A HYBRID METHODOLOGY FOR OPTIMIZING MIG WELDING PROCESS PARAMETERS IN JOINING OF DISSIMILAR METALS

A Thesis

Submitted

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF TECHNOLOGY

In

Mechanical Engineering

With Specialization

In

"Production and Industrial Engineering"

Submitted by

Mohammad Saif

Enrollment No. 1900103128

Department of Mechanical Engineering

INTEGRAL UNIVERSITY, LUCKNOW, INDIA

September, 2021

CERTIFICATE

This is to certify that **Mr. Mohammad Saif** (Enroll. No. 1900103128) has carried out the Research work presented in the thesis titled **"A Hybrid Methodology for Optimizing MIG Welding Process Parameters in Joining of Dissimilar Metals"** submitted for partial fulfillment for the award of the **Degree of Master of Technology in Production and Industrial Engineering** from **Integral University, Lucknow** under my supervision.

It is also certified that:

(i) This thesis embodies the original work of the candidate and has not been earlier submitted elsewhere for the award of any degree/diploma/certificate.

(ii) The candidate has worked under my supervision for the prescribed period.

(iii) The thesis fulfills the requirements of the norms and standards prescribed by the University Grants Commission and Integral University, Lucknow, India.

(iv) No published work (figure, data, table etc.) has been reproduced in the thesis without express permission of the copyright owner(s).

Therefore, I deem this work fit and recommend for submission for the award of the aforesaid degree.

Signature of Supervisor
Mrs. Sumita Chaturvedi
Assistant Professor
Department of Mechanical Engineering
Integral University, Lucknow
Date: 11/09/2021
Place: Lucknow

DECLARATION

I hereby declare that the thesis titled "**A Hybrid Methodology for Optimizing MIG Welding Process Parameters in Joining of Dissimilar Metal**" is an authentic record of the research work carried out by me under the supervision of Mrs. Sumita Chaturvedi Assistant Professor Department of Mechanical Engineering, Integral University, Lucknow. No part of this thesis has been presented elsewhere for any other degree or diploma earlier.

I declare that I have faithfully acknowledged and referred to the works of other researchers wherever their published works have been cited in the thesis. I further certify that I have not willfully taken other's work, para, text, data, results, tables, figures etc. reported in the journals, books, magazines, reports, dissertations, theses, etc., or available at web-sites without their permission, and have not included those in this M.Tech. thesis citing as my own work.

Date: 11/09/2021

Signature

Name .**Mohammad Saif**

Enroll. No. **1900103128**

ACKNOWLEDGEMENT

First of all I am highly indebted and thankful to the Almighty God, the most merciful and benevolent to all, who taught men that which he knew not and bestowed the men with epistemology and gave him the potential to ameliorate the same. It is my pleasant duty to acknowledge the help received from several individuals during the work

I wish to express my profound gratitude, respect and honour to my supervisor **Mrs. Sumita Chaturvedi** Assistant Professor, Department of Mechanical Engineering, Integral University, Lucknow, for his illuminative and precious guidance, constant supervision, critical opinion and timely suggestion, constant useful encouragement and technical tips which has always been a source of inspiration during the preparation of dissertation.

I would also like to thank the rest of thesis committee, Prof**. Dr. Prem Kumar Bharti** (HOD Department of Mechanical Engineering), my Dissertation Incharge Dr. Mohd. Anas, Associate Professor, entire Faculties and staff of Department of Mechanical Engineering for their supports, encouragement and providing me the opportunities while working on this exciting research.

I will be failing in my duties if I miss to express my profound and deepest sense of gratitude to my beloved parents and other members of family and friends for their keen interest in my studies, immense support and encouragement, without which it was impossible to complete this dissertation.

I also place on record my sense of gratitude to one and all who directly or indirectly. Have lent their hand in this thesis.

Mohammad Saif

Roll. No. 1901301003

LIST OF TABLES

LIST OF FIGURES

FLOW CHART

TABLE OF CONTENTS

ABSTRACT

In this paper application of Taguchi and Grey relational analysis methodologies in determining optimal process parameters for MIG Welding are presented. Taguchi method is widely used in designing the optimal experiments, while grey relation analysis is useful in decision making when multiple criteria's are considered, this combination serves as an effective tool in determining the optimal parameters of the process. In the present work welding current, voltage, speed, bevel angle were considered as input parameters in joining two dissimilar metals (AISI1044 & AISI1018), as these influence the output characteristics like tensile strength and hardness, these parameters need to be optimized. Selection and per review under responsibility of the scientific committee of the International Conference on Recent Advances in Materials, Manufacturing & Energy Systems.

The aim of my work is to study the hardness that affects the welding joint of dissimilar metals. Carbon steel(AISI1044) was welded to mild steel (AISI1018) using a metal inert gas welding which also known as gas metal arc is welding with the help of filler wire of carbon steel and 0.8 0mm diameter. Argon gas was used as shielding gas in this process. Dissimilar metals welding have great scope in advanced technology nowadays owing to their high hardness, high strength and corrosion resistance properties. The combination of mild steel and carbon steel has got large number of application in industry such as power plant, nuclear plant, and heat exchanger assembly etc. Due to the fact that low cost of mild steel and corrosion resistance property of mild steel. All these application requires welding of the two which can perform the desired service requirement of the industry. The difference in the properties such as melting point, thermal conductivity, carbon content difference makes carbon steel and mild steel difficult to weld and gives rise to various failures in the future service life. The results indicate the optimum value of current and voltage which will be applied to developed weld for maximum hardness of welded mild steel and carbon steel specimens.

CHAPTER 1

INTRODUCTION

1.1 General

MIG welding is an arc welding system wherein a non-stop solid wire electrode is fed thru a welding gun and into the weld pool, joining the 2 base materials together. A protecting fuel is likewise despatched thru the welding gun and protects the weld pool from infection. In reality, MIG stands for steel inert gas.

MIG (Metal Inert Gas) Or Gas Metal Arc Welding (GMAW) is a welding technique in which a consumable metal electrode is used to supply the electric arc to sign up for the metal portions collectively in the surroundings of a defensive fuel. Shielding gasoline protects the weld from atmospheric contamination. Constant voltage, direct cutting-edge strength source is used to supply the arc.

Figure 1.1 MIG Welding

- This welding turned into first invented inside the yr. 1940 for welding aluminum and different non-ferrous substances.
- This procedure may be semi-automatic or computerized.
- It makes use of argon and helium as the defensive gas because those two are maximum low in cost and inert.

- The metallic switch in MIG welding takes location in four number one approaches, and those are globular, short-circuiting, spray, and pulsed-spray. Each technique has its personal feature properties, blessings, and corresponding limitations.

1.2 CIRCUIT DIAGRAM OF GMAW OR MIG WELDING PROCESS

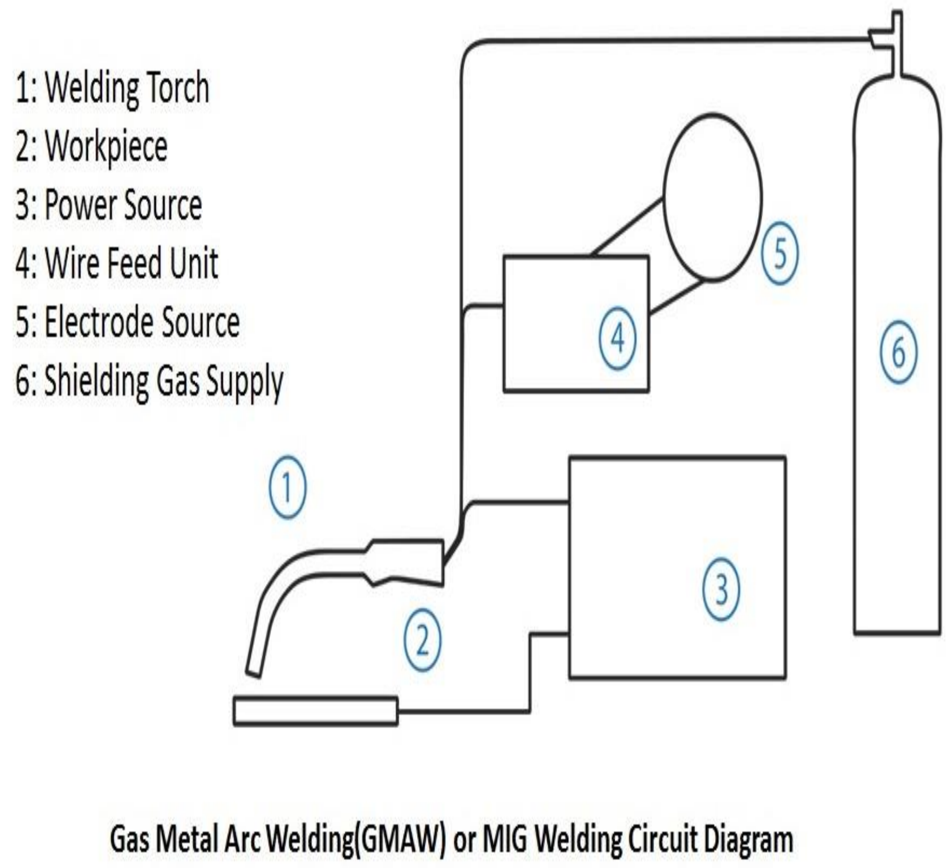


Figure 1.2 Circuit Diagram of Gmaw or Mig Welding Process

1.3 EQUIPMENTS

The various gadgets that is used in GMAW or MIG welding method are:

- **A Welding Gun**: It consists of a twine electrode and a defensive fuel supply.
- **A Wire Feed Unit**: It gives continuous twine feed steel electrode at some stage in welding operation.
- **A Welding Power Supply**: It is regular voltage energy supply whose one terminal is attached with the welding gun and the other is attached to the work piece thru clamping device

Figure 1.3 Equipments of Mig Welding

- **A Welding Electrode Wire**: It is the steel twine which is used as the metallic electrode inside the GMAW welding.
- **A Shielding Gas Supply**: It is a cylinder which includes the shielding fuel argon or helium.

1.4 WORKING PRINCIPLE

The MIG welding manner is primarily based on the principle that a consumable metallic electrode is used to provide an arc in between the metal electrode and the work piece. The arc so produced creates a massive quantity of warmth and this heat is used to enroll in the 2 steel pieces together. The whole system takes location below a protecting gas (argon or helium) to prevent the weld from atmospheric infection.

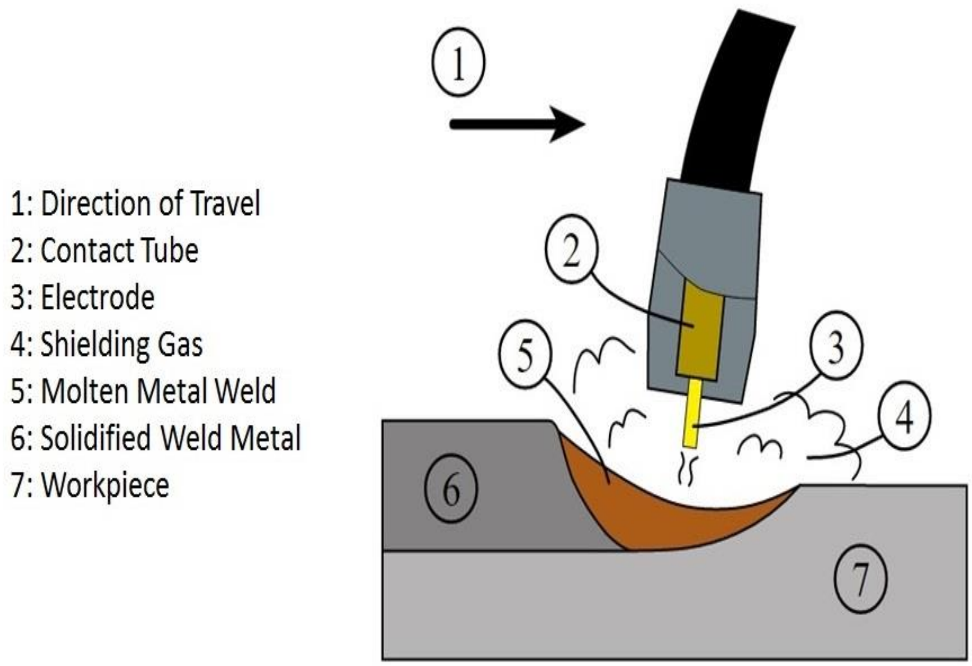


Figure 1.4 Working Principles

1.4.1TOOL STYLE

In gasoline steel arc welding, the most generally used electrode holders are:-

- **Semi-Automatic Air-Cooled Holder**: This kind of holder uses compressed air to keep the temperature at the required level. It makes use of low-degree currents to make lap and butt joints.
- **Semi-Automatic Water-Cooled**: Its working is equal us above holder however the distinction is that it uses water for the cooling in preference to compressed air. This makes use of higher stage of currents to weld T or corner joints.
- **Water Cooled Automatic Electrode Holder**: It is a typical electrode holder and is used with automated system.

1.4.2 POWER SUPPLY

The MIG welding process or GMAW most commonly uses constant voltage, direct current power source for the welding. It can also use constant current systems and alternating current

1.4.3 SHIELDING GAS

The shielding gases are of two types- inert or semi inert. The shielding gases that are used in MIG welding are

- Argon and helium are inert and most cost effective shielding gas used in the MIG welding. Pure argon and helium is used to weld non-ferrous materials.

- The semi- inert gases are the mixtures of carbon dioxide, nitrogen, hydrogen, and oxygen in the argon

1.5 WORKING OF MIG WELDING

- In MIG welding manner, the electrode twine from the cord feed unit and shielding gas supply is hooked up with the welding gun. The advantageous terminal of the DC electricity supply is hooked up to the welding gun and the bad terminal is connected to a clamp.

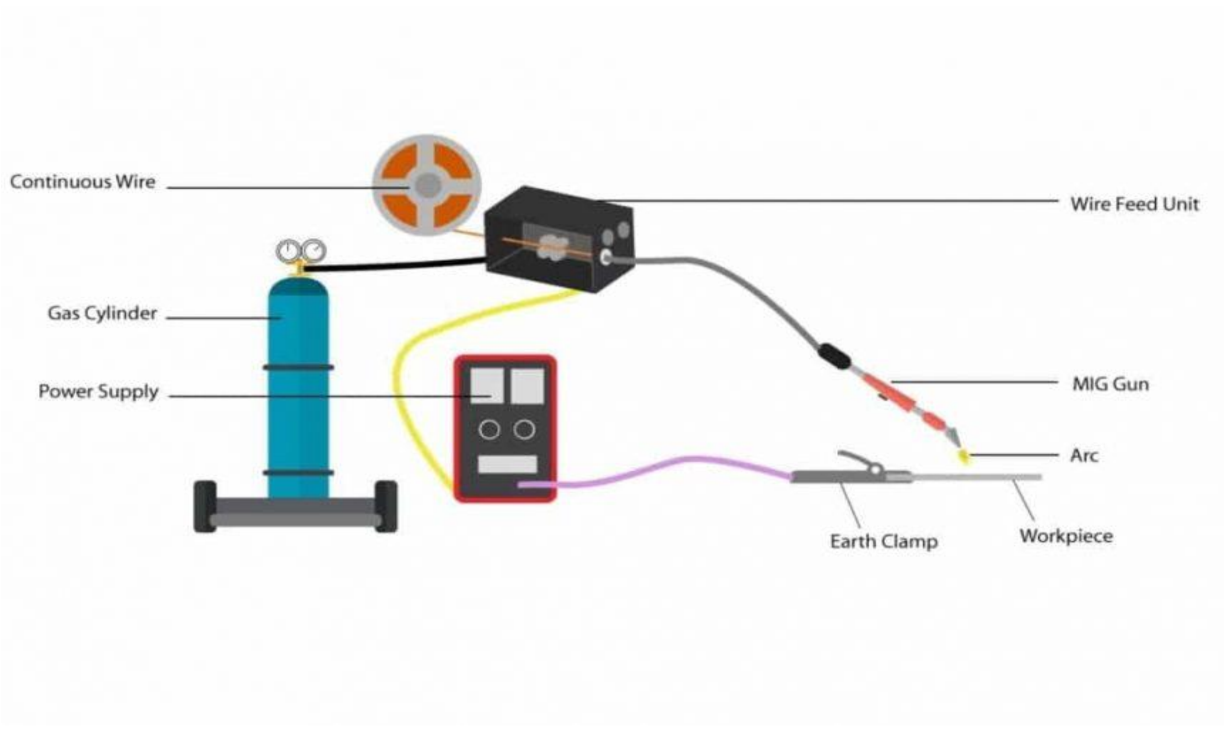


Figure 1.5 Mig Welder Works

- The clamp is hooked up to the work piece to be joined. The welding gun is brought near the work piece and as the trigger is pressed, the arc is produced on the tip of the welding gun. The arc produced melts the electrode twine and it gets deposited in between the two metal pieces to be joined and form a slag unfastened weld.
- A shielding gasoline additionally starts off evolved to unfold because the arc is produced. It protects the weld from reacting with atmospheric air and stops weld from contamination.
- The weld fashioned in Gas Metal Arc Welding is loose from slag. It is an easy and efficient system.
- This is the working of the GMAW or MIG welding procedure.

Metal Inert Gas (MIG) welding become first patented in the USA in 1949 for welding aluminium. The arc and weld pool formed using a naked twine electrode become blanketed via helium gasoline, without problems to be had at that point. From about 1952, the technique became popular in the UK for welding aluminium the usage of argon because the defensive gasoline, and for carbon steels using CO_2. CO_2 and argon-CO_2 combinations are called metallic energetic fuel (MAG) procedures. MIG is an appealing alternative to MMA, supplying excessive deposition costs and excessive productivity.

Gas metallic arc welding (GMAW), now and again referred to by using its subtypes, metallic inert gasoline (MIG) welding or metallic lively fuel (MAG) welding, is a semi-computerized or computerized arc welding technique in which a non-stop and consumable cord electrode and a protecting gas are fed thru a welding gun.

A constant voltage, direct contemporary power source is most normally used with GMAW, however constant present day systems, as well as alternating present day, can be used.

There are 4 primary methods of steel switch in GMAW:

- Globular
- Short-circuiting
- Spray
- Pulsed-spray
- Each of which has wonderful properties and corresponding benefits and barriers.
- Shielding is obtained from an externally furnished gas or gas combination.

Figure 1.6 Shielding Is Obtained From an Externally Supplied Gas or Gas Mixture

1.6 HISTORY

Originally developed for welding aluminum and other non-ferrous substances in the Forties, GMAW become quickly implemented to steels as it allowed for lower welding time as compared to different welding procedures.

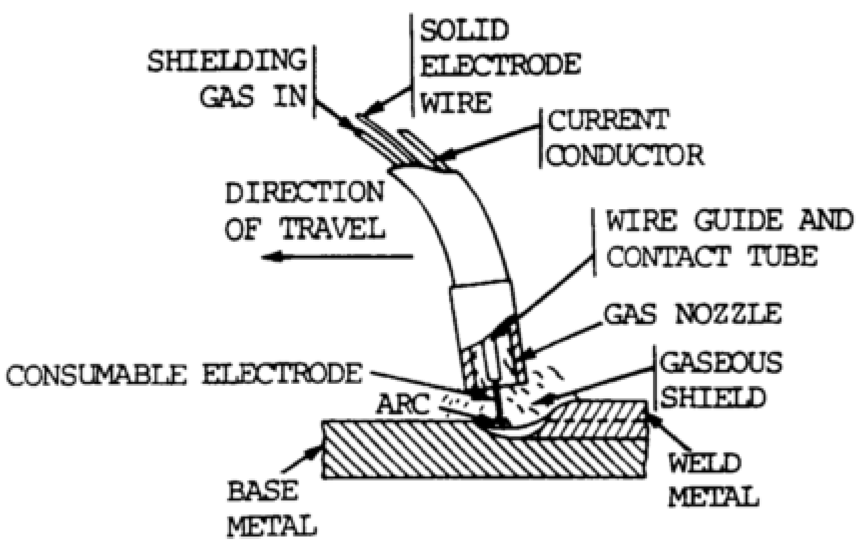


Figure 10-44. Gas metal arc welding process.

Figure 1.7 Gmaw

The cost of inert gasoline confined its use in steels till numerous years later, whilst using semi-inert gases which include carbon dioxide became commonplace.

1.7 MIG WELDING BASICS

MIG welding is operated in semiautomatic, gadget, and automated modes. It is applied in particular in high production welding operations.

All commercially critical metals which includes carbon metallic, stainless-steel, aluminum, and copper can be welded with this manner in all positions by using choosing the suitable shielding gasoline, electrode, and welding conditions.

Gas steel arc welding equipment includes a welding gun, a energy supply, a shielding gas supply, and a wire-drive device that draws the twine electrode from a spool and pushes it through a welding gun.

A supply of cooling water can be required for the welding gun.

In passing thru the gun, the wire will become energized by using contact with a copper touch tube, which transfers cutting-edge from a strength source to the arc.

While easy in precept, a system of accurate controls is hired to provoke and terminate the shielding fuel and cooling water, operate the welding contractor, and manage electrode feed speed as required.

The fundamental features of MIG welding device are

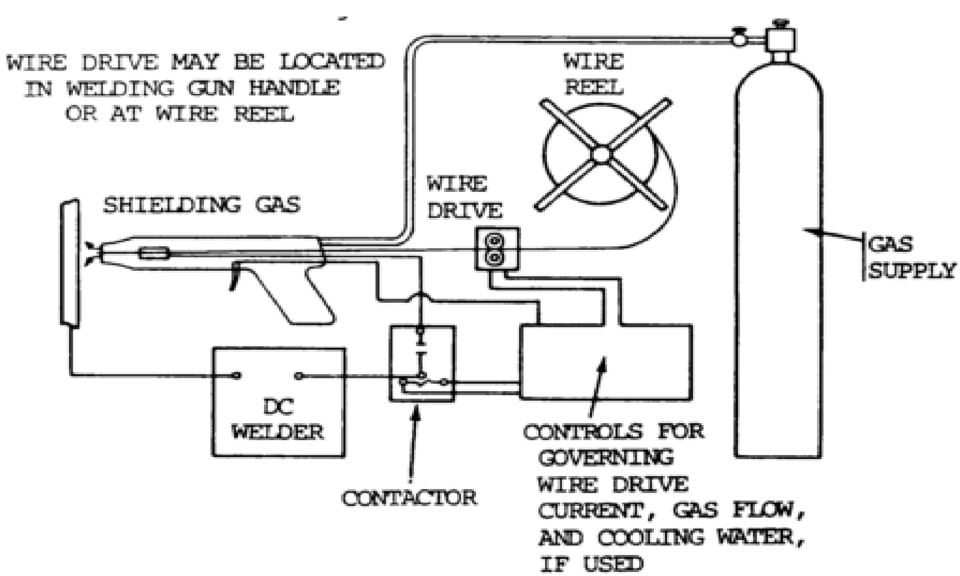


Figure 10-45. MIG welding process.

Figure 1.8 The Fundamental Features of Mig Welding Device

The MIG process is used for semiautomatic, gadget, and automatic welding. Semiautomatic MIG welding is often referred to as guide welding.

Developments all through the Fifties and 1960s gave the manner greater versatility and as a result, it became a extraordinarily used industrial procedure.

Today with the a number of the pleasant MIG machines round, GMAW is usually used in industries together with the auto enterprise, wherein it's far desired for its versatility and velocity.

Unlike welding procedures that don't appoint a defensive gasoline, which include shielded steel arc welding, it is rarely used exterior or in different regions of air volatility.

A related Mig system, flux cored arc welding, regularly does now not make use of a defensive gas, alternatively using a hole electrode wire that is filled with flux at the internal.

Two sorts of energy resources are used for MIG welding: consistent present day and consistent voltage.

- **Constant Current Power Supply**

With this type, the welding present day is installed by way of the ideal placing on the energy supply.

Arc length (voltage) is managed by means of the automatic adjustment of the electrode feed price.

This type of welding is first-rate proper to large diameter electrodes and device or automated welding, in which very fast exchange of electrode feed price is not required.

Most consistent contemporary power resources have a drooping volt-ampere output feature.

However, genuine regular current machines are available.

Constant modern strength assets aren't generally decided on for MIG welding because of the control wished for electrode feed pace. The structures aren't self-regulating.

- **Constant Voltage Power Supply**

The arc voltage is installed with the aid of setting the output voltage at the strength deliver.

The electricity supply will deliver the important amperage to soften the welding electrode at the price required to keep the present voltage or relative arc duration.

The speed of the electrode pressure is used to manipulate the common welding contemporary.

This function is typically desired for the welding of all metals.

The use of this type of power supply in conjunction with a regular cord electrode feed results in a self-correcting arc duration device.

Motor generator or dc rectifier power assets of either type may be used.

With a pulsed direct present day power deliver, the power source pulses the dc output from a low background value to a excessive height price.

Because the common power is lower, pulsed welding modern may be used to weld thinner sections than those which can be sensible with consistent dc spray transfer.

1.8 MANUAL AND AUTOMATIC WELDING GUNS

Welding weapons for MIG welding are to be had for guide manipulation (semiautomatic welding) and for gadget or automatic welding.

Because the electrode is fed constantly, a welding gun should have a sliding electric contact to transmit the welding cutting-edge to the electrode.

The guns have to also have a fuel passage and a nozzle to direct the protective fuel around the arc and the molten weld pool.

Cooling is needed to get rid of the warmth generated within the gun and radiated from the welding arc and the molten weld metallic.

Shielding fuel, inner circulating water, or each, is used for cooling.

An electrical transfer is needed to begin and stop the welding present day; the electrode feed system, and protecting gasoline flow.

1.9 SEMIAUTOMATIC MIG WELDING GUNS

Semiautomatic, hand-held weapons are generally much like a pistol in form.

Sometimes they're fashioned just like an oxyacetylene torch, with electrode wire fed through the barrel or handle.

In some versions of the pistol layout, wherein the most cooling is necessary, water is directed thru passages within the gun to cool both the touch tube and the steel protective gas nozzle.

The curved gun makes use of a curved current-wearing frame at the front stop, thru which the protective gasoline is added to the nozzle.

This sort of gun is designed for small diameter wires and is flexible and manoeuvrable.

It is applicable for welding in tight, difficult to reach corners and different constrained locations. Guns are ready with steel nozzles of various internal diameters to make certain ok gas protective.

The orifice typically varies from approximately 3/8 to 7/8 in. (10 to 22 mm), depending upon welding requirements.

The nozzles are commonly threaded to make alternative easier. They can effortlessly be removed with a couple of welding pliers.

The conventional pistol kind holder is also used for arc spot welding programs in which filler metallic is needed.

The heavy nozzle of the holder is slotted to exhaust the gases away from the spot.

The pistol grips cope with lets in clean guide loading of the holder towards the work.

The welding manipulate is designed to adjust the go with the flow of cooling water and the supply of shielding gas.

It is also designed to prevent the twine freezing to the weld through timing the weld over a preset c program language period.

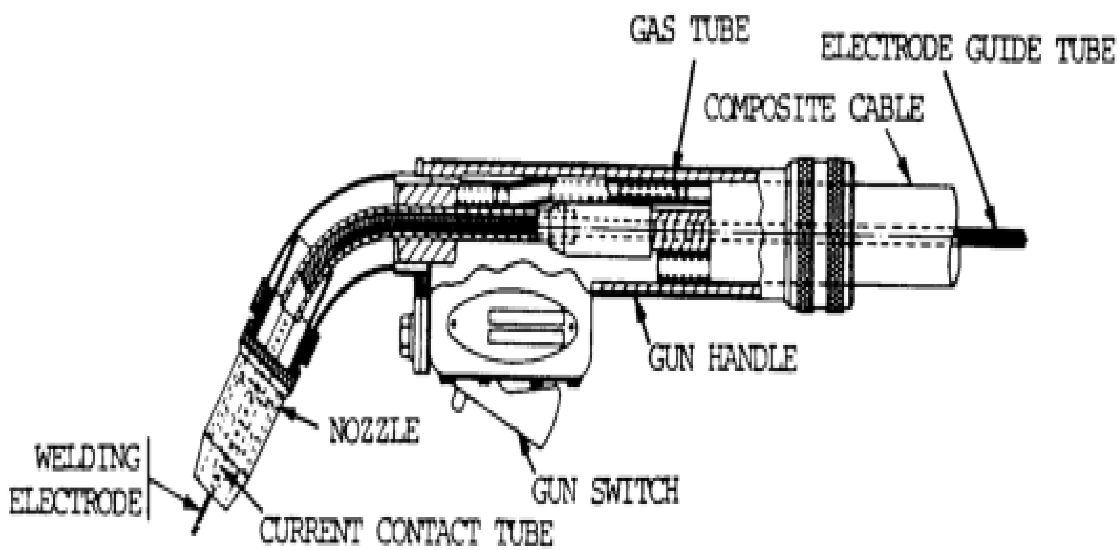


Figure 10-46. Typical semiautomatic gas-cooled, curved-neck gas metal arc welding gun.

Figure 1.9 A Typical Semiautomatic Gasoline-Cooled Gun

1.9.1 AIR COOLED GUNS

Air-cooled guns are available for programs where water is not conveniently obtainable as a cooling medium. These guns are available for carrier up to 600 amperes, intermittent responsibility, with carbon dioxide defensive gas. However, they're typically limited to 2 hundred amperes with argon or helium protecting. The holder is usually pistol-like and its operation is much like the water-cooled kind. Three preferred types of air-cooled guns are available.

1. A gun that has the electrode cord fed to it via a flexible conduit from a remote wire feeding mechanism. The conduit is commonly in the 12 toes (3.7 m) period variety due to the cord feeding barriers of a push-type gadget. Steel wires of 7/20 to 15/16 in. (8.Nine to 23.Eight mm) diameter and aluminum wires of 3/sixty four to 1/8 in. (1.19 to a few.18 mm) diameter may be fed with this association.

2. A gun that has a self-contained twine feed mechanism and electrode cord deliver. The cord deliver is typically in the form of a four in. (102 mm) diameter, 1 to two- 1/2 lb (0.Forty five to one.1 kg) spools. This type of gun employs a pull-kind cord feed device, and it isn't constrained by way of a 12 feet (three.7 m) flexible conduit. Wire diameters of three/10 to 15/32 in. (7.6 to eleven.9 mm) are typically used with this sort of gun.

3. A pull-kind gun that has the electrode twine fed to it thru a bendy conduit from a remote spool. This carries a self-contained cord feeding mechanism. It also can be utilized in a push-pull type feeding device. The machine lets in the use of bendy conduits in lengths up to 50 feet (15 m) or more from the far flung cord feeder. Aluminum and steel electrodes with diameters of three/10 to five/8 in. (7.6 to 15.9 mm) can be used with these sorts of feed mechanisms.

1.9.2 WATER-COOLED GUNS

Water-cooled weapons for guide MIG welding similar to gas-cooled sorts with the addition of water cooling ducts. The ducts circulate water around the touch tube and the gas nozzle. Water cooling permits the gun to function constantly at rated capability and at lower temperatures

Water-coded weapons are used for packages requiring 200 to 750 amperes. The water in and out traces to the gun upload weight and reduce manoeuvrability of the gun for welding.

- **Air vs. Water Cooled Welding Guns**

The selection of air- or water-cooled weapons is based at the kind of shielding gas, welding cutting-edge variety, materials; weld joint layout, and existing store practice. Air-cooled guns are heavier than water-cooled guns of the same welding current capacity. However, air-cooled weapons are less difficult to manipulate to weld out-of-function and in restricted areas.

1.10 METAL TRANSFER

Filler metallic may be transferred from the electrode to the work in methods: whilst the electrode contacts the molten weld pool, thereby establishing a short circuit, which is referred to as short circuiting switch (quick circuiting arc welding); and while discrete drops are moved across the arc gap under the have an effect on of gravity or electromagnetic forces. Drop switch can be either globular or spray kind.

Shape, length, path of drops (axial or non-axial), and sort of switch are decided through a number of things.

The elements having the maximum affect are:

1. Magnitude and form of welding modern.

2. Current density.

3. Electrode composition.

4. Electrode extension.

5. Shielding gas.

6. Power supply traits.

7. Axially directed transfer refers to the movement of drops alongside a line that is a continuation of the longitudinal axis of the electrode. Non-axially directed transfer refers to motion in another course.

- **SHORT CIRCUITING TRANSFER**

Short-circuiting arc welding uses the lowest range of welding currents and electrode diameters associated with MIG welding.

This kind of transfer produces a small, speedy-freezing weld pool that is generally appropriate for the joining of thin sections, out-of-role welding, and filling of huge root openings.

When weld warmth enter is extraordinarily low, plate distortion is small. Metal is transferred from the electrode to the work simplest at some point of aduration whilst the electrode is in contact with the weld pool. There is no steel switch across the arc hole.

The electrode contacts the molten weld pool at a consistent fee in a variety of 20 to over 200 instances each 2nd. As the wire touches the weld metal, the current will increase. It might hold to growth if an arc did not shape. The fee of contemporary growth must be high sufficient to maintain a molten electrode tip until filler steel is transferred. It must no longer arise so fast that it reasons spatter by using disintegration of the moving drop of filler metal. The fee of modern increase is managed by way of adjustment of the inductance in the energy supply. The fee of inductance required relies upon on both the electric resistance of the welding circuit and the temperature variety of electrode melting. The open-circuit voltage of the strength supply ought to be low sufficient in order that an arc cannot maintain underneath the present welding situations. A part of the electricity for arc preservation is furnished by means of the inductive storage of power during the length of quick-circuiting.

As steel transfer best happens throughout short-circuiting, defensive gas has very little effect on this sort of transfer. Spatter can arise. It is normally induced either by gasoline evolution or electromagnetic forces on the molten tip of the electrode.

- **GLOBULAR TRANSFER**

With a superb electrode (dcrp), globular switch takes vicinity whilst the contemporary density is incredibly low, irrespective of the kind of protecting fuel. However, carbon dioxide (CO2) protecting yields this kind of switch in any respect usable welding currents. Globular switch is characterized by way of a drop length of more diameter than that of the electrode.

Globular, axially directed transfer may be finished in a significantly inert gas protect without spatter. The arc duration need to be lengthy enough to guarantee detachment of the drop before it contacts the molten steel. However, the ensuing weld is probable to be unacceptable due to lack of fusion, insufficient penetration, and excessive reinforcement.

Carbon dioxide protecting constantly yields non axially directed globular switch. This is because of an electromagnetic repulsive pressure appearing upon the lowest of the molten drops. Flow of electric present day thru the electrode generates numerous forces that act at the molten tip. The maximum essential of those are pinch pressure and anode reaction pressure. The value of the pinch pressure is a direct feature of welding modern-day and twine diameter, and is normally responsible for drop detachment. With CO2 protective, the cord electrode is melted by using the arc warmth conducted through the molten drop. The electrode tip isn't enveloped by using the arc plasma. The molten drop grows until it detaches through short circuiting or gravity.

➢ SPRAY TRANSFER

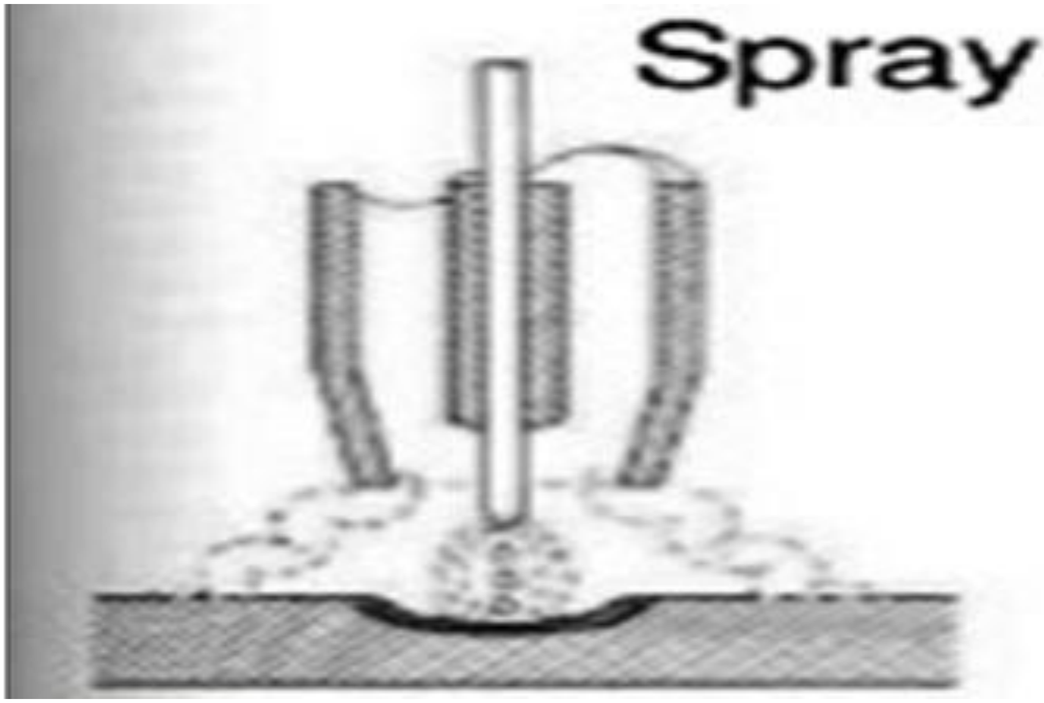


Figure 1.10 Spray Arc Transfer

In a fuel shield of at least eighty percent argon or helium, filler steel transfer changes from globular to spray type as welding current increases for a given size electrode. For all metals, the alternate takes vicinity at a cutting-edge fee called the globular-to-spray transition present day.

Spray kind switch has an average exceptional arc column and pointed wire tip associated with it. Molten filler metallic transfers across the arc as first-rate droplets. The droplet diameter is identical to or less than the electrode diameter. The steel spray is axially directed. The reduction in droplet size is likewise accompanied through an boom in the price of droplet detachment, as illustrated in discern 10-forty seven. Metal switch rate might also range from less than a hundred to numerous hundred droplets per 2d because the electrode feed rate will increase from approximately one hundred to 800 in./min (forty two to 339 mm/s)

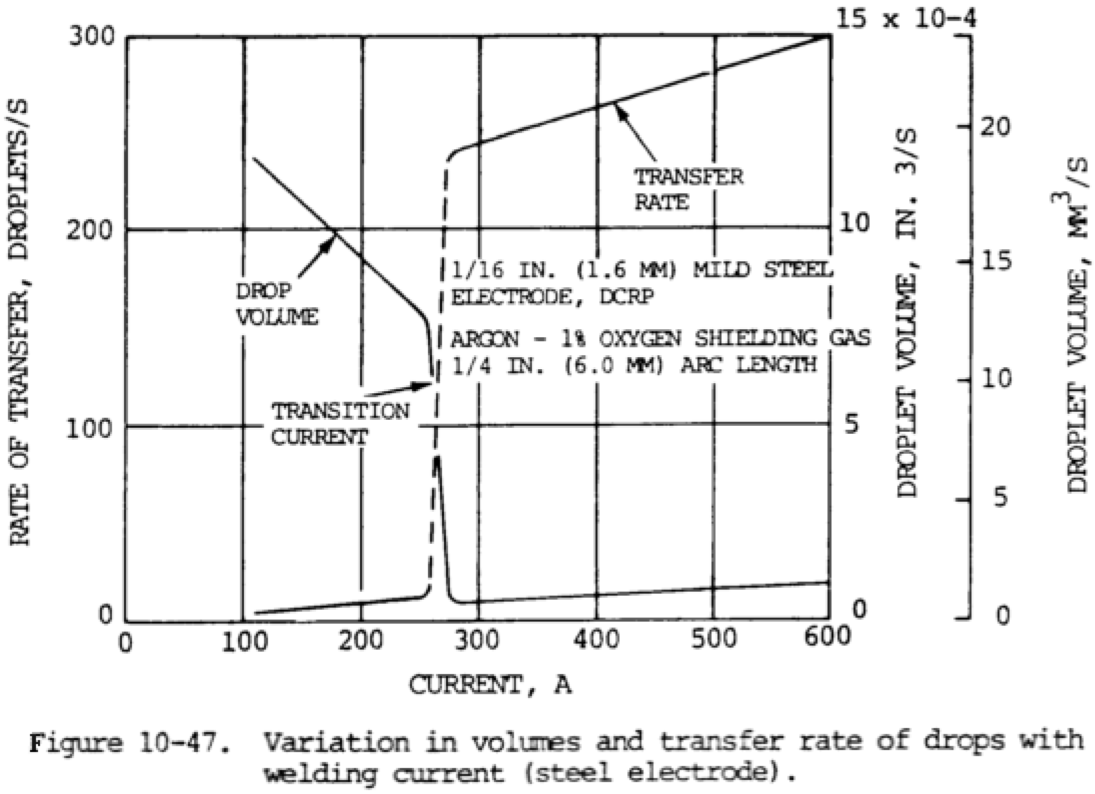


Figure 1.11 Variations in Volumes and Transfer Rate of Dropa with Welding Current (Steel Electrode)

1.11 MIG WELDING PROCEDURES

- The welding procedures for MIG welding are just like those for other arc welding methods.
- Adequate fixturing and clamping of the paintings are required with adequate accessibility for the welding gun.
- Fixturing ought to preserve the work inflexible to limit distortion from welding. It ought to be designed for clean loading and unloading.
- Good connection of the paintings lead (ground) to the workpiece or fixturing is needed. Location of the relationship is important, mainly whilst welding ferromagnetic materials inclusive of metal.
- The best route of welding is far from the paintings lead connection.
- The function of the electrode with admire to the weld joint is important so that you can achieve the desired joint penetration, fusion, and weld bead geometry.
- Electrode positions for automated MIG welding are just like the ones used with submerged arc welding.
- When entire joint penetration is required, a few technique of weld backing will assist to manipulate it.
- A backing strip, backing weld, or copper backing bar can be used.

- Backing strips and backing welds typically are left in vicinity. Copper backing bars are detachable.
- The assembly of the welding gadget should be accomplished consistent with the producer's directions.
- All gasoline and water connections have to be tight; there have to be no leaks.
- Aspiration of water or air into the protective gasoline will result in erractic arc operation and infection of the weld
- Porosity might also arise.
- The gun nozzle size and the shielding gas flow price should be set in line with the advocated welding manner for the material and joint layout to be welded.
- Joint designs that require lengthy nozzle-to-paintings distances will want better gas flow costs than those used with ordinary nozzle-to-paintings distances.
- The gas nozzle ought to be of ok size to provide precise gasoline insurance of the weld vicinity.
- When welding is performed in constrained areas or in the root of thick weld joints, small-length nozzles are used.
- The gun touch tube and electrode feed power rolls are selected for the particular electrode composition and diameter, as designated with the aid of the system producer.
- The contact tube will wear with usage and ought to be replaced periodically if proper electric contact with the electrode is to be maintained and heating of the gun is to be minimized.
- Electrode extension is about by way of the space between the tip of the touch tube and the gasoline nozzle beginning.
- The extension used is related to the form of MIG welding, brief-circuiting or spray kind switch.
- It is crucial to preserve the electrode extension (nozzle-to-paintings distance) as uniform as possible all through welding. Therefore, depending on the software, the contact tube may be inner, flush with, or extending beyond the gas nozzle.
- The electrode feed fee and welding voltage are set to the encouraged values for the electrode length and fabric.
- With a regular voltage strength source, the welding contemporary might be established with the aid of the electrode feed rate.
- A trial bead weld need to be made to set up proper voltage (arc period) and feed rate values.
- Other variables, consisting of slope manipulate, inductance, or each, have to be adjusted to present good arc starting and smooth arc operation with minimum spatter.
- The ideal settings will rely on the system layout and controls, electrode material and size, protective fuel, weld joint layout, base metallic composition and thickness, welding position, and welding speed.

1.12 ADVANTAGES AND DISADVANTAGES

1.12.1Advantages of MIG Welding

- The primary benefit of gasoline metal-arc welding is that first-rate welds may be produced plenty faster than with SMAW or TIG welding.
- Since a flux isn't always used, there may be no hazard for the entrapment of slag within the weld metal.
- The gasoline shield protects the arc in order that there is little or no loss of alloying factors because the metal transfers across the arc. Only minor weld spatter is produced, and it's far without problems eliminated.
- This process is flexible and can be used with a wide style of metals and alloys, consisting of aluminum, copper, magnesium, nickel, and a lot of their alloys, as well as iron and most of its alloys. The system may be operated in several ways, such as semi- and completely automated. MIG welding is extensively utilized by many industries for welding a huge style of materials, components, and systems.

1.12.2 Disadvantages of MIG Welding

- The most important downside of this method is that it cannot be used in the vertical or overhead welding positions due to the high warmness enter and the fluidity of the weld puddle.
- The device is complicated in comparison to gadget used for the shielded steel-arc welding process.
- Arc Power and Polarity
- The huge majority of MIG welding programs require using direct modern-day opposite polarity (electrode advantageous).
- This form of electrical connection yields a strong arc, smooth metal transfer, particularly low spatter loss, and correct weld bead traits for the entire variety of welding currents used.
- Direct current straight polarity (electrode terrible) is seldom used, for the reason that arc can turn out to be volatile and erratic despite the fact that the electrode melting rate is better than that performed with dcrp (electrode high-quality).
- When hired, dcrp (electrode bad) is used in conjunction with a “buried” arc or brief-circuiting steel transfer. Penetration is lower with instantly polarity than with opposite polarity direct current.
- Alternating cutting-edge has observed no industrial reputation with the MIG welding procedure for two reasons: the arc is extinguished at some stage in each half cycle as the current reduces to 0, and it is able to no longer reignite if the cathode cools sufficiently; and rectification of the reverse polarity cycle promotes the erratic arc operation.

CHAPTER 2

LITERATURE REVIEW

Among all the welding process thee chief advantage the using gas metal arc welding for surfacing are highly reliable all robotic system MIG welding with its all position capabilities GMAW has been employed on MIG welding has been studies inspiration and simulation of the finding by the previous researcher are offer and discussed in this chapter.

Lots of studies have been well demented giving deep knowledge and insight on welding technology.

Nur Azhani Abd Razak et al. [1] through their exploration introduced the erosion conduct of low carbon steel while MIG welding at different welding voltages and filler materials. Butt joints were made on the examples materials considered for the examination were ER 304L and ER 70S-6 with 5 mm width.

Rakesh Kumar et al. [2] Investigation of mechanical property in mild steel utilizing metal idle gas welding. The point of the A), root hole on the mechanical property amid the Metal Inert Gas the more prominent effect on the hardness of the weld-pool and circular arc voltage (v). Through their examination found that greatest hardness was seen at a welding current of 180 amp, circular segment voltage of 40 volt and root hole of 3 mm.

S.Utkarsh et al. [3] in their examination considered the impact of information parameter, for example, gas stream rate in l/min, welding current(A), voltage(V) and welding speed in mm/sec in order to ponder the "Ultimate Tensile Strength"(UTS) of 'ST—37' low amalgam mild steel materials in MIG Welding (GMAW). Tests were done by utilizing L9 orthogonal cluster.

Yugang Miao et al.[4] Impact of Heat Input on Microstructural and Mechanical Property of weld-Joints Made by Bypass-Current Welding-Brazing of Magnesium Alloy to coated-Galvanized Steel.

Chandresh N. Patel et al. [6] in the researchs of plan of trial strategies received the dark social examination (GRA) execution measure was hardness. Another examination conveyed by.

2.1 INTRODUCTION

This chapter provides the detail description literature review done according to the title of –MIG Welding of Dissimilar Metal‖. The aim of this project is to investigate the weld joint's quality and defects of steel and aluminum, as well as the type of groove and feed speed. This literature review will give an overview and a brief introduction of the techniques that are suitable to be used to achieve all the objectives.

2.2 WELDING

Welding process is a type of consolidation process to facilitate joining or assembly. It is a permanent joining of two materials, usually metals, by coalescence. It is introduced by a combination of temperature, pressure and metallurgical condition. (Kalpakjian, 2007)

2.2.1 TYPE OF WELDING

There are two major categories of welding which is fusion welding and alsosolid state welding as shown in Figure 2.1. The definitions of this two major type of welding are:

- **Fusion welding** - coalescence is accomplished by melting the two parts to be joined, in some cases adding filler metal to the joint. Some of the examples are arc welding, resistance spot welding and oxyfuel gas welding.

- **Solid state welding** - heat and/or pressure are used to achieve coalescence, but no melting of the base metals occurs and no filler metal is added. Some examples are forge welding, diffusion welding and friction welding.

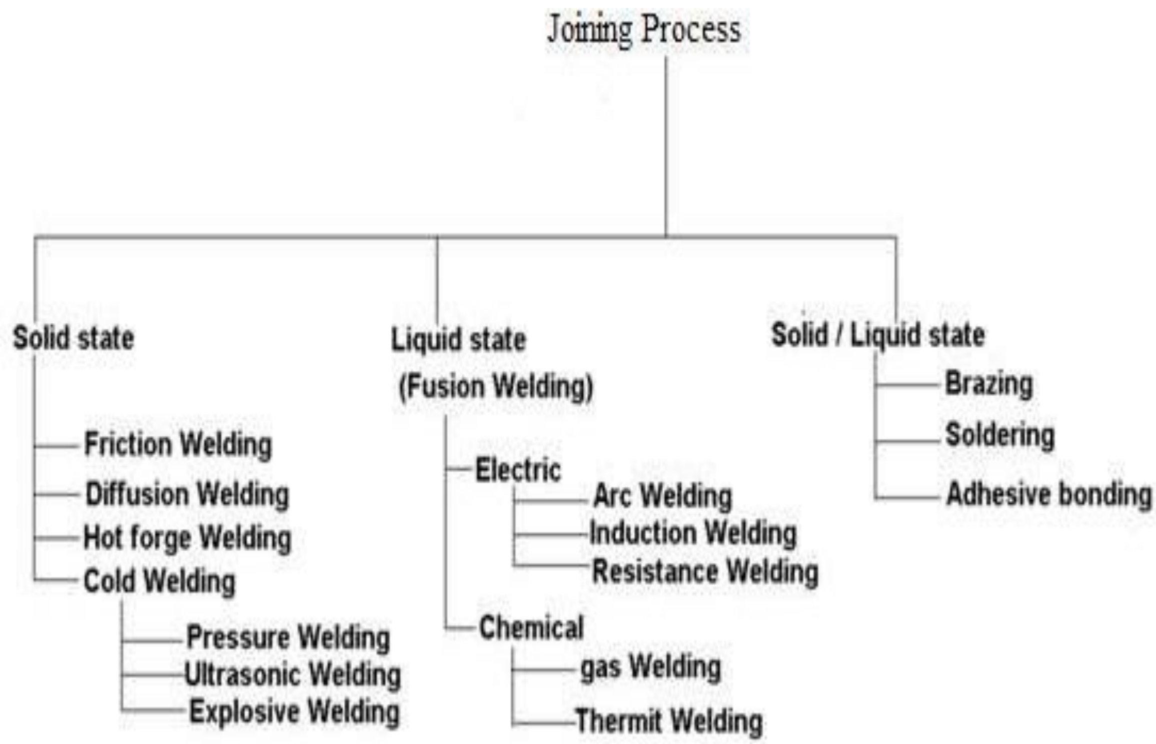


Figure 2.1: Type of Joining (Welding) Processes

Source: Kalpakjian, 2007

2.3 MIG WELDING

MIG welding is a welding process where an electrode wire is continuously fed from an automatic wire feeder through a conduit and welding gun to the base metal, where a weld pool is created. There are two type of MIG welding which is semi- automatic and fully automated. If a welder is controlling the direction of travel and travel speed the process is considered semi-automatic. The process is fully automated when machine control direction of travel and travel speed. (Derek Pritchard, 2001).

In this project, we are focusing on using MIG welding as method use in joining process. It is chosen because:

- It is compatible with all commercial metals.
- Welding can be performed in all positions.
- Manipulation skills are easily learnt and mastered by apprentices.
- It is still practical for using MIG welding in Malaysia.

MIG welding use heat as it power source. More processes use this source than any other source, primarily because heat for fusion can be effectively generated, concentrated, and controlled (Robert W. Messler, Jr. 2004). Figure 2.2 below shows the schematic diagram of the MIG welding.

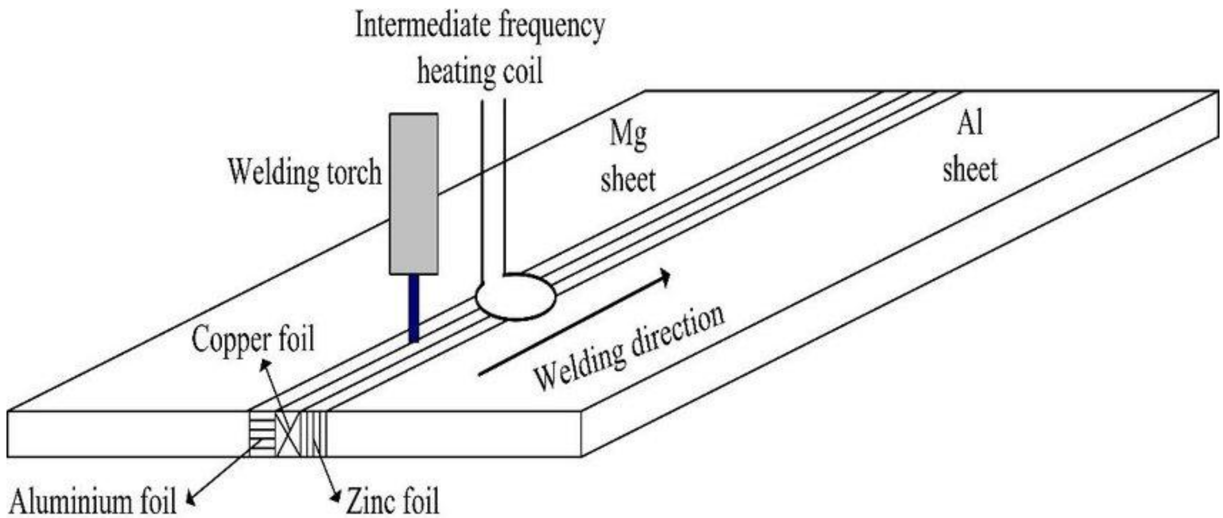


Figure 2.2: Schematic of MIG welding
Source: Serope Kalpakjian, 2007

2.3.1 WELD AREA

Typical fusion weld joint in which filler metal has been added consists of fusion zone, weld interface, and heat affected zone and unaffected base metal zone (Kalpakjian, 2007). These entire zones in weld area are shown in Figure 2.3.1below.

Heat affected zone (HAZ) is where the area experienced temperatures below melting point, but high enough to cause micro structural changes in the solid metal. Chemical composition still same as base metal, but this region has been heat treated so that its properties and structure have been altered (Kalpakjian, 2007).

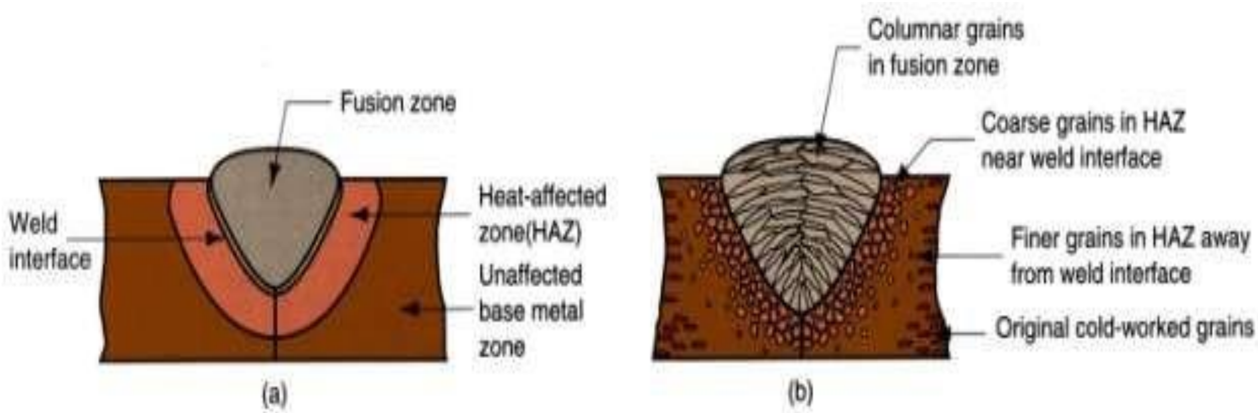


Figure 2.3: Cross Section of a Typical Fusion Welded Joint:

(A) Principal Zones in the Joint, And (B) Typical Grain Structure

Source: Kalpakjian, 2007

2.3.2 TAILOR WELDED BLANKS (TWB)

One of the recent methods used to weld two different type materials together is tailor welded blanks. By using this process, it is possible to produce a finished part with varying material properties, leading to component optimization. Mash seam, high frequency butt, friction, laser welding process and also MIG welding which is used in the project can also be used for welding tailored blanks (Brad Kinsey, 2001).

The potential of tailor welded blanks was soon recognized by the steel industry and was addressed in the collaborative Ultra-Light Steel Auto Body project, which was to become known as ULSAB project. Porsche engineering services in conjunction with 35 steel companies worldwide produced a vehicle design which more than half to the body in white was to be made from tailor welded blanks. Figure 2.4 illustrated how multi-material blanks were use to fabricate many components that make up the body in white, ranging from the large floor pan, which is a simple assembly of three trapezoidal sections, to the more complex five-piece side section utilizing multi-material and pre- cut holes.(Brad L. Kinsey, 2003).

Sheet steel is used widely for the manufacture of products in the electrical goods, packaging and construction markets and a number of these may benefit from the application of tailored blanks. In fact, any product that requires change in material properties within sheet steel components could be improved by the use of tailoredblanks (Brad L. Kinsey, 2003).

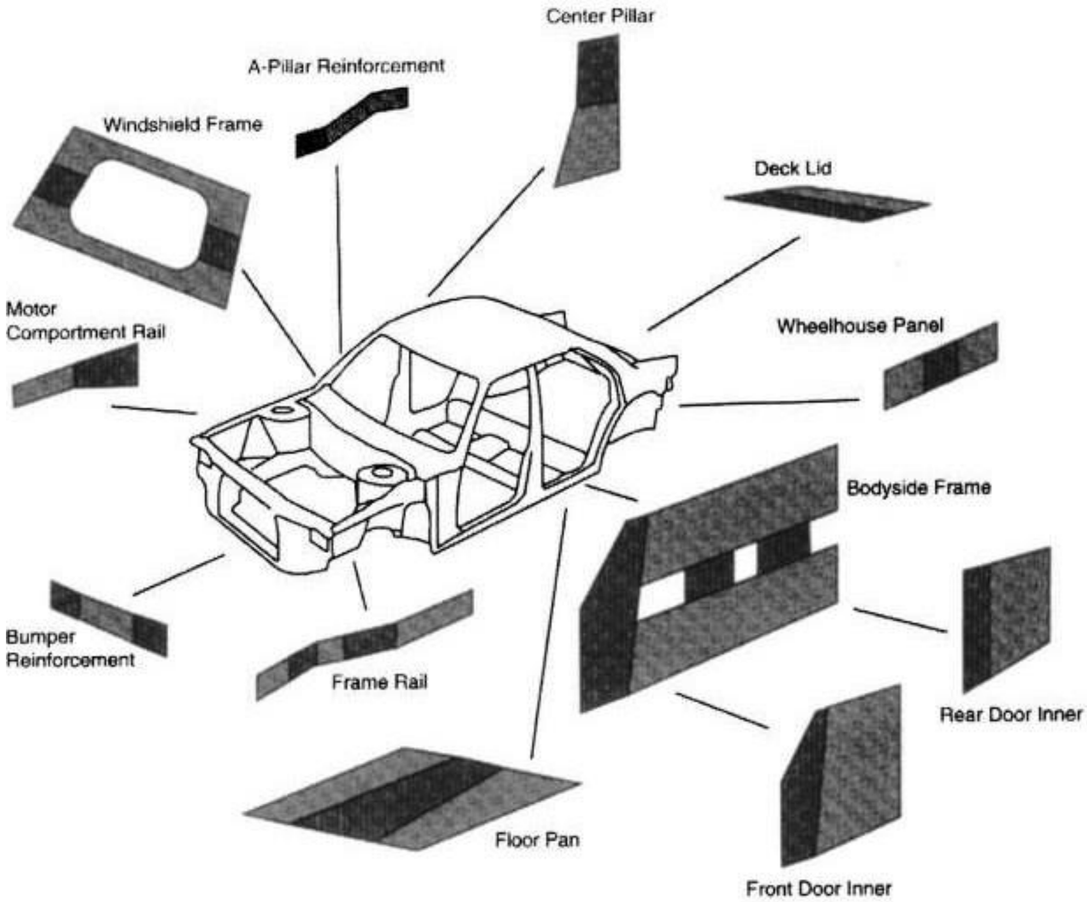


Figure 2.4: Exploded view of current and/or potential automotive TWB applications

Source: Brad L. Kinsey, 2003

2.4 MATERIAL AND WELDABILITY

Weldability is a term used to describe the relative ease or difficulty with which a metal or alloy can be welded. The better the weldability, the easier it is to weld. However, weldability is a complicated property, as it encompasses the metallurgical compability of the metal alloy with a specific welding process.

2.4.1 CARBON STEEL (AISI1044)

Carbon steels are a category of steel containing 0.12 to 2% carbon. When the percentage of carbon content increases, hardness and strength of these steels increase with heat treatment, but lose a little amount of their ductility.

AISI 1044 carbon steel is medium-carbon steel that can be heat treated, flame or induction hardened. It is recommended that carburizing or cyaniding be avoided.

- **CHEMICAL COMPOSITION**

The chemical composition of AISI 1044 carbon steel is outlined in the following table.

Element	Content (%)
Carbon, C	0.43-0.50
Manganese, Mn	0.30-0.60
Sulphur, S	0.05 (max)
Phosphorous, P	0.04 (max)
Iron, Fe	Balance

- **PHYSICAL PROPERTIES**

The physical properties of AISI 1044 carbon steel are tabulated below**.**

Properties	Metric	Imperial
Density	7.85 g/cm3	0.284 lb/in3

- **MECHANICAL PROPERTIES**

The following table shows mechanical properties of cold rolled AISI 1044 carbon steel.

Properties	Metric	Imperial
Tensile strength	550 MPa	79800 psi
Yield strength	310 MPa	45000 psi
Modulus of elasticity	205 GPa	29700 ksi
Shear modulus (typical for steel)	80 GPa	11600 ksi
Poisson's ratio	0.29	0.29
Elongation at break (in 50 mm)	16%	16%
Hardness, Brinell	163	163

Hardness, Knoop		
(converted from Brinell hardness)	184	184
Hardness, Rockwell		
(converted from Brinell hardness)	84	84
Hardness, Vickers		
(converted from Brinell hardness)	170	170

- **THERMAL PROPERTIES**

The thermal properties of cold rolled AISI 1044 carbon steel are given in the following table.

Properties	Metric	Imperial
Thermal conductivity	49.8 W/mK	346 BTU in/hr.ft2.°F
Thermal expansion coefficient		
(at 0.000-100°C/32-212°F)	11.5 µm/m°C	6.39 µm/m°C

- **OTHER DESIGNATIONS**

Other designations that are equivalent to AISI 1044 carbon steel include the following.

ASTM A29	ASTM A510	ASTM A575	ASTM A576
SAE J403	SAE J412	SAE J414**A**	

2.4.2 MILD STEEL (1018)

Steels are commonly weldable, but there are many types of steel where special Welding-steel procedures must be implemented to perform acceptable welds. Welding- steel concerned with the weldability of various kinds of this material. Low carbon steels, having less than 0.25% carbon, display good weldability, meaning it can easily weld by using any arc, gas and resistance welding (Kalpakjian and Schmid, 2006).

There are many different categories of steel, and carbon steels are one such category that contains 0.12 to 2% carbon in them. The steel gains hardness and strength with heat treatment when the carbon percentage content increases; however its ductility is reduced.

AISI 1018 carbon steel is a free machining grade that is the most commonly available grade around the world. Although its mechanical properties are not very unique, it still can be easily formed, machined, welded and fabricated

- **CHEMICAL COMPOSITION**

The chemical composition of AISI 1018 carbon steel is outlined in the following table.

Element	Content (%)
Manganese, Mn	0.60-0.90
Carbon, C	0.15-0.20
Sulphur, S	0.05 (max)
Phosphorous, P	0.04 (max)
Iron, Fe	Balance

- **PHYSICAL PROPERTIES**

The physical properties of AISI 1018 carbon steel are tabulated below.

Properties	Metric	Imperial
Density	7.87 g/cm3	0.284 lb/in3

- **MECHANICAL PROPERTIES**

The following table shows mechanical properties of cold drawn AISI 1018 carbon steel.

Properties	Metric	Imperial
Tensile strength	440 MPa	63800 psi
Yield strength	370 MPa	53700 psi
Modulus of elasticity	205 GPa	29700 ksi
Shear modulus (typical for steel)	80 GPa	11600 ksi
Poisson's ratio	0.29	0.29
Elongation at break (in 50 mm)	15%	15%
Hardness, Brinell	126	126
Hardness, Knoop		

(converted from Brinell hardness)	145	145
Hardness, Rockwell B		
(Converted from Brinell hardness)	71	71
Hardness, Vickers		
(Converted from Brinell hardness)	131	131
Machinability	70	70

- **THERMAL PROPERTIES**

The thermal properties of AISI 1018 carbon steel are given in the following table.

Properties	**Metric**	**Imperial**
Thermal conductivity	51.9 W/mK	360 BTU in/hr.ft2.°F

- **OTHER DESIGNATIONS**

Other designations that are equivalent to AISI 1018 carbon steel include the following**.**

AMS 5069 ASTM A29 ASTM A512 ASTM A611 (D-1)

ASTM A635

AMS 5069A ASTM A510 ASTM A794 ASTM A519 ASTM A544

ASTM A108 ASTM A513 ASTM A830 ASTM A545ASTM A548

ASTM A549 ASTM A659 SAE J412 SAE J1397 MIL S-11310 (CS 1018)

ASTM A576 SAE J403 SAE J414 MIL J-1397 MIL J-403

MIL J-412

2.5 WELD JOINT

The weld joint is where two or more metal parts are joined by welding. The several basic types of weld joints are the butt, corner, tee, lap, and edge, as shown in Figure 2.5. (Kalpakjian, 2007).

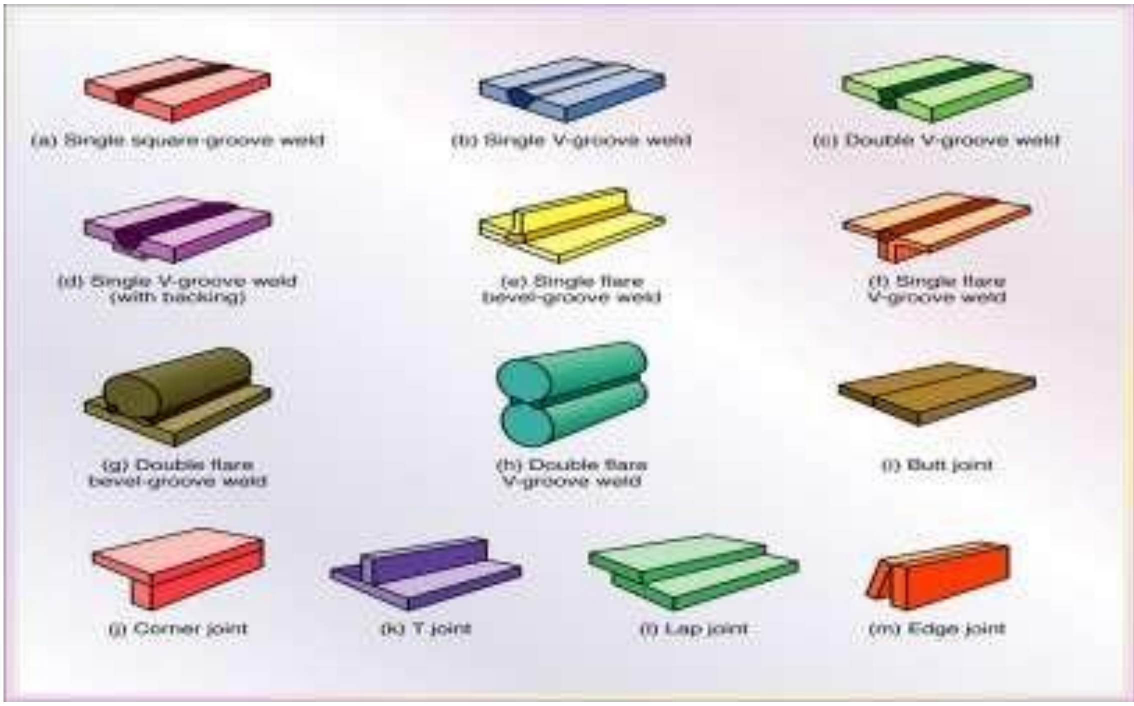


Figure 2.5 The Several Basic Types Of Weld Joints Are The Butt, Corner, Tee, Lap, And Edge

- **SOME COMMON TYPES OF WELDING:**

1. A butt joint is used to join two members aligned in the same plane (Figure 2.5, view a). This joint is frequently used in plate, sheet metal, and pipe work. A joint of this type may be either square or grooved. Some of the variations of this joint are discussed later in this chapter.

2. Corner and tee joints are used to join two members located at right angles to each other (Figure 2.5, view and k). In cross section, the corner joint forms an L-shape, and the tee joint has the shape of the letter *T*. Various joint designs of both types have uses in many types of metal structures.

3. A lap joint, as the name implies, is made by lapping one piece of metal over another (Figure 2.5, view l). This is one of the strongest types of joints available;however, for maximum joint efficiency, you should overlap the metals a minimum of three times

the thickness of the thinnest member you are joining. Lap joints are commonly used with torch brazing and spot welding applications.

4. An edge joint is used to join the edges of two or more members lying in thesame plane. In most cases, one of the members is flanged, as shown in Figure 2.5, view m. While this type of joint has some applications in plate work, it is more frequently used in sheet metal work An edge joint should only be used for joining metals 1/4 inch or less in thickness that are not subjected to heavy loads.

In this project on joining mild steel and carbon using MIG welding, lapjoints were used as the type of weld joint. This type of joint is use because of the high difference in melting temperature of mild steel and carbon. Mild steel were put on top of the carbon so that carbon will not directly contact with the heat source. It is to avoid carbon from melt to fast.

CHAPTER-3

OBJECTIVES

The objectives of this thesis are to:-

- Investigate the effects joining mild steel – carbon steel. With various voltage and feed speed.
- Investigate the weld quality and defects using optical devices.
- Investigate the specimen's mechanical property using mechanical testing machine.

The application of Taguchi and grey relational analysis methodologies in determining optimal process parameters for MIG are presented.

Taguchi method is widely used in designing the optimal experiments, while grey relation analysis is useful in decision making when multiple criteria`s are considered, this combination serves as an effective tool in determining the optimal parameters of the parameters of the process.

In the present work welding current, voltage, speed, were considered as input parameters in joining two dissimilar metals **(AISI1044 & AISI1018),** are these influence the output characteristics like tensile strength and hardness these parameters need to be optimized.

3.1 SCOPES

This project is confined to the following scopes of study:

- Fabricate aluminum-steel tailor welded blanks using MIG welding with various voltages and feed speed.
- Analysed the microstructure and phase composition of the joints using optical microscope.
- Analysed the weld quality and the mechanical property using mechanical testing machine

CHAPTER -4

OPTIMIZATION METHODS

4.1 TAGUCHI METHOD

Every experimenter develops a nominal system/product that has the favoured capability as demanded with the aid of users. Beginning with those nominal processes, he wishes to optimize the processes/merchandise by using varying the control factors at his disposal, such that the results are dependable and repeatable (i.E. Display less versions).

In Taguchi Method, the phrase "optimization" implies "dedication of BEST degrees of manage factors". In turn, the BEST stages of manipulate elements are those that maximize the Signal-to-Noise ratios. The Signal-to-Noise ratios are log features of desired output characteristics. The experiments, which might be conducted to determine the BEST tiers, are based totally on "Orthogonal Arrays", are balanced with appreciate to all manipulate elements and yet are minimum in wide variety. This in flip means that the sources (materials and time) required for the experiments also are minimum.

Taguchi approach divides all troubles into 2 classes - STATIC or DYNAMIC. While the Dynamic problems have a SIGNAL thing, the Static problems do now not have any sign factor. In Static problems, the optimization is performed by means of using three Signal-to-Noise ratios - smaller-the-higher, LARGER-THE-BETTER and nominal-the-fine. In Dynamic issues, the optimization is completed by the use of 2 Signal-to-Noise ratios - Slope and Linearity.

Taguchi Method is a method/product optimization approach this is primarily based on 8-steps of planning, carrying out and evaluating effects of matrix experiments to determine the first-rate ranges of manage elements. The number one goal is to keep the variance within the output very low even in the presence of noise inputs. Thus, the approaches/products are made ROBUST towards all versions.

Every experimenter has to plan and behavior experiments to acquire sufficient and applicable information in order that he can infer the science behind the found phenomenon. He can achieve this by way of.

- **TRIAL-AND-ERROR APPROACH**

Performing a series of experiments each of which gives a few expertise. This requires making measurements after every test so that analysis of determined records will allow him to determine what to do next - "Which parameters have to be various and by way of how much". Many a instances such collection does not progress tons as poor consequences may discourage or will no longer permit a ramification of parameters which ought to be modified within the next test. Therefore, such experimentation typically ends nicely earlier than the variety of experiments reach a double digit! The record is inadequate to draw any sizeable conclusions and the principle trouble (of understanding the technological know-how) nevertheless remains unsolved.

- **DESIGN OF EXPERIMENTS**

A nicely deliberate set of experiments, in which all parameters of hobby are numerous over a detailed range, is a much higher approach to attain systematic statistics. Mathematically speaking, this kind of complete set of experiments ought to deliver favored effects. Usually the range of experiments and sources (substances and time) required are prohibitively big. Often the experimenter decides to carry out a subset of the whole set of experiments to save on time and money! However, it does now not easily lend itself to information of science at the back of the phenomenon. The analysis isn't very clean (though it is able to be clean for the mathematician/statistician) and accordingly results of numerous parameters at the observed facts are not easily apparent. In many instances, especially those wherein some optimization is required, the approach does no longer factor to the BEST settings of parameters. A classic instance illustrating the downside of design of experiments is located in the making plans of an international cup occasion, say football. While all matches are well arranged with recognize to the specific groups and unique venues on exceptional dates and but the planning does now not care approximately the result of any match (win or lose)!!!! Obviously, the sort of method is not acceptable for carrying out clinical experiments (besides for co-ordinating diverse establishments, committees, people, gadget, substances etc.).

Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan has developed a way based on **"ORTHOGONAL ARRAY "** experiments which gives lots reduced " variance " for the test with " most effective settings " of manipulate parameters. Thus the marriage of Design of Experiments with optimization of manipulate parameters to achieve BEST results is performed within the Taguchi Method. "Orthogonal Arrays" (OA) provide a hard and fast of well balanced (minimal) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which can be log capabilities of desired output, function objective capabilities for optimization, help in records analysis and prediction of top of the line outcomes

Taguchi Method treats optimization problems in two categories,

4.1.1 STATIC PROBLEMS:

Generally, a system to be optimized has numerous manage factors which without delay determine the target or preferred price of the output. The optimization then entails determining the satisfactory control thing levels so that the output is at the the goal cost. Such a problem is known as a "STATIC PROBLEM".

This is first-rate defined the usage of a P-Diagram that's shown below ("P" stands for Process or Product). Noise is proven to be gift within the process however must don't have any effect at the output! This is the primary purpose of the Taguchi experiments - to decrease versions in output despite the fact that noise is gift within the manner. The system is then stated to have turned out to be ROBUST.

4.1.2 DYNAMIC PROBLEMS:

If the product to be optimized has a signal input that directly comes to a decision the output, the optimization entails figuring out the high-quality manipulate issue ranges in order that the "enter signal / output" ratio is closest to the favoured relationship. Such a problem is referred to as as a "DYNAMIC PROBLEM".

This is pleasant explained through a P-Diagram that is proven under. Again, the primary goal of the Taguchi experiments - to decrease versions in output despite the fact that noise is present in the technique- is done by means of getting progressed linearity within the enter/output relationship

- **STATIC PROBLEM (BATCH PROCESS OPTIMIZATION)**

There are three Signal-to-Noise ratios of commonplace hobby for optimization of Static Problems:

- **SMALLER-THE-BETTER:**

n = -10 Log10 [mean of sum of squares of measured data]

This is normally the chosen S/N ratio for all unwanted characteristics like “defects” and many others. For which the appropriate value is zero. Also, when a great value is finite and its maximum or minimal price is described (like maximum purity is a hundred% or maximum Tc is 92K or minimum time for making a smartphone connection is 1 sec) then the difference among measured information and best value is expected to be as small as possible. The common form of S/N ratio then becomes,

n = -10 Log10 [mean of sum of squares of measured - ideal]

- **LARGER-THE-BETTER:**

n = -10 Log10 [mean of sum squares of reciprocal of measured data]

This case has been converted to SMALLER-THE-BETTER by taking the reciprocals of measured facts and then taking the S/N ratio as within the smaller-the-higher case.

- **NOMINAL-THE-BEST**

Rectangular of mean

n = 10 Log10 variance

This case arises whilst a particular fee is MOST favoured, which means that neither a smaller nor a larger price is acceptable.

Examples are;

(i) Most parts in mechanical fittings have dimensions which are nominal-the-best type.

(ii) Ratios of chemicals or mixtures are nominally the best type.

e.g. Aqua regia 1:3 of HNO3:HCL
Ratio of Sulphur, KNO3 and Carbon in gun powder

(iii) Thickness should be uniform in deposition /growth /plating /etching

- **DYNAMIC PROBLEM (TECHNOLOGY DEVELOPMENT) :**

In dynamic problems, we come across many applications where the output is supposed to follow input signal in a predetermined manner. Generally, a linear relationship between "input" "output" is desirable.

For example: Accelerator peddle in cars, volume control in audio amplifiers, document copier (with magnification or reduction) various types of moldings etc.

There are 2 characteristics of common interest in "follow-the-chief" or "Transformations" sort of applications,

(i) Slope of the I/O characteristics and

(ii) Linearity of the I/O characteristics

(Minimal deviation from the pleasant-suit directly line)

The Signal-to-Noise ratio for these 2 characteristics have been defined as

I) SENSITIVITY SLOPE:

The slope of I/O characteristics ought to be at the desired price (normally 1).

It is frequently handled as Larger-The-Better whilst the output is a perfect characteristic (as in the case of Sensors, where the slope suggests the sensitivity).

N = 10 Log10 [square of slope or beta of the I/O characteristics]

On the opposite hand, while the output is an undesired traits, it is able to be handled as Smaller-the-Better.

N = -10 Log10 [square of slope or beta of the I/O characteristics]

(II) LINEARITY (LARGER-THE-BETTER)

Most dynamic characteristics are required to have direct proportionality among the enter and output. These applications are consequently referred to as as "TRANSFORMATIONS”. The directly line relationship among I/O need to be really linear i.e. With as little deviations from the straight line as possible.

Square of slope or beta

n = 10 Log10 ----variance

Variance in this case is the imply of the sum of squares of deviations of measured records points from the great-suit immediately line (linear regression)

4.2 STEPS IN TAGUCHI METHODOLOGY:

Taguchi method is a scientifically disciplined mechanism for evaluating and implementing improvements in products, techniques, substances, gadget, and centers. These enhancements are aimed at improving the preferred traits and concurrently decreasing the number of defects by means of analysing the key variables controlling the procedure and optimizing the tactics or layout to yield the great outcomes.

The technique is applicable over a extensive variety of engineering fields that encompass techniques that manufacture uncooked materials, sub structures, merchandise for expert and consumer markets. In reality, the method may be carried out to any method be it engineering fabrication, pc-aided-design, banking and provider sectors and many others. Taguchi method is beneficial for 'tuning' a given process for 'satisfactory' consequences.

Taguchi proposed a popular eight-step method for making use of his method for optimizing any system,

- **STEPS IN TAGUCHI METHODOLOGY:**

Step-1: Identify the Main Function, Side Effects, and Failure Mode

Step-2: Identify the Noise Factors, Testing Conditions, And Quality Characteristics

Step-Three: Identify the Objective Function to Be Optimized

Step-Four: Identify the Control Factors and Their Levels

Step-5: Select the Orthogonal Array Matrix Experiment

Step-6: Conduct the Matrix Experiment

Step-7: Analyse The Data, Predict The Optimum Levels And Performance

Step-8: Perform The Verification Experiment And Plan The Future Action

4.3 GREY RELATIONAL ANALYSIS

Grey relational evaluation (GRA), also referred to as Grey Incidence Analysis, turned into evolved through Julong Deng of Huazhong University of Science and Technology. It is one of the maximum extensively used fashions of gray gadget theory. GRA uses a specific concept of facts. It defines situations without a statistics as black, and those with best data as white. However, neither of these idealized conditions ever occurs in real world troubles. In fact, situations among these extremes, which comprise Dispersed knowledge (partial statistics), are described as being gray, hazy or fuzzy. A variant of GRA model, Taguchi-based GRA version, may be very famous in engineering.

1. Grey relation analysis is an critical a part of gray system theory.

2. Originated by means of Professor Julong Deng (1933 – 2013), professor at Huazhong University of Science and Technology, Wuhan, China.

Generally, the black is represented, as lack of statistics, however the white is complete of information. Thus, the statistics that is either incomplete or undetermined is referred to as Grey

1 .A system having incomplete statistics is known as Grey device.

2. The Grey range in Grey gadget represents quite a number with much less complete information

3. The Grey element represents an element with incomplete facts.

4. The Grey relation is the relation with incomplete records.

5. Those 3 phrases (Grey wide variety, Grey element and Grey relation) are the everyday symbols and functions for Grey machine and Grey phenomenon.

6. With existence of internal and outside disturbances and the constraints in knowledge, when investigating systems the to be had information consists of various kind of uncertainty and noises.

4.4 INCOMPLETE INFORMATION

1. Incompleteness in facts is one of the fundamental traits of unsure structures. The most commonplace situations concerning incomplete gadget facts encompass instances where:

2. Information approximately device factors (parameters) is incomplete

3. Information at the structure of the device is incomplete

4. Information approximately the boundaries of the machine is incomplete

5. Information on the device's behaviours is incomplete.

4.5 INACCURACIES IN DATA

1. In grey systems theory, the meanings of uncertain and misguided are roughly the same.

2. Both terms stand for errors or deviations from real statistics values.

3. Based on the essence of the way uncertainties are brought on, inaccuracies can be classified into 3 types:

1. The conceptual type

2. The level kind

3. The prediction type inaccuracies.

- **THE CONCEPTUAL TYPES**

1. Inaccuracies of the conceptual type originate from the expression of a sure event, item, concept, or wish.

2. For instance, all such often used principles as "large," "small," "many," "few," "high," "low," "fats," "thin," "properly," "horrific," "younger," and "stunning" are erroneous due to loss of clear definition.

It is very difficult to apply exact portions to express those principles

- **THE LEVEL TYPE**

1. This form of data inaccuracy is because of a change at the level of studies or observation.

2. This approach that the available facts is probably accurate while visible at the level of the device; macroscopic stage or at the extent of the complete.

3. For example, the height of someone may be measured appropriately to the unit of centimeters or millimetres.

4. However, if the dimension needs to be correct to the extent of one ten-thousandth micrometers, the previous accurate studying becomes extraordinarily faulty

- **THE PREDICTION (ESTIMATE) TYPE**

1. It is hard to have whole understanding of the laws of evolution; any prediction of the destiny tends to be inaccurate.

2. In data, its miles frequently the case that samples are accrued to estimate the entire.

3. Therefore, a great deal statistical records are misguided.

4. As a be counted of truth, irrespective of what method is used, it's miles very tough for everybody to achieve any actually accurate (predicted) cost.

4.6 NEED FOR GRA

1. Grey Relational Analysis (GRA) is used to determine the ideal situation of diverse enter parameters to acquire the best best characteristics.

2. Grey Relational analysis is extensively carried out in comparing or judging the overall performance of a complicated assignment with meager records.

3. GRA can be used to derive ultimate circumstance for multi-objective troubles through providing weightages to individual responses.

4.7 STEPS IN GRA

Steps in Grey Relational Analysis approach:

1. Determine the first-rate function/objective.
2. Finding the control factors and their tiers.
3. Design of a suitable OA Matrix and define the information evaluation.
4. Conduct the experimental trails & attain output values.
5. Normalization of information.
6. Finding out Grey relational Coefficient.
7. Calculation of Grey relational Grade.
8. Ranking & Selection of Optimal values.

4.8 PROPOSED HYBRID TECHNIQUE

Mostly Taguchi approach is used for optimization of single parameter. By combining Taguchi with gray relational analysis optimization based totally on a couple of parameters can be accomplished without difficulty and successfully. The grey relational evaluation entails calculation of grey relational coefficient for each parameter. Averaging of all grey relational coefficients will offers grey relational grade (GRG) and S/N ratio values are calculated to those GRGs.

- **STEPS IN HYBRID METHODOLOGY:**

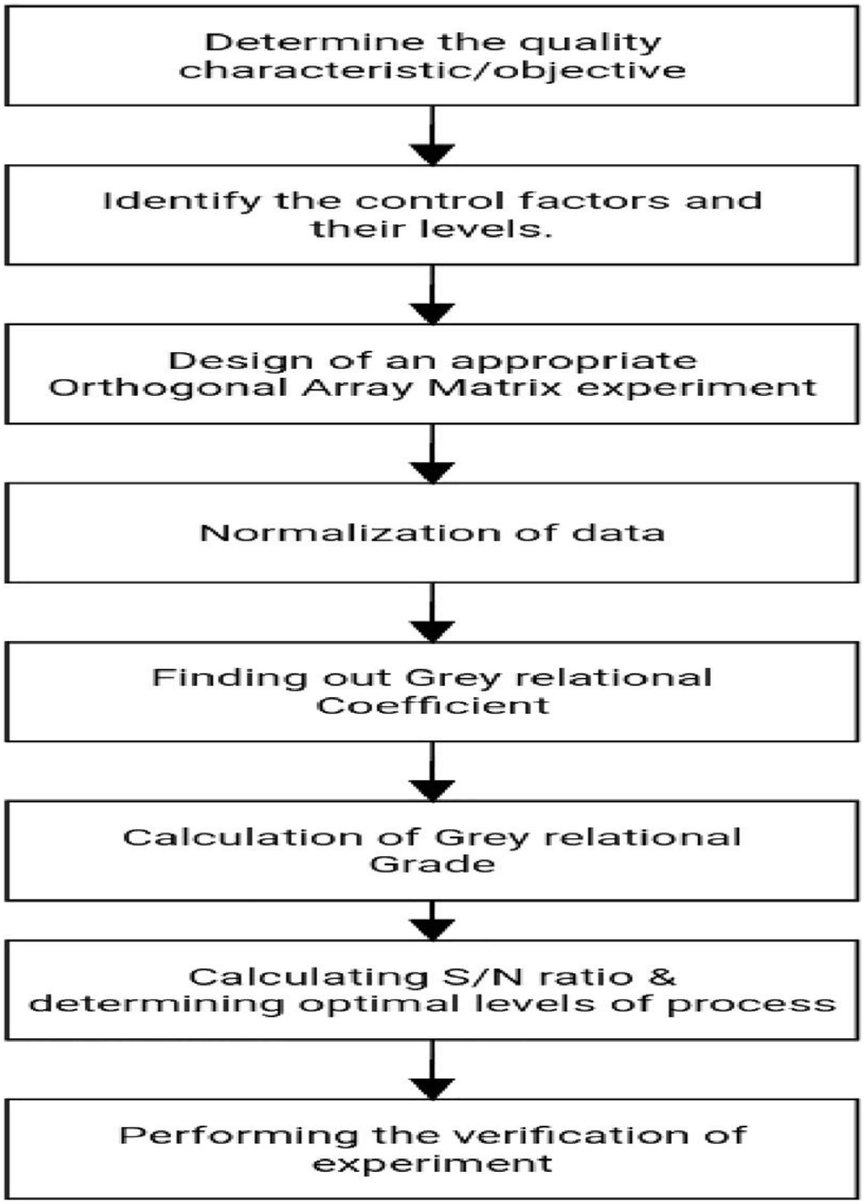
1. Determine the first-rate feature/goal: It is locating out the ideal output feature, which desires to be increased or reduced for getting better output in phrases of pleasant.

2. Finding the control factors and their tiers: A managed component is a characteristic that can be controllable parameter. Initially all the elements which influencing the output function ought to be listing down & then control elements that are going to be optimised are decided on via brainstorming.

Factor: A factor is a variable below study; an input that may be controlled.

Level: A degree is a cost that a thing can count on when used in a test.

Design of an appropriate Orthogonal Array Matrix and carry outing experimentation: Orthogonal arrays are determined out using quantity of parameters and ranges of parameters. It is predefined and normally calls for handiest a fraction of the full factorial combinations considering in every pair of columns, all component mixtures arise at the same variety of instances. Experimental trails need to be conducted in keeping with the mixture sets of parameters that are acquired from orthogonal array. The output parameters are to be measured via trying out the experimental portions on a preferred trying out system or with proper equipment.



Flow Chart 4.1 Steps In Hybrid Methodology

4.9 NORMALIZATION OF DATA

- The experimental response data are to be normalized in the range of 0 and 1. This normalization is done because it is difficult to compare between the different kinds of factors because they exert a different value. Three formulas can be used for this purpose

$$x_{\text{norm}} = \frac{x - \min(x)}{\max(x) - \min(x)}$$

This formula is used when the corresponding output value need to be maximized

$$X_{norm} = \max(x) - x / \max(x) - \min(x)$$

This formula is used when the corresponding output value need to be minimized.

$$X_{norm} = x - x_0 / \max x - x_0$$

This formula is used when the corresponding output value need to be maintained at certain value.

- Finding out Grey relational Coefficient (GRC)

The GRC is calculated by following steps:

- The absolute difference of the compared series and the referential series should be obtained. And the maximum and the minimum difference should be found.
- Calculation of the GRC using following formula.

$$\xi_i(k) = \frac{\Delta\min + \xi\Delta\max}{\Delta_{oj}(k) + \xi\Delta\max}$$

Generally, Distinguishing coefficient $p = 0.5$

- Calculation of Grey relational Grade:
  Grey relational Grade can be obtained by averaging the GRC values in each row.
- Calculating S/N ratios & determining optimal levels of process: Here Taguchi method was introduced and the S/N values for Grey Relational Grade were calculated using following formula $S = N$ ¼ —10 log 1$= y^2 = N$. By using S/N ratios, graphs need to be plotted and optimisation values to be find out by analysis.

- Perform the verification experiment: It is needed to be verify, whether the given result by that method is valid or not by con- ducting experiment with optimal values.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 EXPERIMENTAL MANNER AND OUTCOMES

5.1.1SELECTION OF MATERIAL

In this examine, we used multiple metals to join by using the usage of MIG welding gadget. The two distinct metals are AISI1044 and AISI1018 mild metallic. The size of Mild steel plates is 150 * 40 * 8 mm.

5.1.2SELECTION OF MIG WELDING PARAMETERS AND THEIR TIERS

In this examine we chose the following parameters and degrees on the grounds that they will display tremendous impact at the weldments properties

5.1.3SELECTION OF ORTHOGONAL ARRAY

Based on predefined orthogonal array matrix, we can get L9 orthogonal array for the aggregate of four parameters and 3 ranges.

The Table 2 shows the combination of parameters with various levels of parameters.

As in step with the Table 2, nine trails each path repeated twice for the same enter parameters were finished. The Fig. Three indicates the weldments received from the paths.

5.1.4 EXPERIMENTAL END RESULT

The Tensile energy of weldments had been tested the use of familiar testing device and additionally Hardness of welded location the usage of Brinell hardness checking out approach.

The Table 3 indicates the tensile power and Hardness values for Weldments, which obtained from experimental trails.

TABLE 1

PARAMETER AND TRAILS

PARAMETERS	LEVEL1	LEVEL2	LEVEL3
Current (Ampers)	171	180	300
Voltage (volts)	21	28	35

Weld speed (m/min)	.92	98	1.3
Angles (degree)	30	45	60

TABLE 2

ORTHOGONAL ARRAY

Exp.NO	Current (Ampers)	Voltage (volts)	Weld speed (m/min)	Angles (degree)
1	171	21.5	.92	30
2	161	24.2	.94	45
3	164	25.8	.96	60
4	180	28.5	.97	60
5	214	29.9	1.2	45
6	248	31.5	.98	30
7	272	34.4	1.3	45
8	294	34.7	.92	45
9	328	35.9	.98	60

Fig 5.1 Weldments from the Trails

TABLE 3

Tensile strength and Hardness values of Weldments.

Exp.No.	Tensile Strength (MPa)	Hardness (BHN)
1	325	140.5
2	336.3	133
3	381.8	136
4	363.4	123.5
5	398.7	114
6	321.2	123
7	365.13	144.6
8	328.38	129.2
9	334.7	130.5

TABLE 4

TENSILE STRENGTH AND HARDNESS VALES OF WELDMENT

Exp. No.	Tensile Strength (MPa)	Hardness	Normalised Tensile Strength (MPa)	Normalised Hardness
1	325	140.5	.442	.336
2	336.3	133	.521	.234
3	381.8	136	.231	.631
4	363.4	123.5	.332	1
5	398.7	114	.398	.431
6	321.2	123	.448	.383
7	365.13	144.6	.512	.289
8	328.58	129.2	.439	.373
9	334.7	130.5	.14	.784

TABLE 5

GRC, GRG, S/N RATIO VALUES FOR ALL THE EXPERIMENTAL RUNS

Exp. No	GRC of Tensile Strength	GRC of Hardness	GREY RELATIONAL GRADE (GRG)	S/N RATIO
1	.432	.534	.483	-4.23
2	.321	.489	.405	-4.73
3	.349	.321	.335	-3.43
4	.412	.512	.462	-6.31
5	.298	.389	.3435	-5.89
6	.323	.412	.3675	-6.75
7	.444	.326	.385	-3.86
8	.532	.478	.505	-4.65
9	.639	.335	.487	-4.71

.

TABLE 6

S/N RATIO VALUES FOR DIFFERENT LEVELS OF PARAMETERS

Level	Current (Amps.)	Voltage (Volts)	Speed (m/min	Angle (Degree)
Lvl1	-7.51	-4.45	-4.43	-6.014
Lvl2	-6.93	-5.89	-4.89	-4.03
Lvl3	-5.31	-5.63	-6.36	-5.098

TABLE 7

OPTIMAL VALUES OF MIG WELDING PROCESS

Current (Amps)	Voltage (Volts)	Weld Speed (m/min	Angle (degrees)
300	21.5	.92	45

TABLE 8

TENSILE STRENGTH AND HARDNESS VALUES OBTAINED FROM THE CONFIRMATION TEST

Tensile Strength (MPa)	Hardness
432.6	144.6

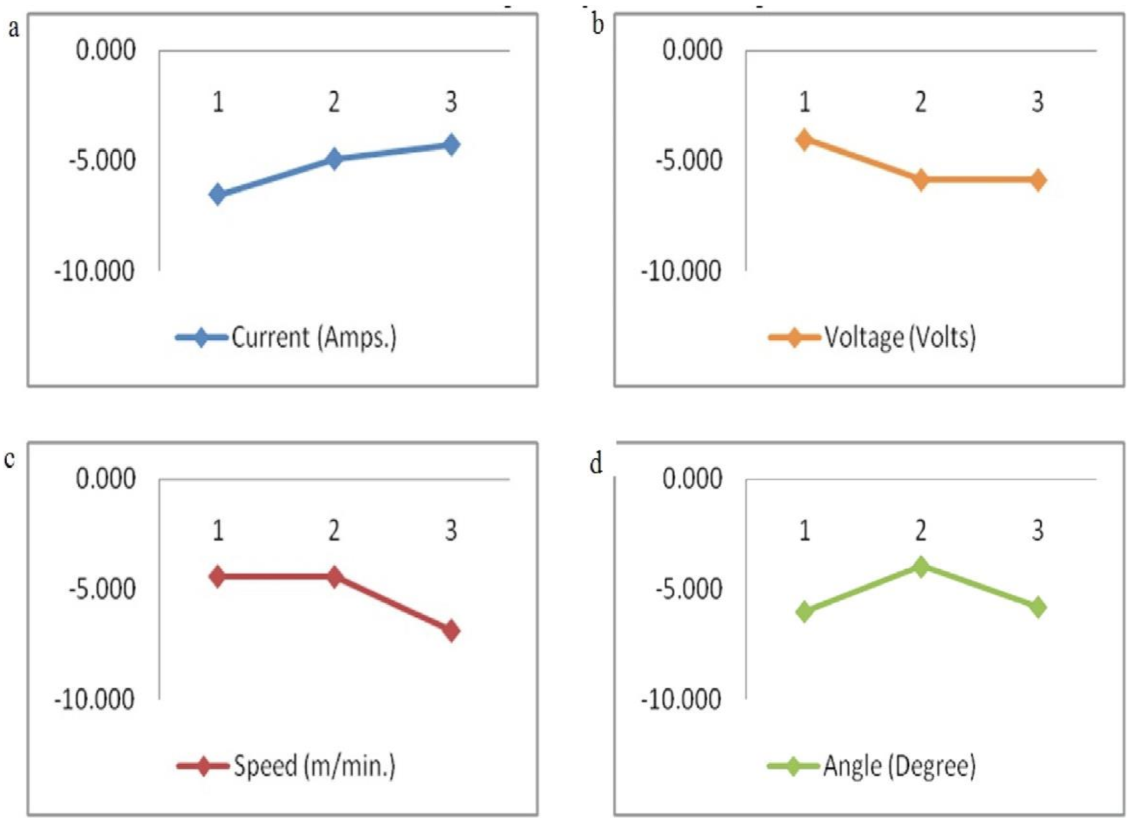


Figure 5.2.S/N ratio Graph for (a) Current; (b) Voltage; (c) Weld Speed;(d)Angle.

5.1.4 CONFIRMATION TEST

Confirmation trail was conducted using above optimal values to confirm that the obtained values will give better Tensile strength and Hardness.

From the confirmation test, we observed better Tensile strength and Hardness. The Tensile strength and Hardness values of the confirmation test.

CHAPTER-6

CONCLUSION

Nine experimental trails each trail repeated twice were con- ducted as per the orthogonal array, the data obtained is analysed using the hybrid algorithm. From the weldments obtained by joining the two dissimilar metals (AISI1044 & AISI1018) using MIG welding process, it is noticed that characteristics like tensile strength and hardness has been improved, when the process, is been carried out at the following optimal parameter values i.e. current at 300 Amps, voltage at 21.5 Volts, weld speed of 0.92 m/min and angle at 45 degrees.

From Graphs, It is observed that the tensile strength and hard- ness of weld area increases with increase in the current and tensile strength and hardness of weld area decreases with increase in Voltage as well as Weld speed. And the tensile strength and hardness are high at angle of 45 degrees.

CHAPTER-7

REFERENCES

[1] Rakesh Kumar et al. (2011). "Study of mechanical properties in mild steel using metal inert gas welding". Mater Character ; vol 23, issue59: pp. 751–756

[2] Radha Raman TA et al.(2004) "A study of Tensile Strength of MIG and TIG welded dissimilar joints of mild steel and stainless steel ." Mater SciEng A2004; vol 53,issue pp 23 - 32.

[3] Farzeen shadhid et al.(2007), "Mechanical and microstructural analysis of dissimilar metal welds "IJRRAS 2007;vol 25,issue 1:pp 6-14.

[4] Sheikh Irfan et. al. (2014): "An experimental study on the effect of MIG welding parameters on the weldability of galvanize steel." intenational journal on emerging technologiesvol32, issue 45,pp146- 152.

[5] Chandresh et.al "Parametric Optimization of Weld Strength Of Metal Inert Gas Welding and Tungsten Inerts Gas Welding By Using Analysis Of Variance And Grey Relational Analysis". J Mater Process Technol 1998:vol 1,issue 3,pp 48-56.

[6] Rajendra Singh et.al(2009) "Analysis of Defects in MIG of A312tp3161 Stainless Steel pipe using Taguchi Optimization Method And Testing" materials processing technology 209 (2009) vol.3 issue 6,pp 11- 22.

[7] DaviSampaioCorreia,et.al (2005),"Comparison between genetic algorithms and response surface methodology in GMAW welding optimization" Journal of Materials Processing Technology vol64,issue160,pp 70-76.

[8] Yang WH, et.al.(1998), "Optimization of the weld bead geometry in gas tungsten arc welding by the Taguchi method", Int J AdvManufTechnol; vol14,issue82 pp549-554

[9] Van wortel. et.al. (2000), "integrity of weld metal joints in hydrogen service" stainless steel world journal, vol58, issue 22 pp 49- 55.

[10] A text book on "Welding Technology" by Dr. R.S.Parmar

[11] R.S. Chandel, H.P. Seow, F.L. Cheong, Effect of increasing deposition rate on the bead geometry of submerged arc welds, Journal of Materials Processing Technology 72: 124–128 (1997).

[12] J.Tusek, M. Suban, High-productivity multiple wire submerged-arc welding and cladding with metal powder addition, Journal of Materials Processing Technology 133: 207–213 (2003)

[13] K. Y. Benyounis, A. G. Olabi , Optimization of different welding processes using statistical and numerical approaches - A reference guide Volume 39: 483-496 (2008)

[14] SerdarKaraoğlu and Abdullah Seçgin, Sensitivity analysis of submerged arc welding process parameters, Journal of Materials Processing Technology, 202: 500- 507(2008)

[15] P. Yongyutph ,K. Ghoshp, C. Guptaa, K. Patwardha And SatyaPrakash, Influence of Macro/Microstructure on the Toughness of'All Weld' Multipass Submerged Arc Welded C-Mn Steel Deposits, ISIJ International. Vol.32: 771-778(1992)

[16] L.J. Yang, R.S. Chandel and M.J. Bibby, The effects of process variables on the bead width of submerged-arc weld deposits, Journal of Materials Processing Technology,Vol.29: 133-144 (1992)

[17] N.D. Pandey, A. Bharti and S.R. Gupta, Effect of submerged arc welding parameters and fluxes on element transfer behavior and weldmetal chemistry, Journal of Materials Processing Technology, Vol.42: 195-211 (1994)

[18] P. Kanjilal, T.K. Pal and S.K. Majumdar, Combined effect of flux and welding parameters on chemical composition and mechanical properties of submerged arc weld metal. Journal of Material Processing Technology, Vol.171: 223-231 (2006)

[19] De-liangRen, Fu-ren Xiao, PengTian, Xu Wang and Bo Liao, Effects of welding wire composition and welding process on the weld metal toughness of submerged arc welded pipeline steel, International Journal of Minerals, Metallurgy and Materials Vol.16: 65-70 (2009)

[20] Ana Ma. Paniagua-Mercado, Victor M. López- Hirata and Maribel L. Saucedo Muñoz, Influence of the chemical composition of flux on the microstructure and tensile properties of submerged-arc welds. Journal of Materials Processing Technology,Vol. 169: 346-351 (2005)

[21] Chan, R.S. Chandel, L.J. Yang and M.J. Bibby, A software system for anticipating the size and shape of submerged arc welds. Journal of MaterialsProcessing Technology, Vol. 40: 249-262 (1994)

[22] N. Murugan, R.S. Parmar and S.K. Sud, Effect of submerged arc process variables on dilution and bead geometry in single wire surfacing. Journal of Materials Processing Technology, Vol. 37: 767-780 (1993)

[23] Abhay Sharma, NavneetArora, Bhanu K. Mishra Analysis of Flux Consumption in Twin-Wire Submerged Arc Welding Process with Unequal Wire Diameters. Trends in Welding Research, Proceedings of the 8th International Conference ASM International: 626-630 (2009)

[24] PrasantaKanjilal; Tapan Kumar Pal ;Sujit Kumar Majumdar,Prediction of Mechanical Properties in Submerged Arc Weld Metal of C-MnSteel,Journal of materials and manufacturing process, Vol. 22: 114- 127(2007)

[25] S. W. Wen, P. Hilton and D. C. J. Farrugia, Finite element modeling of a submerged arc welding process. Journal of Materials Processing Technology, Vol. 119: 203-209 (2001)

[26] Armentani, R. Esposito, R. Sepe,The effect of thermal properties and weld efficiency on residual stresses in welding. Journal of Achievements in Materials and Manufacturing Engineering, Vol 20:319-322 (2007)

[27] Kook-soo Bang, Chan Park, Hong-chul Jung and Jong-bong Lee,Effects of flux composition on the element transfer and mechanical properties of weld metal in submerged arc welding, Journal of Metals and Materials International ,Vol. 15: 471-477 (2009)