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A Review on Various Welding Techniques

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ABSTRACT: *Qualityand productivity play important role in today's manufacturing market. Now a day's due to very stiff and cut throat competitive market condition in manufacturing industries. The main objective of industries reveals with producing better quality product at minimum cost and increase productivity. Welding is the most vital and common operation use for joining of two similar and dissimilar parts.In the present research paper an attempt is made to understand various welding techniques and to find the best welding technique for steel. Special focuses have been put on TIG and MIG welding. On hardness testing machine and UTM various characteristics such as strength, hardness, modulus of rigidity, ductility, breaking point, % elongation etc. at constant voltage were analyzed.*

Keywords: *MIG, TIG, Welding*

I. INTRODUCTION

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces.

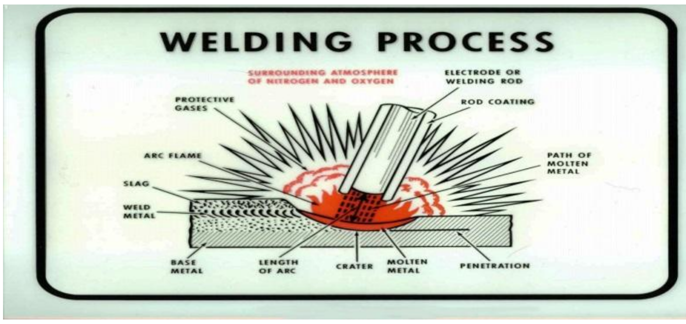


Fig 1: WELDING PROCESS

Why welding is used- Because it is,

i. Suitable for thickness ranging from fractions of a millimeter to a third of a meter.
ii. Versatile, being applicable to a wide range of component shapes and sizes.

Some of the best known welding techniques include:

1.1 Shielded metal arc welding (SMAW) - also known as "stick welding", uses an electrode that has flux, theprotectant for the puddle, around it. The electrode holder holds the electrode as it slowly melts away. Slag protects the weld puddle from atmospheric contamination.

1.2 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.

1.3 Gas metal arc welding (GMAW) - commonly termed MIG (metal, inert gas), uses a wire feedinggun that feeds wire at an adjustable speed and flows an argon-based shielding gas or a mix ofargon and carbon-dioxide (CO_2) over the weld puddle to protect it from atmosphericcontamination.

1.4 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.

1.5 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.

1.6 Electro slag 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.

II. LITERATURE SURVEY

Many investigators have suggested various methods to explain the effect of process parameter on mechanical properties and weld bead geometry, depth of penetration etc.

S. R. Meshram, N. S. Pohokar (2013) [1]used Taguchi optimization technique pair with grey relational analysis has been adopted for optimize parametric complex to carry out effect of process parameter on Penetration, Reinforcement and Bead width in GMAW welding process of stainless steel AISI410 (Dimension 70mm×25 mm×12mm thickness). The welding process parameters considered in this analysis are voltage, wire feed rate, Welding Speed, Nozzle to Plate Distance and Gas Flow. The Optimum welding Parameter combination was obtained by using analysis of signal to noise (S/N) ratio. The S/N ratio calculated and used to obtain the optimum level for every input factor.Using Analysis of Variance (ANOVA) the adequacy of develop model is checked and significant coefficient for each input factor on weld bead geometry were determined.

Dinesh Mohan Arya, Vedansh Chaturvedi and Jyoti Vimal(2013)[8]in the paper “PARAMETRIC OPTIMIZATION OF MIG PROCESS PARAMETERS USING TAGUCHI AND GREY TAGUCHI ANALYSIS” studied on various welding operating parameters for alloy steel using grey analysis method. They found the following results:

i. The higher the penetration the better is the weld strength.
ii. Bead width, Bead height and Heat affected zone (HAZ) lower is better of the alloy steel element by using Metal inert gas welding.
iii. The most significant factor also found in MIG is welding current.

“EXPERIMENTAL STUDY OF CO2 ARC WELDING PARAMETERS ONWELD STRENGTH FOR AISI 1022 STEEL PLATES USING RESPONSESURFACE METHODOLOGY” by Shukla B.A., Prof. Phafat N.G.,(2013)[5] focuses on the investigation of CO2 welding parameters to maximize the weld strength using Response Surface Methodology. Welding current, welding voltage, wire feed rate and gas pressure was taken as input parameters while the response was only weld strength.

The higher the feed rate square (R^2) value the better is the quality of welding. The current, voltage, wire feed rate and gas pressure are significant terms in maximizing the weld strength.

In the present research paper by Naitik S Patel, Prof. Rahul B Patel(2013) [6]an attempt is made to understand the effect of TIG welding parameters such as welding current , gas flow rate ,welding speed ,that are influences on responsive output parameters such as hardness of welding, tensile strength of welding, by using optimization philosophy. In TIG welding process most of welding parameters like welding current, welding speed, depth to width ratio are generally used in research work. TIG welding can be carried on different materials like mild steel, titanium alloy, brass, carbon, stainless steel etc. the best result of welding is found on the austenitic type stainless steel with the grade E310.

Kovacevic (2003)[2]in their research friction stir welding (FSW) is a relatively new welding process that may have significant advantages compared to the fusion processes as follow: joining of conventionally non-fusion weld able alloys, reduced distortion and improved mechanical properties of weld able alloys joints due to the pure solid-state joining of metals. In this paper, a three-dimensional model based on finite element analysis is used to study the thermal history and thermo mechanical process in the butt-welding of aluminum alloy 6061-T6.

Gautam Kocher, Sandeep Kumar, Gurcharan Singh(2012) [11]studied on welding speed as process variable while arc voltage, welding current, wire feed rate distance between the nozzle and the plates are fixed in this experiment. The effect of weld speed on the weld bead profile is been discussed with the effect of weld speed on the fusion angle and wetting angle. The effect of weld speed on the weld bead dilution i.e. penetration area and reinforcement area also be discussed.

Bhargav C. Patel, Jaivesh Gandhi (2013)[9]in their research paper “Optimizing and analysis of parameter for pipe welding: A literature review” emphasis on the study of the effect of different input parameter of TIG and MIG welding on the weld quality. They studied the effect of various welding parameter by conducting different experiments.

As we know the most popular method for welding pipe is the shielded metal-arc process; however, gas shielded arc methods have made big inroads as a result of new advances in welding technology.

Krishankant, Sandeep Jindal & Shashi Kant Shekhar(2012) [4]in their paper "Determination of Flux Consumption in Submerged arc Welding by the Effect of Welding Parameters by Using R.S.M Techniques" researched on the effect of operating voltage, welding current, welding speed and basicity index on flux consumption by using RSM (Response Surface Methodology). They came up with the following results:

1) Flux consumption increased with the increase in open circuit voltage and very small increases with increases in current.
2) Welding speed has negative effect on flux consumption.
3) Flux consumption also small decreases with the increase in nozzle to plate distance.

"SAFETY CONSIDERATIONS IN A WELDING PROCESS: A REVIEW" by Kapil Singh, Ankush Anand (2013)[3]aimed at highlighting the safety aspects in a welding process. In this research article, following aspects of welding had been considered: (a) HAZARDS IN WELDING. (b) SAFETY ASPECTS. (c)RISK ASSESMENT. It will help system designers, industrialists and welding professionals to overcome the issues being faced by the present day welders in a manufacturing environment, thus ensuring greater safety.

Mohan B. Raut, S. N. Shelke(2014) [10]in their paper "Optimization of Special Purpose Rotational MIG Welding by Experimental and Taguchi Technique" presented the case study to find the design optimization for special purpose MIG welding operation. This paper presents the effect of welding parameters like welding current, welding voltage, welding speed, gas flow rate, rotational speed of work piece, filler wire feed rate on MIG welding. An Orthogonal Array, Signal to Noise (S/N) ratio and analysis of variance (ANOVA) are used to find out the welding characteristics and optimization parameters. Finally the confirmations tests have been carried out to compare the predicted values with the experimental values.

"IMPACT OF VOLTAGE ON AUSTENTIC STAINLESS STEELFOR THE PROCESS OF TIG AND MIG WELDING" by L Suresh Kumar(2010) [7]et. al. studied on the mechanical properties of austenitic steel for TIG and MIG process. They used the TIG and MIG process to find out the characteristic of metal after it is welded. The voltage is taken constant and various characteristics such as strength, hardness, ductility, grain structure, modulus of elasticity, breaking point etc. were analysis. They concluded that for austenitic steel TIG welding is more suitable while hardness is more in case of MIG welding.

N. M. Gamit, P. S. Puranik, B. M. Garala(2014)[14]researched on Various kinematic mechanisms like four bar mechanism etc. are studied to obtain design for holding welding torch and its circular movement. And also various mechanisms are studied to develop holding device for holding the object. They concluded four bar mechanism should be appropriate for desired welding machine. It is simple and easy to design or modify, also for maintaining welding quality and increase the productivity.

Manoj Singla, Dharminder Singh, Dharmpal Deepak(2010)[13]in their paper "Parametric Optimization of Gas Metal Arc Welding Processes by Using Factorial Design Approach" aimed toptimizing various Gas Metal Arc welding parameters including welding voltage, welding current, welding speed and nozzle to plate distance (NPD) by developing a mathematical model for sound weld deposit area of a mild steel specimen. Factorial design approach has been applied for finding the relationship between the various process parameters and weld deposit area. The study revealed that the welding voltage and NPD varies directly with weld deposit area and inverse relationship is found between welding current and speed with weld deposit area.

"FINITE ELEMENT MODEL TO PREDICT RESIDUAL STRESSES IN MIG WELDING" by Harshal K. Chavan, Gunwant D. Shelake, M. S. Kadam (2012)[12]researched on the responses of single pass corner-joint of arc welding are evaluated through the finite element software (ANSYS). They studied the effects of varying heat input, welding speed on the thermo mechanical responses of the weldment after cooling down to room temperature. The results were as follows:

i. As heat input changes, strain changes respectively.
ii. As the heat input increases temperature generates in the plat increases and thus the stress generated decreases.
iii. The faster the welding speed is made, the less heat is absorbed by the base metal and thus stresses induced decreases.

III. METHODOLOGY

1.1 MIG WELDING

Metal Inert Gas Welding melts and joins metals by heating them with an arc established between a continuously fed filler wire electrode and the metals. Ar and He are also used as inert shielding gases to protect the molten weld pool. It is often called metal inert gas (MIG). However, non-inert gases, i.e., CO_2 are also used for carbon and low alloy steels.

Ar, He or Mixtures of (25%) Ar, (75%) He are used for non-ferrous (mostly Al) as well as stainless and alloy steels.

The Ar arc plasma is stable and beneficial for transferring metal droplets through the arc plasma.

Modes of Metal Transfer

The molten metal at the electrode tip can be transferred to the weld pool by:

I. **Spray Transfer:**
- Occur above a critical current level (280-320A)
- Small metal droplets travel across the gap under the influence of the electromagnetic force at much higher frequency and speed than in the globular mode.
- More stable and spatter free.

II. **Short-circuit Transfer:**
- Molten metal droplets are transferred from electrode tip to the weld pool when it touches the pool surface (short-circuit).
- Require very low current and electrode diameter, giving small and fast freezing weld pool desirable for welding thin section or out of position welding.

III. **Globular Transfer**
- Metal droplets travel across the arc gap under the influence of gravity.
- Often not smooth and cause spatter.
- Low welding current (180A).

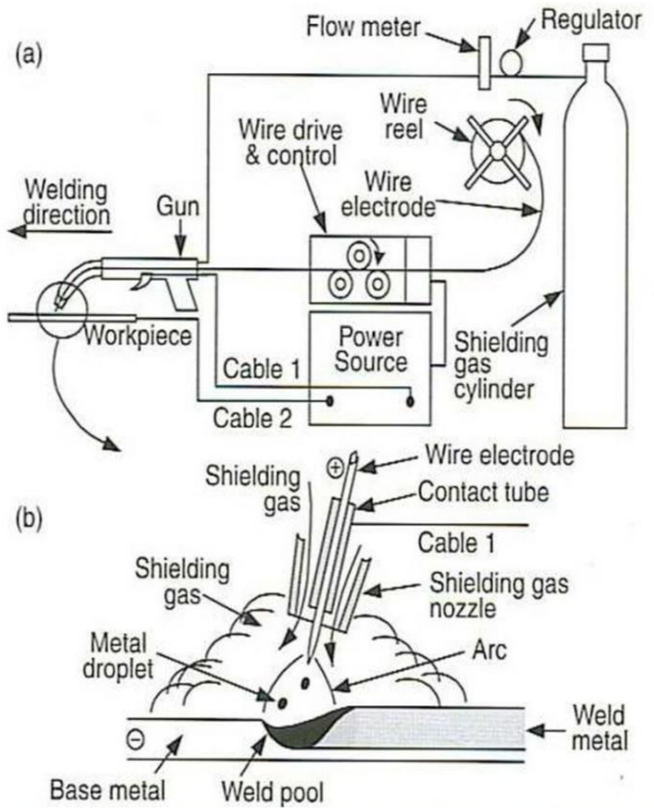


FIG: METAL INERT GAS WELDING

1.2 TIG WELDING

Gas-tungsten arc welding (GTAW) is a process that melts and joins metals by heating them with an arc established between a non-consumable tungsten electrode and the metals.

The tungsten electrode is normally contacted with a water cooled copper tube, which is connected to the welding cable to prevent overheating. The shielding gas (Ar, He) goes through the torch body and nozzle toward the weld pool to protect it from air. Filler metal (for joining of thicker materials) can be fed manually or automatically to the arc. It is also called tungsten inert gas (TIG) welding.

ELECTRODES: Tungsten electrodes with 2% cerium or thorium give better electron emissivity, current-carrying capacity, and resistance to contamination than pure electrodes. Hence, the arc is more stable.

SHIELDING GASES: Ar is heavier and offers more effective shieldingand cheaper than He.

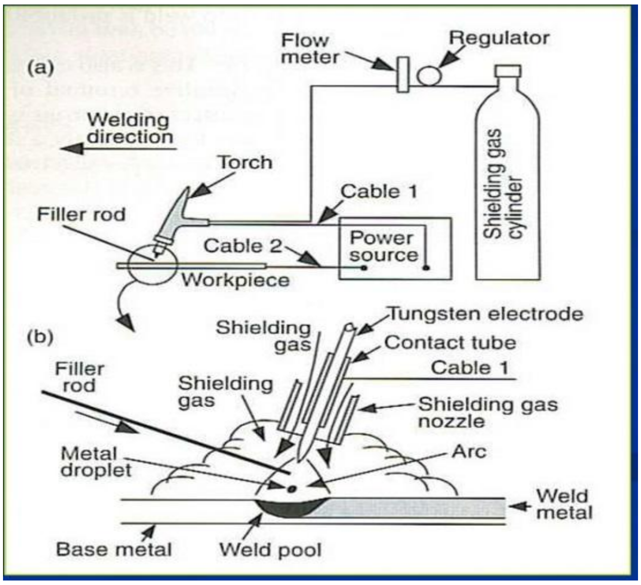


FIG: TUNGSTEN INERT GAS WELDING

3.3 EXPERIMENTAL ANALYSIS

The standard specimen of austenite stainless steel of type 304 is prepared and welding under varied condition of current, voltage and speed. Mechanical properties, percentage of elongation, reduction in area and yield strength are measured with universal testing machine. Hardness of the material and corrosion resistance is also studied. And finally comparison is to be made between TIG and MIG welding process under varied conditions and optimize the condition so as to achieve higher mechanical properties.

TABLE 1: Chemical composition of austenite stainless steel

Composition	C	Si	Mn	Cr	S	P	Ni
AISI 304	0.06	0.32	1.38	18.4	0.28	0.4	8.17

3.3.1 HARDNESS TEST

The test is conducted on welding pieces on the following machine:

a. Brinell's Hardness Test
b. Tension test on UTM (Universal Testing Machine)

a. BRINELL'S HARDNESS TEST

Hardness may be defined as resistance of metal to plastic deformation usually by indentation. Indentation hardness may be measured by various hardness test like Brinell's, Rockwell's etc.
Pieces which are welded by both the process (TIG and MIG) are taken under this test.

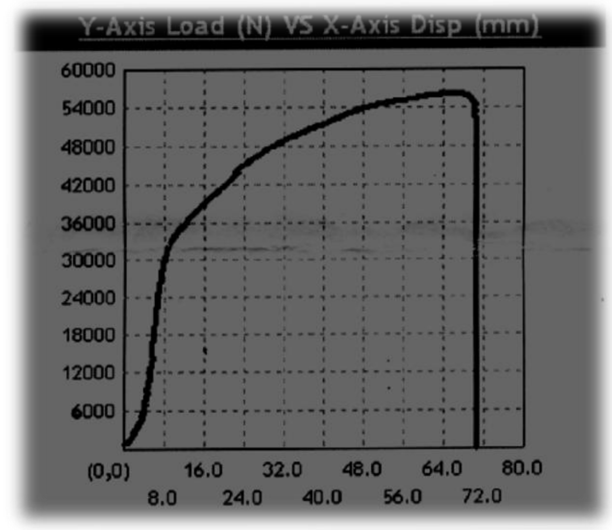
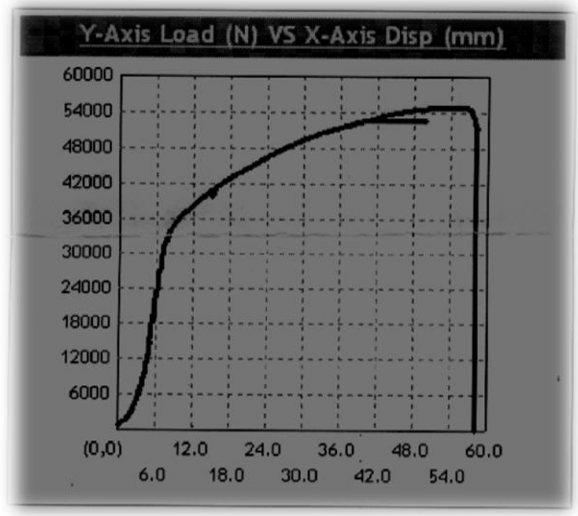
TABLE 2: The hardness values of SS obtained by TIG and MIG process

PROCESS	BHN			
TIG	185	198	220	245
MIG	349	354	387	394

3.3.2 TENSION TEST CARRIED ON UTM (Universal Testing Machine)

It is one of the most widely used mechanical tests machine.
A tensile test help determining ultimate tensile strength, yield stress, % elongation, % reduction in area and modulus of elasticity.
Formulas used in tension test:

i. Yield stress = Load at yield / original area (A_0)
ii. Ultimate tensile strength = Ultimate Load (P_{max}) / Original Area (A_0)
iii. % Elongation = ($L_F - L_O$) / (L_O x 100)
iv. % Reduction = ($A_0 - A_F$) / (A_0 x 100)
v. Young's Modulus Of Elasticity, € = Stress at any point / Strain at that point

MIG WELING ON UTM	TIG WELDING ON UTM
	

3.3.3 HEAT AFFECTED ZONE (HAZ)

The heat-affected zone is the area of base material, either a metal or a thermoplastic, which has had its microstructure and properties altered by welding or intensive cutting operation.

The thermal diffusivity plays an important role – if the diffusivity is high, the material cooling rate is also high and HAZ is alternatively small. Alternatively, a low diffusivity leads to a lesser cooling rate and hence HAZ is high. The following formula is used to calculate the heat input:

$$Q = \left[\frac{V \times I \times 60}{s \times 1000}\right] \times \text{Efficiency}$$

Where Q = heat input (KJ/min)
V = Voltage (volts)
I = Current (ampere)
S = Speed (mm/min)
Heat Input Rate of sample 1 (TIG) = 7.5 KJ/min
Heat Input Rate of sample 2 (MIG) = 6.6 KJ/min

IV. RESULTS

PARAMETER	TIG	MIG
Hardness	185 BHN	349 BHN
Ultimate Load	57600 Newton	56160 Newton
Ultimate Tensile Strength	675.22 MPa	652.029 N/mm^2
Percentage Elongation	40.50 %	47.8 %
Yield Stress	400.238 N/mm^2	353.419 N/mm^2

As the speed decreases and the current increases, the heat affected zone increases.

V. CONCLUSION

- Hardness of MIG welding is greater than TIG welding.
- Ductility is higher in MIG welding compared to TIG welding.
- TIG welding specimen can bear higher load, yield stress and tensile strength.
- As per the experimental result all parameters in TIG welding is better. Therefore, TIG welding is best suitable for steel.

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