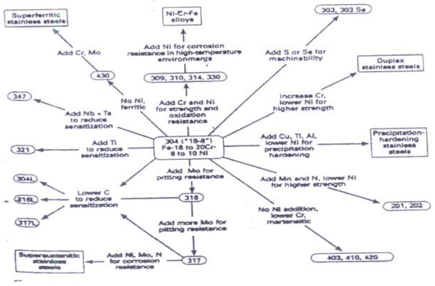
Hot cracks are inter-granular. To avoid hot cracks, it is essential to keep these joints with least restraint and to have least amount of heat input. Proper matching of electrodes and cooling rate will reduce the probabilities of cracking. The cracks on the craters of weld metal are examples for hot cracking. MPI or LPI are used to detect surface cracks while ultrasonic testing is suitable for internal cracks.

Cold cracking:

Cold cracking in steels refers to cracking which occurs even after a few days. In general, cold cracking starts in the Heat Affected Zone (HAZ) of the weld metal. It is primarily associated with combined effects of hydrogen, restraint and martensite formation. Increasing the carbon content in the base metal and the manganese content in the weld metal also prompts cold cracking. To minimize cracking it is essential to use low hydrogen electrodes and pre heating. Usually MPI for ferrous materials and LPI for non ferrous materials are used to d etect these cracks at surface. In this project we have decided to minimize the cold crack that's why we have many attempts of weld test conducts in ss304l.

INTRODUCTION OF STAINLESS STEEL

Stainless Steels are iron-base alloys that contain a minimum of about 12% Cr, the amount needed to prevent the formation of rust in unpolluted atmospheres (hence the designation stainless). Few stainless steels contain more than 30% Cr or less than 50% iron. They achieve their stainless characteristics through the formation of an invisible and adherent chromium-rich oxide film. This oxide forms and heals itself in the presence of oxygen. Other elements added to improve particular characteristics include nickel, manganese, molybdenum, copper, titanium, silicon, niobium, aluminum, sulfur, and selenium, Carbon is normally present in amounts ranging from less than 0.03% to over 1.0% in certain grades. Figure 4.1 provides a useful summary of some of the compositional and property linkages in the stainless steel family.



Composition and Property Linkages in the Stainless Steel family of Alloys

Classification of Stainless Steels

Historically, stainless steels have been classified by microstructure and are described as austenitic, martensitic, ferrite, or duplex (austenitic plus ferritic). in addition a fifth family, the precipitation hard enable (PH) stainless steels, is based on the type of heat treatment used rather than the microstructure. It should be noted that many of the wrought grades described below have cast counterparts. Which deal with cast corrosion resistant and heat – resistant stainless steels, respectively, should be consulted.

Austenitic Stainless steels

This type stainless steels the largest stainless steel family in terms of alloys and usage. They include these grades.

Iron – chromium – nickel grades corresponding to both standard AISI 300 – series alloys and modified versions of these alloys. Such alloys, which are based on type 304 (18-8) stainless steel. Generally contain 16 to 26% Cr. 10 to 22% Ni. And small amounts of other alloying elements such as molybdenum, titanium, niobium and nitrogen.

Iron – chromium – manganese – nickel grades corresponding to both standard AISI 200 – series alloys and modified versions of these alloys. In these alloys, manganese (15 to 18%) replaces some of the nickel, Nitrogen alloying is also common with these alloys.

Highly alloyed iron – nickel – chromium stainless steels for more severe corrosive environments. Nickel contents in these alloys can be as high as 35%. Molybdenum and copper additions are also common.

Superaustentitic grades (See fig 4.1) containing 6% Mo as well as liberal amounts of chromium, nickel, and nitrogen for improved corrosion resistance.

Physical and Mechanical Properties of Stainless Steels

The physical and mechanical properties of stainless steels are quite different from those of commonly used nonferrous alloys such as aluminum and copper alloys. However, when comparing the various stainless families with carbon steels, many similarities in properties exist, although there is some key difference. Like carbon steels, the density of stainless steels in ≈ 8.0 g/cm^3. Which is approximately three times greater than that of aluminum alloys (2.7 g/cm^3). Like carbon steels, stainless steels have a high modulus of elasticity (200 Mpa, or 30 Ksi) that is nearly twice that of copper alloys (115 Mpa, or 17 ksi) and nearly three times that f aluminum alloys (70 Mpa, or 10 ksi)

Differences among these materials are evident in thermal conductivity, thermal expansion, and electrical resistively, as well as the large variation in thermal conductivity among various types of materials: 6061 aluminum ally (Al-lmg – 0.6Si-0.3Cu-0.2Cr) has a very high thermal conductivity. Followed by aluminum bronze (Cu – 5A1), 1080 carbon steel and then stainless steels. For stainless steels, alloying additions, especially nickel, copper and chromium, greatly decrease thermal conductivity.

Therefore, the ferrite and martensitic stainless steels have lower electrical resistively than the austenitic duplex and PH alloys, but higher electrical resistivity than 1080 carbon steel. Electrical resistivity of stainless steels in ≈ 7.5 times greater than that of aluminum bronze and nearly 20 times greater than that of type 6061 aluminum alloy.

Factors in Selection of Stainless Steels

The selection steels can base on corrosion resistance, fabrication characteristics, availability, mechanical properties in specific temperature ranges, and product cost. However, corrosion resistance and mechanical properties are usually the most important factors in selecting a grade for a given application.

Characteristics to be considered in selecting the proper type of stainless steel for a specific application include these:

Corrosion resistance
Resistance to oxidation and sulfidation
Strength and ductility at ambient and service temperatures
Suitability for intended fabrication techniques
Suitability for intended cleaning procedures
Stability of properties in service
Toughness
Resistance to abrasion, erosion, galling, and seizing
Surface finish and / or reflectivity
Physical property characteristics, such as magnetic properties, thermal conductivity, and electrical resistivity
Total cost, including initial cost, installed cost, and the effective life expectancy of the finished product.
Product availability

MATERIAL USED

SS 410

Grade 410is the basic martensitic stainless steel; like most non-stainless steels it can be hardened by a "quench-and-temper" heat treatment. It contains a minimum of 11.5 per cent chromium, just sufficient to give corrosion resistance properties. It achieves maximum corrosion resistance when it has been hardened and tempered and then polished. Grade 410 is a general purpose grade often supplied in the hardened, but still machinable condition, for applications where high strength and moderate heat and corrosion resistance are required.

Martensitic stainless steels are optimized for high hardness, and other properties are to some degree compromised. Fabrication must be by methods that allow for poor weldability and usually the need for a final heat treatment. Corrosion resistance of the martensitic grades is lower than that of the common austenitic grades, and their useful operating temperature range is limited by their loss of ductility at sub-zero temperatures and loss of strength by over-tempering at elevated temperatures.

EXPERIMENTAL ANALYSIS

EDGE PREPARATION

Preparation or edge shaping may be applied to each piece (joint member) in the same way, or combinations of the joint preparations may be used. The edge preparation for welding these joints depends on the strength requirements and other design considerations. The Welder needs to be aware of the most common edge preparations as shown below:

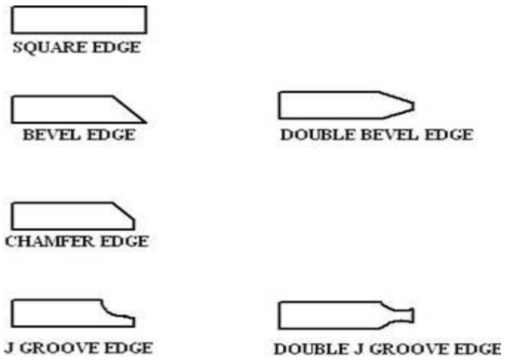


Fig.6.1Edge Profile

6.1.1 JOINT ARRANGEMENTS AND WELDS

The edge preparations are arranged to make the weld joint. The pieces to be welded may be connected or a gap between the pieces to ensure penetration may be used. On most joints the gap is at the bottom of the joint and is referred to as the root of the joint. The term root opening or open root is used to describe this condition. For example; Open root V groove, or V groove with an open root. When the joint design allows, a backing strip or insert may be used for easier welding.

Some joints may have a backing weld, or back weld applied. A back weld is applied after the groove is filled. A backing weld is applied before the groove is filled. See examples below:

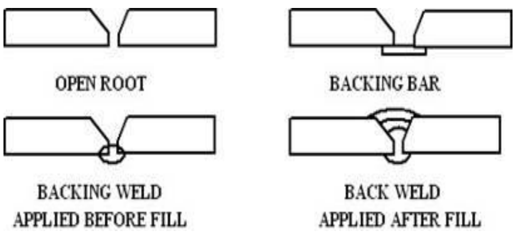


Fig 6.2Edge Joints

6.2 EXPERIMENTAL SETUP

An AC constant current Sun power source (DC Inverter machine MIG/MMA 500) was used in our experiment. The process required clamping joint in fixtures, setting welding parameters (voltage, welding current, arc travel speed, wire feed rate, electrode position and orientation of gun). The setting of welding parameters is very important so that the correct relationship must be obtained between current, voltages, stick-out, gas flow, welding speed and gun angles. There should be proper selection of filler wires, and shielding gases. The process does not require very skilled welders; the welders can be semiskilled welders. During the welding special attention should be given to the arc glare, smokes, fumes, electrode changing, and nozzle clean. After the welding has been done, the quality of weld bead appearance has to be examined.

WELDING EQUIPMENTS

Power source

Power source used for this research work is an important factor worth mentioning in the subject of welding of sheet metal using modified arc. Latest developments in electronic technology have a considerable impart on the arc welding method to make it adjustable. These developments have made modified arc welding process faster and more productive. FastMigTMsynergic welding machine can be used in Fast ROOT welding program together with MIG/MAG processes.

Fig.6.3 Sun Power Welding Machine

Fig 6.4

SHIELDING GASES

The shielding gas forms the arc plasma, stabilizes the arc on the metal being welded, and shields the arc and molten weld pool so that the chemical and physical reactions are not affected by atmospheric pollutants. It also affects the transfer mode of the metal. There are three primary metal transfer modes: Spray transfer, Globular transfer, and Short circuiting transfer. There are different types of gases that can be used in a particular metal transfer mode. The principal gases used are can be inert (argon, helium) or oxidizing (CO2, O2). The gases used in the GMAW are mixtures of inert gases which may also contain small quantities of oxygen and CO2. The selection of the best shielding gas is based on the consideration of the material to be welded and the type of metal transfer that will be used. In short circuit transfer mode, the mixtures of these gases depend on the type of base material, the thickness of base material and the characteristic of the weld. Argon Most of the gas metal arc welding uses argon as the shielded gas; this is because it gives no spatter, good arc characteristics, mechanical properties and strength of a weld. Welding of ferrous and non ferrous metals is obvious with argon, but welding of ferrous metal is good with a mixture of CO2 or O2.This is because when used pure argon as shielded gas, there will be lack of transfer of molten metal along the sides of the weld due to relatively low thermal conductivity of argon gas and hence gives the undercut and porosity. Short circuit type metal transfer mode can be better achieved with argon as shielded gas for the welding of sheet metal.

Argon creates an excellent current path and gives very good arc stability due to its low ionization potential. Thin arc column can be produced by Argon at an elevated current density which causes the arc energy to be concentrated in a small area. This results into deep penetration and good bead shape. Spray transfer mode Can also be achieved with argon as shielded gas.

Helium

Helium is best used on welding applications that are requiring the improved of bead wetting, deeper penetration and higher travel speed, this is due of its elevated thermal conductivity and voltage gradient which results in a broader and more shallow penetration pattern than argon. Pure helium gas is appropriate for the welding of thick aluminum, magnesium and copper alloys. The helium arc column is wider than argon which reduces current density. It is recommended to mix helium and argon together so as to seize the advantages of the good quality of both, e.g. helium improves wetting and weld metal coalescence and argon get better arc stability and cleaning action, in the case of aluminum and magnesiurn. Helium is a very light gas and therefore tends to disperse into the air after coming out from the nozzle, therefore restricted flow is needed.

CO2

CO2 is a reactive gas that is mostly used in its pure form in the gas metal arc welding of carbon and low alloy steel. CO2 is only restricted in globular and short circuiting transfer. It has a high welding speed, greater joint penetration and good weld shape due to its high thermal conductivity. It is easily available, has a lower cost and easily installed. In CO2 shielding, the tip of the electrode should be below the surface of the work ` buried arc ´ in order to minimize spatters. With CO2 welding, very low sound deposits, good mechanical properties are achieved but may be adversely affected due to the oxidizing nature. The use of deoxidizers in filler wire is recommended while welding with CO2 to avoid the loss of some alloying elements. To off-set the performance characteristic of pure CO2 it is often mixed with Argon.

PROCESS PARAMETER

Knowledge and control of the process variable is essential so as to produce a weld of satisfactory quality. These variables are not completely independent of one another, changing one variable generally requires changing one or more to produce a good quality weld.

Electrode Size

The base metal thickness changes with the size of the electrode and all these changes have been proposed in the manual of the welding equipment used. In the manual the thickness of the base metal size increases so as the electrode size. The proposed electrode wires in this user manual range from 0.8 to 2.4 mm. Each size depends on the precise arc type (spray or short circuit) which in turn depends on the acceptable current range. Higher current produces additional electrode melting, larger penetration and larger more fluid weld deposit, but may avoid the use of some electrode in the vertical position. The electrode influences the weld bead pattern.

Amperage

The choice of current depends on the electrode size, the mode of transfer of metal and the thickness of the base metal. In our experimental work, the current were changed particular range. When the current is low the surface of the weld is rough, and there is incomplete fusion whereas when the current is high it causes porosity, spatter and poor bead shape. With the welding equipment used when the wire feed rate is high the amperage is also high, and low with low amperage.

Arc Voltage

The arc voltage has a lot to play in the welding process because it affects the quality of the weld in several ways. The choice of voltage decides the amperage and the type of metal Transfer. The selection of voltage is based on the thickness of base metal, electrode size, the joint type, shielding gas composition and the type of weld and when the value is too high or too low above the usage value there will be defeats on the weld like porosity, undercut, spatter and Overlap at the weld edges.

Electrode Extension

Electrode extension is mostly called the wire stick out. It is the distance between the last Point of electrical contact and the end of the electrode. An increase in the amount of this extension causes an increase in electrical resistance. This, in turn, generates additional heat in the electrode, which contributes to a greater electrode melting rate. When the arc voltage is less, the weld bead will be narrow and high-crowned. The most favorable electrode extension generally ranges from 6 to 13 mm for short circuiting transfer and dip transfer.

Arc travel speed

The arc travel speed affects the penetration and the weld bead shape. When the other parameters have been evaluated and fixed, a certain welding speed will give a better penetration and smooth welded. The weld pool is low and larger when the travel speed is lesser; this is because the arc falls on the weld pool instead on the base metal. The weld bead is narrow when the penetration is reduced. This is caused by the reduced heat input which comes as a result of high travel speed. Extreme arc travel speed causes undercutting because there will not be not adequate amount of weld metal deposits.

Electrode position

The electrode position influences the weld penetration and bead shape to a great extent larger than arc voltage and arc current. Commonly used welding torch angle for all position should range from 5 to 150 (from the perpendicular) provides a weld with greatest penetration and narrow, curved surface arrangement, it provides for maximum shielding of the molten weld pool. On the other hand, the technique utilizes a leading travel angle, which provides better visibility for the operator and a weld with flatter surface profile.

Inductance

Current raise as soon as the electrode shorts to the work. The circuits attribute affecting the time rate of this increases in current is inductance. For short arc welding, the best dynamic is usually between two extremes. Right droplet formation is held back when the inductance is too high, and spatter might result when the inductance is too low.

Arc length

Arc length is necessary when the arc regulation utilizes a constant- current power source and a variable-speed, voltage sensing electrode supplier. With the change in arc length, consequently there is changed in the voltage across the arc. When this change is made, the wire feed speed should also be changed so as to provide either more or less electrode per unit time. This method of regulation is usually limited to larger electrode with lower feed speed.

EXPERIMENTAL RESULT

INTRODUCTION OF HARDNESS

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

1. Rockwell Hardness systems use a direct readout machine determining the hardness number based upon the depth of penetration of either a diamond point or a steel ball. Deep penetration indicated a material having a low Rockwell Hardness number.
2. However, a low penetration indicates a material having a high Rockwell Hardness number. The Rockwell Hardness number is based upon the difference in the depth to which a penetrator is driven by a definite light or “minor” load and a definite heavy or “Major” load.
3. The ball penetrators are chucks that are made to hold 1/16” or 1/8” diameter hardened steel balls. Also available are ¼” and ½” ball penetrators for the testing of softer materials.
4. There are two types of anvils that are used on the Rockwell hardness testers. The flat faceplate models are used for flat specimens. The “V” type anvils hold round specimens firmly.
5. Test blocks or calibration blocks are flat steel or brass blocks, which have been tested and marked with the scale and Rockwell number. They should be used to check the accuracy and calibration of the tester frequently.

Using the “B” Scale;
a. Use a Diamond indenter
b. Major load: 100 Kg, Minor load: 10 Kg
c. Use for Case hardened steel titanium, tool steel.
d. Do not use on hardened steel

IMPACT TEST

Izod impact strength testing is an ASTM standard method of determining impact strength. A notched sample is generally used to determine impact strength. Impact is a very important phenomenon in governing the life of a structure. In the case of aircraft, impact can take place by the bird hitting the plane while it is cruising, during take - off and landing there is impact by the debris present on the runway An arm held at a specific height (constant potential energy) is released.

The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact strength is determined. The North American standard for Izod Impact testing is ASTM D256. The results are expressed in energy lost per unit of thickness (such as ft-lb/in or J/cm) at the notch. Alternatively, the results may be reported as energy lost per unit cross-sectional area at the notch (J/m² or ft-lb/in²). In Europe, ISO 180 methods are used and results are based only on the cross-sectional area at the notch (J/m²). The dimensions of a standard specimen for ASTM D256 are 4 x 12.7 x 3.2 mm (2.5" x 0.5" x 1/8"). The most common specimen thickness is 3.2 mm (0.125"), but the width can vary between 3.0 and 12.7 mm (0.118" and 0.500"). The Izod impact test differs from the Charpy impact test in that the sample is held in a cantilevered beam configuration as opposed to a three point bending configuration.

IMPACT STRENGTH

In our Project Impact Strength determined through impact testing machine by charpy method.

Specification of the machine and Size of the specimen
Energy Range = 0 – 300 J
Least Count (1 Division) = 2J
Specimen size = 10 X 10 X 55 mm
Notch = V NOTCH
Notch Depth = 2mm

RESULT &CONCLUSION

MIG welding can be used successfully to join SS410 and mild steel. The processed joints exhibited better mechanical and metallurgical characteristics. The joints exhibited 90-95% of parent material's Hardness value. The specimen failures were associated depending upon the improper changes of heat value In our experiment we found out the input parameter value 140 AMPS VOLT-26 GAS PRESSURE is the best value and it does not create any major changes and failures in the testing process. The DOP value of the MIG welded SS410 steel was comparatively higher value (140 AMPS VOLT-22 GAS PRESSURE 4) than other value. It also induces high tenstilestrength.Fianllly we concluded that in this project investigation the 140 AMPS VOLT-26 GAS PRESSURE is the best parameter for SS410-10 MM thickness plate for obtains the good weldment state. According to the Taguchis design and optimized Impact parameter is value for the 10 mm plate of SS410 steel is (140 AMPS VOLT-26 GAS PRESSURE4 5)

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