EXPERIMENTAL INVESTIGATION OF EFFECT OF WELD PARAMETERS ON HARDNESS OF TIG WELDED STAINLESS STEEL202 MATERIAL

A Project report submitted in partial fulfillment of the requirement for the award of the degree of

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IN
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CERTIFICATE

This is to certify that the Project Report entitled " **EXPERIMENTAL INVESTIGATION OF EFFECT OF WELD PARAMETERS ON HARDNESS OF TIG WELDED STAINLESS STEEL 202 MATERIAL"** has been carried out by Botta Prathyusha (314126520022) , Pushpaja Allada(314126520006) , Jashwanth Boddu (314126520070) , Ganta Snthosh(314126520054) , Behara Akhil Kumar(314126520015) under my guidance, in partial fulfillment of Degree of Bachelor of Mecganical Engineering of Andhra University, Visakhapatnam.

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ABSTRACT

The aim of the present study is to show the influence of different input parameters such as welding current, gas flow rate and filler rod diameter on the mechanical properties during the gas tungsten arc welding of stainless steel 202 grade. Mainly the hardness of weld specimen are investigated in this study. The selected three input parameters were varied at three levels. On the anology, nine experiments were performed based on L9 orthogonal array of Taguchi's methodology, which consist three input parameters. Analysis of variance (ANOVA) was employed to designate the levels of significance of input parameters. Current has the maximum influence on the output characteristics.

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CHAPTER - 1

INTRODUCTION

Chapter-1

1 INTRODUCTION

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that is usually stronger than the base material. Pressure may also be used in conjunction with heat, or by itself, to produce a weld. Welding also requires a form of shield to protect the filler metals or melted metals from being contaminated or oxidized. Although less common, there are also solid state welding processes such as friction welding in which metal does not melt.

Some of the best known welding methods include: Oxy-fuel welding – also known as oxyacetylene welding or oxy welding, uses fuel gases and oxygen to weld and cut metals. Shielded metal arc welding (SMAW) – also known as "stick welding" or "electric welding", uses an electrode that has flux around it to protect the weld puddle. The electrode holder holds the electrode as it slowly melts away. Slag protects the weld puddle from atmospheric contamination.

Gas tungsten arc welding (GTAW) – also known as TIG (tungsten, inert gas), uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas such as argon or helium. Gas metal arc welding (GMAW) – commonly termed MIG (metal, inert gas), uses a wire feeding gun that feeds wire at an adjustable speed and flows an argon-based shielding gas or a mix of argon and carbon dioxide (CO2) over the weld puddle to protect it from atmospheric contamination. Flux-cored arc welding (FCAW) – almost identical to MIG welding except it uses a special tubular wire filled with flux; it can be used with or without shielding gas, depending on the filler. Submerged arc welding (SAW) – uses an automatically fed consumable electrode and a blanket of granular fusible flux. The molten weld and the arc zone are protected from atmospheric contamination by being "submerged" under the flux blanket.

Electroslag welding (ESW) – a highly productive, single pass welding process for thicker materials between 1 inch (25 mm) and 12 inches (300 mm) in a vertical or close to vertical position. Electric resistance welding (ERW) – a welding process that produces coalescence of laying surfaces where heat to form the weld is generated by the electrical resistance of the material. In general, an efficient method, but limited to relatively thin material. Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including in open air, under water, and in outer space.

Welding is a hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation. Until the end of the 19th century, the only welding process was forge welding, which blacksmiths had used for millennia to join iron and steel by heating and hammering. Arc welding and oxyfuel welding were among the first processes to develop late in the century, and electric resistance welding followed soon after. Welding technology advanced quickly during the early 20th century as the world wars drove the demand for reliable and inexpensive joining methods. Following the wars, several modern welding techniques were developed, including manual methods like SMAW, now one of the most popular welding methods, as well as semi-automatic and automatic processes such as GMAW, SAW, FCAW and ESW.

Developments continued with the invention of laser beam welding, electron beam welding, magnetic pulse welding (MPW), and friction stir welding in the latter half of the century. Today, the science continues to advance. Robot welding is commonplace in industrial settings, and researchers continue to develop new welding methods and gain greater understanding of weld quality.

1.1 GAS TUNGSTEN ARC WELDING (GTAW)

The gas tungsten arc welding process uses an electric arc, established by a non-consumable tungsten electrode and the base metal, to join the metal being welded.

A separate welding filler rod is fed into the molten base metal, if needed. The torch holding the tungsten electrode is connected to a shielding gas cylinder and to one of the terminal of the power source. The tungsten electrode is usually in contact with a water-cooled copper tube, called the contact tube, which is connected to the terminal as well. This allows both the welding current to enter the electrode and the electrode to be cooled to prevent overheating.

The work piece is connected to the other terminal of the power source through a different cable. The shielding gas goes through the torch body and is directed by a nozzle toward the weld pool to protect it from the surrounding atmosphere. The gaseous protection in GTAW is much better than SMAW, because an inert gas, such as argon or helium, in usually used as the shielding gas and because the shielding gas is directed toward the weld pool. In the GTAW process three different polarities can be achieved. The current being used may be AC or DC, where DC is subdivided according to the electrode polarity (negative or positive). In a more detailed description the polarities are

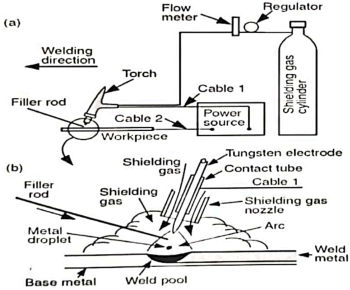


Fig.1(a) TIG welding process

Gas Tungsten Arc Welding Process a) Overall Process and b) Welding area

Direct current electrode negative(DCEN) This, also called straight polarity, is the most common polarity in GTAW. With DCEN, the amount of power located in the work piece is more than the one at the end of the electrode. In this way a relatively narrow and deep weld pool is produced.

Direct current electrode positive. (DCEP) This is also called reverse polarity. Consequently, with DCEP, more power will be located at the electrode, which is why water-cooled electrodes must be used, and less penetration of the weld metal will be achieved.Also, positive ions of the shielding gas will bombard the base metal knocking off oxide films and producing a clean weld surface.

Alternative current (AC). As illustrated reasonably good penetration and oxide cleaning action can be obtained.

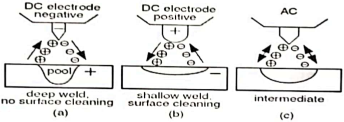


Fig 1.(b) Three different polarities in GTAW a) DCEOP, b) DCEP c)AC

As shielding gases, both argon and helium can be used in the GTAW process. The ionization potentials fro argon and helium are 15.7 and 24.5 eV, respectively. Since it is easier to ionize argon than helium, arc initiation is easier and the voltage drop across the arc is lower with argon. Also, argon is heavier than helium, offering a more effective shielding in the weld pool. These advantages, plus the lower cost of argon, make it more attractive for GTAW than helium.

1.2 HARDNESS OF A MATERIAL:

Hardness is a measure of the resistance to localised plastic deformation induced by either mechanical indentation or abrasion. Some materials (e.g. metals) are harder than others (e.g. plastics). Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex;

therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness. Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness,visco elasticity, and viscosity. Common examples of hard matter are ceramics, concrete, certain metals, and superhard materials, which can be contrasted with soft matter.

1.2.1 MEASUREMENT OF HARDNESS:

There are three main types of hardness measurements: scratch, indentation, and rebound. Within each of these classes of measurement there are individual measurement scales. For practical reasons conversion tables are used to convert between one scale and another.

1.2.2 SCRATCH HARDNESS:

Scratch hardness is the measure of how resistant a sample is to fracture or permanent plastic deformation due to friction from a sharp object. The principle is that an object made of a harder material will scratch an object made of a softer material. When testing coatings, scratch hardness refers to the force necessary to cut through the film to the substrate. The most common test is Mohs scale, which is used in mineralogy. One tool to make this measurement is the sclerometer. Another tool used to make these tests is the pocket hardness tester. This tool consists of a scale arm with graduated markings attached to a four-wheeled carriage. A scratch tool with a sharp rim is mounted at a predetermined angle to the testing surface. In order to use it a weight of known mass is added to the scale arm at one of the graduated markings, the tool is then drawn across the test surface. The use of the weight and markings allows a known pressure.

1.2.3 INDENTATION HARDNESS:

Indentation hardness measures the resistance of a sample to material deformation due to a constant compression load from a sharp object; they are primarily used in engineering and metallurgy fields. The tests work on the basic premise of measuring the critical dimensions of an indentation left by a specifically dimensioned and loaded indenter. Common indentation hardness scales are Rockwell, Vickers, Shore, and Brinell.

1.2.4 REBOUND HARDNESS:

Rebound hardness, also known as dynamic hardness, measures the height of the "bounce" of a diamond-tipped hammer dropped from a fixed height onto a material. This type of hardness is related to elasticity. The device used to take this measurement is known as a scleroscope. Two scales that measures rebound hardness are the Leeb rebound hardness test and Bennett hardness scale.

1.2.5 MECHANISM AND THEORY:

The key to understanding the mechanism behind hardness is understanding the metallic microstructure, or the structure and arrangement of the atoms at the atomic level. In fact, most important metallic properties critical to the manufacturing of today's goods are determined by the microstructure of a material. At the atomic level, the atoms in a metal are arranged in an orderly three-dimensional array called a crystal lattice. In reality, however, a given specimen of a metal likely never contains a consistent single crystal lattice.

A given sample of metal will contain many grains, with each grain having a fairly consistent array pattern. At an even smaller scale, each grain contains irregularities. There are two types of irregularities at the grain level of the micro structure that are responsible for the hardness of the material. These irregularities are point defects and line defects. A point defect is an irregularity located at a single lattice site inside of the overall three-dimensional lattice of the grain.

There are three main point defects. If there is an atom missing from the array, a vacancy defect is formed. If there is a different type of atom at the lattice site that should normally be occupied by a metal atom, a substitutional defect is formed. If there exists an atom in a site where there should normally not be, an interstitial defect is formed. This is possible because space exists between atoms in a crystal lattice. While point defects are irregularities at a single site in the crystal lattice, line defects are irregularities on a plane of atoms. Dislocations are a type of line defect involving the misalignment of these planes.

In the case of an edge dislocation, a half plane of atoms is wedged between two planes of atoms. In the case of a screw dislocation two planes of atoms are offset with a helical array running between them.In glasses, hardness seems to depend linearly on the number of topological constraints acting between the atoms of the network.Hence, the rigidity theory has allowed predicting hardness values with respect to composition. Dislocations provide a mechanism for planes of atoms to slip and thus a method for plastic or permanent deformation. Planes of atoms can flip from one side of the dislocation to the other effectively allowing the dislocation to traverse through the material and the material to deform permanently. The movement allowed by these dislocations causes a decrease in the material's hardness. Mechanisms and theory A representation of the crystal lattice showing the planes of atoms.

Hardness - The way to inhibit the movement of planes of atoms, and thus make them harder, involves the interaction of dislocations with each other and interstitial atoms. When a dislocation intersects with a second dislocation, it can no longer traverse through the crystal lattice. The intersection of dislocations creates an anchor point and does not allow the planes of atoms to continue to slip over one another .A dislocation can also be anchored by the interaction with interstitial atoms. If a dislocation comes in contact with two or more interstitial atoms, the slip of the planes will again be disrupted.

The interstitial atoms create anchor points, or pinning points, in the same manner as intersecting dislocations. By varying the presence of interstitial atoms and the density of dislocations, a particular metal's hardness can be controlled. Although seemingly counter-intuitive, as the density of dislocations increases, there are more intersections created and consequently more anchor points.

Similarly, as more interstitial atoms are added, more pinning points that impede the movements of dislocations are formed. As a result, the more anchor points added, the harder the material will become.

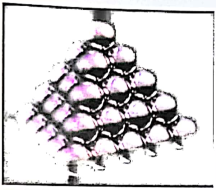


Fig.1,(c) lattice structure in solids

Hardness of steel is The important to many processes. Steel hardness describes the properties of steel that enable it to resist plastic deformation, indentation, penetration, and scratching. In engineering, steel hardness is important because the inherent resistance of the surface to withstand friction or erosion by oil, steam, and water, typically increases with the relative hardness of steel.

The higher the steel hardness, the more resistant the surface will be. This creates difficulties in surface operations, such as cutting and machining. There is no one quality that influences the hardness of steel, or that can be termed 'hardness'. There are various empirical steel hardness tests. The most important and popular of these measures are Brinell, Rockwell, and Vickers.

The hardness tests do not measure hardness in units, but as an index. Because each of the steel hardness tests are so common, the index is given as a number followed by a code to indicate the test method.

1.3 Which steel hardness test to use

Traditionally, Brinell is used for softened steels and Vickers is used more widely. These tests measure the diameter of the indentation left on the surface of the metal. The Rockwell method assesses steel hardness by measuring the depth of penetration of an indentation.

1.3.1 Brinell steel hardness test

The Brinell test was the first widely used standardised steel hardness test. It requires a large test piece and leaves a large indentation; therefore, it is limited in its usefulness. The acronym BHN is used to show a Brinell Hardness Number. The term 'Brinelling' has come to mean the permanent indentation of any hard surface. The test involves a large, heavy ball, which is pushed against steel at a predetermined level of force. The depth and diameter of the mark are measured and indexed to provide a BHN.

1.3.2 Rockwell steel hardness test

The Rockwell scale is also based on the diameter of an indentation. A Rockwell hardness tester is much lighter and more mobile. It determines steel hardness by putting pressure on steel. It was developed in the US to determine the change in hardness between steel and heat treated steel.

1.3.3 Vickers s test

Developed in the UK as an alternative to the Brinell test, the Vickers hardness test can test all materials, whether hard or soft. It was the widest scale of indices, and is easier to use than the other steel hardness tests. The Vickers hardness test provides a Vickers Pyramid Number (HV) or a Diamond Pyramid Hardness (DPH) number. This is because the indentor is a pyramid or cone shape.

CHAPTER-2

LITERATURE SURVEY

CHAPTER 2

LITERATURE SURVEY

This chapter will be discussing the back ground studies related to the project. That is,the studies which focused on TIG butt welding, its parameters and limitations,and also the hardness of ductile materials, specifically that of mild steel.

Juang conducted an experiment to obtain process parameters for optimizing weld pool geometry in the tungsten inert gas welding [TIG] of stainless steels. Here Taguchi method was adopted to analyze the effect of each welding process parameters on the weld pool geometry, and then to determine the process parameters with the optimal weld pool geometry.

Wang discussed about obtaining the weld pool vision information during aluminum alloy tungsten inert gas welding [TIG]. Here the relationships between the image sensing system and the characteristic of welding current were discussed in detail. A neural network method was used to extract the edge of the images of the weld pool. The result of detecting the edge with a neural network was excellent. It was observed that using the image sensing to control the TIG weld width for aluminum alloy is an effective method.

Durgutlu conducted an experimental investigation of the effect of hydrogen in argon as a shielding gas on TIG welding of austenitic stainless steel. Here hydrogen gas is added with the argon gas for welding. The microstructure, penetration and mechanical properties were examined. It was observed that the highest tensile strength was obtained from the sample which was welded under shielding gas of argon with the addition of hydrogen.

Shahi discussed about the various primary welding variables which affect the mechanical strength of sub merged arc welding butt welded joints. Welding current was found to be most significant welding variable among welding voltage and the welding speed as regards to UTS, impact strength and hardness of the welded joints.

A. Kumar TIG welding process is generally used for welding of Al-Mg-Si alloys. In any welding process, the input parameters have an influence on the joint mechanical properties. By varying the input process parameters combination the output would be different welded joints with significant variation in their mechanical properties.

Fung studied the GRA to obtain the optimal parameters of the injection molding process for mechanical properties of yield stress and elongation in polycarbonate /acrylonitrile-butadiene-styrene (PC / ABS) composites.

Shen studied different polymers (such as PP, PC, PS, POM) with various process parameters of the micro-gear. The simulation used Taguchi method and GRA was provided. Dharmalingam et al [8] conducted an experimental study on optimizing Tribological properties in aluminum hybrid metal matrix composites using Grey-Taguchi method. Here orthogonal array with grey relation analysis is used to optimize the multiple performance dry sliding characteristics of aluminum hybrid composites.

An L27 orthogonal array was employed for the experimental design

W.H. Yang described the Taguchi method, a powerful tool to design optimization for quality, is used to find the optimal cutting parameters for turning operations. An orthogonal array, the signal-to-noise (S:N) ratio, and the analysis of variance (ANOVA) are employed to investigate the cutting characteristics of S45C steel bars using tungsten carbide cutting tools.

From the above literatures it is clearly identified that no one have undergone the research work in 6063 Aluminum alloy so it chosen to do with aluminum alloy.

Nabendu Ghosh, Pradip Kumar Palband, GoutamNandic,conductedvisual inspection and X-ray radiographic tests in order to detect surface and sub-surface defects of weld specimens made of AISI 316L austenitic stainless steels. Effect of current, gas flow rate and nozzle to plate distance on quality of weld in metal inter gas arc welding of AISI 316L austenitic stainless steel has been studied in the present work through experiments and analyses. Butt welded joints have been made by using several levels of current, gas flow rate and nozzle to plate distance. The quality of the weld has been evaluated in terms of yield strength, ultimate tensile strength and percentage of elongation of the welded specimens. The observed data have been interpreted, discussed and analyzed by using Grey - Taguchi methodology.

Raghuvir Singh et al,investigated the effect of TIG welding parameters like welding speed, current and flux on depth of penetration and width in welding of 304L stainless steel has been studied. From the study it was observed that flux used has the most significant effect on depth of penetration followed by welding current. However SiO_2 flux has more significant effect on depth. Optimization was done to maximize penetration and having less bead width.

Ugur Esme et al,investigated the multi-response optimization of tungsten inert gas welding (TIG) process for an optimal parametric combination to yield favorable bead geometry of welded joints using the Grey relational analysis and Taguchi method. Sixteen experimental runs based on an orthogonal array of Taguchi method were performed to derive objective functions to be optimized within experimental domain. The objective functions have been selected in relation to parameters of TIG welding bead geometry, bead width, bead height, penetration, area of penetration as well as width of heat affected zone and tensile load. The Taguchi approach followed by Grey relational analysis was used to solve the multi-response optimization problem. The significance of the factors on overall quality characteristics of the weldment has also been evaluated quantitatively by the analysis of variance method (ANOVA). Optimal results have been verified through additional experiments. This shows application feasibility of the Grey relation analysis in combination with Taguchi technique for continuous improvement in product quality in manufacturing industry.

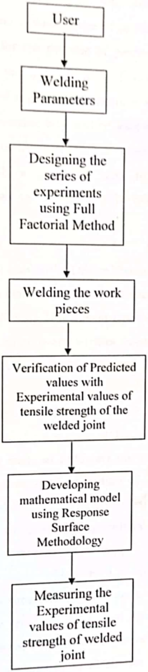
CHAPTER - 3

DESIGN OF EXPERIMENTS

Chapter 3

DESIGN OF EXPERIMENTS

3.1 METHODOLOGY:



3.2 Introduction to Design of Experiments

"Design of Experiments" is an experimental or analytical method that is commonly used to statistically signify the relationship between input parameters and output responses. DOE has a wide range of applications, especially in the field of science and engineering for the purpose of process optimization and development, process management and validation tests. DOE is essentially an experimental based modeling and is a designed experimental approach which is far superior to unplanned approach, whereby, a systematic way will be used to plan the experiment, collect the data and analyze the data. A mathematical model has been developed by using analysis techniques such as ANOVA and regression analysis whereby the mathematical model shows the relationship between the input parameters and the output responses.

Among the most prominently used DOE techniques are Response Surface Methodology with Central Composite Design, Taguchi's method and Factorial Design. In DOE, synergy between mathematical and statistical techniques such as Regression, Analysis of Variance (ANOVA), Non-Linear Optimization and Desirability functions helps to optimize the quality characteristics considered in a DOE under a cost effective process. ANOVA helps to identify each factor effect versus the objective function.

Experimental design was first introduced in the 1920s by R. A. Fischer working at the agricultural field station at Rothamsted in England. Fischer was concerned with arranging trials of fertilizers on plants to protect them against the underlying effect of moisture, gradient, nature of soils, etc. Fischer developed the basic principles of factorial design and the associated data analysis known as ANOVA during research in improving the yield of agricultural crops.

3.2.1. Advantages & Disadvantages of DOE

DOE became a more widely used modeling technique superseding its predecessor one-factor-at- time (OFAT) technique. One of the main advantages of DOE is that it shows the relationship between parameters and responses. In other words, DOE shows the interaction between variables which in turn allows us to focus on controlling important parameters to obtain the best responses. DOE also can provide us with the most optimal setting of parametric values to find the best possible output characteristics. Apart from that, the mathematical model generated can be used as a prediction model which can predict the possible output responses based on the input values. Another main reason DOE is used because it saves time and cost in terms of experimentation. DOE functions in such a manner that the number of experiments or the number of runs is determined before the actual experimentation is done. This way, time and cost can be saved as we do not have to repeat unnecessary experiment runs.

Usually, experiments will have errors occurring. Some of them might be predictable while some errors are just out of control. DOE allows us to handle these errors while still continuing with the analysis. DOE is excellent when it comes to prediction of linear behavior. However, when it comes to nonlinear behavior, DOE does not always give the best results.

3.3 FACTORIAL METHOD

Factorial designs allow for the simultaneous study of the effects that several factors may have on a process. When performing an experiment, varying the levels of the factors simultaneously rather than one at a time is efficient in terms of time and cost, and also allows for the study of interactions between the factors. Interactions are the driving force in many processes. Without the use of factorial experiments, important interactions may remain undetected.

Different types of designs available in Factorial Method

- Two-level full factorial designs
- Two-level fractional factorial designs
- Plackett-Burman designs
- General full factorial designs

3.4 Mixture Design

Mixture experiments are a special class of response surface experiments in which the product under investigation is made up of several components or ingredients. In the simplest mixture experiment, the response (the quality or performance of the product based on some criterion) depends on the relative proportions of the components. In contrast, in a factorial design, the response varies depending on the amount of each factor.

Minitab can create three designs (simplex lattice, simplex centroid, and extreme vertices) and analyze data from these types of experiments:

- Mixture experiments
- Mixture-amounts (MA) experiments
- Mixture-process variable (MPV) experiments.

TAGUCHI DESIGN, MINITAB, OTHER TABLES, ETC.,

3.5 SELECTION OF MATERIAL

Austenitic stainless steel is most commonly used in petrochemical, chemical and power engineering, also in vehicle and aviation industries. Stainless steel is used when both the properties of steel and resistance to corrosion are required. The welding of automotive exhaust gas systems, stainless steel pipes, repairing of chemical industries' equipment etc., are done with the help of gas tungsten inert gas welding (GTAW or commonly known as TIG). Chrome-manganese austenitic stainless steel grades (standard 200-series) with well-defined and well-documented technical properties have proved acceptable materials for specific applications for many years. There has recently been a significant increase in the use of new and economical 696 Sahil Bharwal and Charit Vyas chrome manganese grades (which can be referred to as "new 200-series" grades). These 200-series grade use different chemistries, characterized by reduced chromium and extra low nickel content.

As well as currently being significantly cheaper, from a material cost point of view, 200-series stainless steels can offer good strength, depending on their chemistry. Certain grades (equivalent to 201-, 202- and 205-series) even offer about 30% higher "mechanical properties" (yield strength) than the classic 304-series chrome nickel grade – allowing designers to cut weight. Almost the complete replacement of Nickel is possible by combined Manganese and Nitrogen addition with Carbon. Lower nickel addition requires more manganese and nitrogen to stabilize the austenitic phase.

Higher draw ability properties may be obtained with lower nitrogen additions but then chromium content must be reduced down to 14-15% in order to provide the stability to the austenitic phase. AISI 304 stainless steel is widely used in forming applications because of its superior formability. The high nickel price in recent years prompted an investigation into the feasibility of replacing AISI 304 with AISI 202 in applications requiring comparable mechanical properties.

The aim of this investigation was therefore to study the weldability of AISI 202 stainless steel using uniaxial tensile tests. A huge rectangular slab of Stainless Steel SS 202 was cut into 18 pieces in order to get 9 welded joints. Material used is shown in Fig

The size of work piece used is 160*50*4.5 mm^3

The length of weld is 50 mm

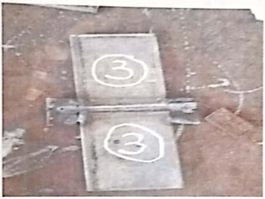


Fig 3 (a) size of work piece

3.(b) Final work pieces

Table 3.1. Chemical composition of Stainless Steel SS 202

Element	Percentage of weight
Carbon	0.065
Silicon	0.373
Manganese	8.131
Sulphur	0.007
Phosphorus	0.012
Chromium	17.310
Nickel	4.380
Molybdenum	0.272
Copper	0.194
Aluminum	0.000
Titanium	0.005
Vanadium	0.057
Cobalt	0.026
Niobium	0.020
Wolfram	0.012
Iron	68.842

Table 3.2. Physical properties of Stainless Steel SS 202

Property	Value
Density	7.8×10^3 kg/m^3
Poisson's Ratio	0.27-0.30
Elastic Modulus	190-210 GPa
Tensile Strength	515 MPa
Yield Strength	275 MPa
Elongation	40 %

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CHAPTER - 4

EXPERIMENTAL SETUP

CHAPTER 4

EXPERIMENTAL SETUP

The work pieces were made initially by cutting them in workshop using workshop tools. The cut work pieces were butt-welded using "TIG welding equipment" as shown in Fig

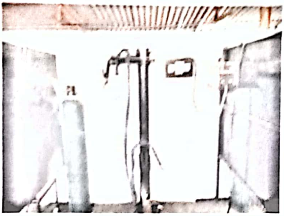


Fig 4.(a) experimental setup for welding

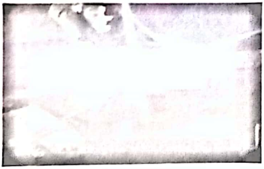


Fig 4.(b) TIG welding

4.1.0 Torch

There is a wide range of torch designs for welding, depending on the application. Designs which have the on/off switch and current control in the handle are often preferred to foot controls. Specialised torches are available for mechanised applications, e.g. orbital and bore welding of pipes.

4.1.1 Electrode

The electrode tip is usually ground to an angle of 60 to 90 degrees for manual welding, regardless of the electrode diameter. For mechanised applications as the tip angle determines the shape of the arc and influences the penetration profile of the weld pool, attention must be paid to consistency in grinding the tip and checking its condition between welds.

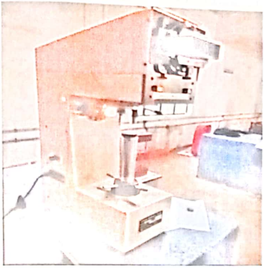
For AC current, the electrode often pure tungsten. The tip normally adopts a spherical profile due to the heat generated in the electrode during the electrode positive half cycle..we used s.s material 202 grade.

4.1.2 Gas shielding

A gas lens should be fitted within the torch nozzle, to ensure laminar gas flow. This will improve gas protection for sensitive welding operations like welding vertical, corner and edge joints and on curved surfaces. There is also a wide range of nozzles available, ensuring different gas coverage. The nozzle's selection depends mainly on the electrode diameter and on the accessibility, defined by the assembly to be welded.

Here large sheet of ss 202 grade material is taken and cutting has been done and these pieces are welded together and finally we have cut the workpiece so that we got only required potion for further investigation.

4.2 EQUIPMENT FOR HARDNESS TEST:

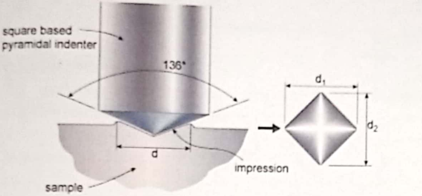


4.2. (A) vicker`s equipment for hardness test

The **Vickers hardness test** was developed in 1921 by Robert L. **Smith and George E. Sandland** at Vickers Ltd as an alternative to the Brinellmethod to measure the hardness of materials.The Vickers test is often easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness.

The basic principle, as with all common measures of hardness, is to observe the questioned material's ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as the **Vickers Pyramid Number (HV)** or **Diamond Pyramid Hardness (DPH)**. The hardness number can be converted into units of pascals, but should not be confused with pressure, which uses the same units. The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force, and is therefore not pressure.

He we used diamond indenter angle of 136 degrees for the indentation.



(a) Vickers indentation (b) measurement of impression diagonals

Fig.4.2.(b) diamond indenter

4.3 PREPERATION OF WORKPIECE:

Here our final aim to test hardness of ss material which is tig welded hence the most suitable indentation hardness test method depends on the material's microstructure, e.g. the homogeneity of the material. It is important that the material, under the indent performed by the hardness tester, is representative of the whole microstructure, unless the task is to study the different constituents in the microstructure. This means that if a micro-structure is very coarse and heterogeneous, a larger impression is required than for a homogeneous .

4.3.(a) disc polishing machine

4.3.(b) abrasive papers

CHAPTER - 5

ANALYSIS AND RESULTS

CHAPTER-5

ANALYSIS AND RESULTS

5.1. ANALYSIS OF VARIANCE

In statistics, analysis of variance (ANOVA) is a collection of statistical models, and their associated procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are all equal, and therefore generalizes t-test to more than two groups. Doing multiple two-sample t-tests would result in an increased chance of committing a type I error. For this reason, ANOVAs are useful in comparing three, or more means.

5.2 Characteristics of ANOVA

ANOVA is used in the analysis of comparative experiments, those in which only the difference in outcomes is of interest. The statistical significance of the experiment is determined by a ratio of two variances. This ratio is independent of several possible alterations to the experimental observations: Adding a constant to all observations does not alter significance. Multiplying all observations by a constant does not alter significance. So ANOVA statistical significance results are independent of constant bias and scaling errors as well as the units used in expressing observations.

5.3 RESPONSE SURFACE METHODOLOGY

In statistics, response surface methodology (RSM) explores the relationships between several explanatory variables and one or more response variables. The method was introduced by G. E. P. Box and K. B. Wilson in 1951. The main idea of RSM is to use a sequence of designed experiments to obtain an optimal response. Box and Wilson suggest using a second-degree polynomial model to do this. They acknowledge that this model is only an approximation, but use it because such a model is easy to estimate and apply, even when little is known about the process.

5.4 Practical Concern

Response surface methodology uses statistical models, and therefore practitioners need to be aware that even the best statistical model is an approximation to reality. In practice, both the models and the parameter values are unknown, and subject to uncertainty on top of ignorance. Of course, an estimated optimum point need not be optimum in reality, because of the errors of the estimates and of the inadequacies of the model.

Nonetheless, response surface methodology has an effective track-record of helping researchers improve products and services: For example, Box's original response-surface modeling enabled chemical engineers to improve a process that had been stuck at a saddle-point for years. The engineers had not been able to afford to fit a cubic three-level design to estimate a quadratic model, and their biased linear-models estimated the gradient to be zero. Box's design reduced the costs of experimentation so that a quadratic model could be fit, which led to a (long-sought) ascent direction.

5.5 Mathematical model of Response Surface Methodology

The Response Surface is described by an second order polynomial equation of the form –

$$Y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii} x_{i^2} + \sum\sum_{i<j} \beta_{ij} x_i x_j + \in$$

Where,

Y is the corresponding response

(1,2, . . . , S) are coded levels of S quantitative process variables

The terms are the second order regression coefficients

Second term is attributable to linear effect

Third term corresponds to the higher-order effects

Fourth term includes the interactive effects

The last term indicates the experimental error

5.6.0 TERMS & GRAPHS IN RESPONSE SURFACE METHODOLOGY

5.6.1 Regression table

1. P-values

P-values (P) are usedto determine which of the effects in the model are statistically significant.

- If the p-value is less than or equal to α (0.05)□, conclude that the effect is significant.
- If the p-value is greater than α, conclude that the effect is not significant.

2. Coefficients

Coefficients are used to construct an equation representing the relationship between the response and the factors.

3. R-squared

R and adjusted R represent the proportion of variation in the response that is explained by the model.

- R (R-Sq) describes the amount of variation in the observed responses that is explained by the model.
- Predicted R reflects how well the model will predict future data.
- Adjusted R is a modified R that has been adjusted for the number of terms in the model. If we include unnecessary terms, R can be artificially high. Unlike R , adjusted R may get smaller when we add terms to the model.

4. Analysis of variance table

P-values (P) are used in analysis of variance table to determine which of the effects in the model are statistically significant. The interaction effects in the model are observed first because a significant interaction will influence the main effects.

5. Estimated coefficients using uncoded units

Minitab displays the coefficients in uncoded units in addition to coded units if the two units differ.

For each term in the model, there is a coefficient. These coefficients are useful to construct an equation representing the relationship between the response and the factors

5.6.2 Graphs

1. Histogram of residuals

Histogram of the residuals shows the distribution of the residuals for all observations

2. Normal plot of residuals

Graph is plotted between the residuals versus their expected values when the distribution is normal. The residuals from the analysis should be normally distributed. In practice, for balanced or nearly balanced designs or for data with a large number of observations, moderate departures from normality do not seriously affect the results. The normal probability plot of the residuals should roughly follow a straight line.

3. Residuals versus fits

Graph is plotted between the residuals versus the fitted values. The residuals should be scattered randomly about zero.

4. Residuals versus order

This graph plots the residuals in the order of the corresponding observations. The plot is useful when the order of the observations may influence the results, which can occur when data are collected in a time sequence or in some other sequence. This plot can be particularly helpful in a designed experiment in which the runs are not randomized.

5.7 REGRESSION EQUATION:

$$H = -8761 + 63.13*I + 655.5*GF + 2320*FD - 0.1148\, I*I - 6.095\, GF*GF - 919.6\, FD*FD - 5.093\, I*GF + 11.53\, I*FD$$

GF = GAS FLOW RATE
FD =FILLER ROD DIAMETER
I = CURRENT
H =HARDNESS

Here we are going to vary three input parameters such as current,gas flow rate and filler rod dimeter. So finally we are going to investigate on 9 welded plates of stainless steel 202 grade material.

5.8 INPUT PARAMETERS:

GAS FLOW RATE (GF)	CURRENT (I)	FILLERROD DIAMETER (FD)
90	12	1.6
90	14	2.0
90	16	2.5
100	12	2.0
100	14	2.5
100	16	1.6
110	12	2.5
110	14	1.6
110	16	2.0

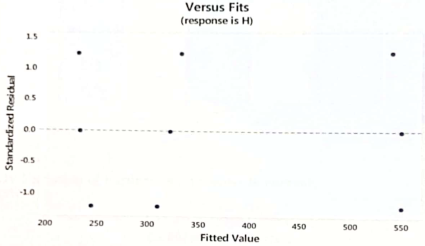
5.8.1 ANALYSIS OF VARIANCE:

SOURCE	D.O.F	ADJ S.S	ADJ MS	F-VALUE	P-VALUE
model	6	155109	25852	3.09	0.065
linear	6	155109	25852	3.09	0.265
I(current)	2	35742	17871	2.13	0.319
GF(gas flow rate)	2	34438	17219	2.05	0.327
FD(filler rod dia)	2	84930	42465	5.07	0.165
error	2	16759	8380		
total	8	171869			

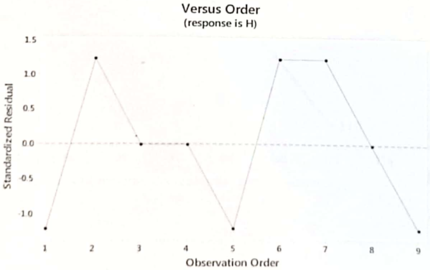
S	R-sq	R-sq(Adj)	R-sq(predicted)
91.5409	90.25%	60.99%	0.00%

5.9 GRAPHS:

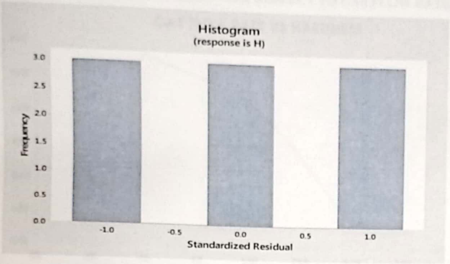
5.9.1 versus fits:



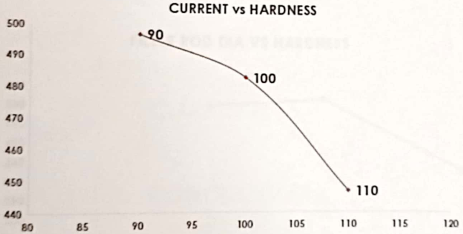
5.9.2.versus order :



5.9.3.histogram:

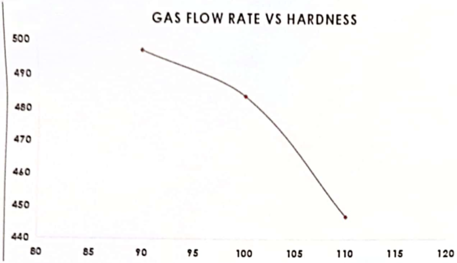


5.10 Variation of hardness with respect to current:



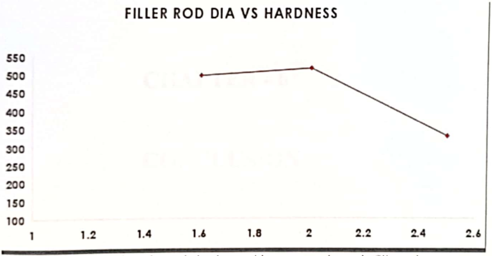
Here hardness of material decreases as current increases.

5.11 VARIATION OF HARDNESS WITH RESPECT TO GAS FLOW RATE:



Here hardness decreases with respect to increased gas flow rate

5.12.VARIATION OF HARDNESS WITH RESPECT TO FILLER ROD DIAMETER:



Here we can find a random change in hardness with respect to change in filler rod diameter.

CHAPTER - 6

CONCLUSION

CHAPTER-6

CONCLUSION

The following conclusions are made from the experiments made in this project:

- When Stainless steel 202 grade material was cut into pieces and tig welded and observed in different input parameters like filler rod diameter,gas flow rate and current.From surface response method analysis we can form a regression equation and from that we can know the hardness of material directly by substituting the values of gas flow rate,current and gas flow rate.
- And also we can know that hardness of material is decreasing with increase in current.
- Hardness of material is is decreases with increase in gas flow rate.
- We don't find appreciable change in hardness of material with change in Filler rod diameter.
- Material shows the difference in hardness when variable input weld parameters are changed in tig welding.

CHAPTER - 7

REFERENCES

CHAPTER-7

REFERENCES

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