Experimental Investigation of Process Parameters on Strength of Welding Joint in GMAW

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Abstract

The strength value most desired in any welding process is an excellent Ultimate Tensile Strength (UTS) of the weld, compared with the parent metal. Process parameters applied during the welding process ought to be subjected to continuous scrutiny and assessment because of the ever increasing demand for structural and industrial materials with weld joints possessing higher strength values. This study is intended to investigate the inadequacies of existing GMAW welding process parameters utilized by the investigated industrial firm in its signature welding protocol, by suggesting alternative, uniquely crafted, and improved process parameters to replace its existing signature welding protocol, thereby improving the weld results by attaining higher UTS. These suggested process parameters were thereafter subjected to reported literature, following which optimization was achieved by employing the Taguchi Method. Then in future work we will study the strength on universal testing machine and calculating the results.

Keywords— *GMAW Welding, GMAW, Taguchi method, ANNOVA*

• Introduction

Metal Inert Gas welding as the name suggests, is a process in which the source of heat is an arc formed between a consumable metal electrode and the work piece, and the arc and the molten puddle are protected from contamination by the atmosphere (i.e. oxygen and nitrogen) with an externally supplied gaseous shield of inert gas such as argon, helium or an argon-helium mixture. No external filler metal is necessary, because the metallic electrode provides the arc as well as the filler metal. It is often referred to in abbreviated form as MIG welding. MIG is an arc welding process where in coalescence is obtained by heating the job with an electric arc produced between work piece and metal electrode feed continuously. A metal inert gas (MIG) welding process consists of heating, melting and solidification of parent metals and a filler material in localized fusion zone by a transient heat source to form a joint between the parent metals. Gas metal arc welding is a gas shielded process that can be effectively used in all positions.

- *GMAW can be done in three different ways*
- **Semiautomatic Welding -** equipment controls only the electrode wire feeding. Movement of welding gun is controlled by hand. This may be called hand-held welding.
- **Machine Welding -** uses a gun that is connected to a manipulator of some kind (not hand-held). An operator has to constantly set and adjust controls that move the manipulator.
- **Automatic Welding -** uses equipment which welds without the constant adjusting of controls by a welder or operator. On some equipment, automatic sensing devices control the correct gun alignment in a weld joint.

- *Working Principle of MIG Welding*

  • As shown in fig. the electrode in this process is in the form of coil and continuously fed towards the work during the process. At the same time inert gas (e.g. argon, helium, or CCCC) is passed around electrode from the same torch. Inert gas usually argon, helium, or a suitable mixture of these is used to prevent the atmosphere from contacting the molten metal and HAZ. When gas is supplied, it gets ionized and an arc is initiated in between electrode and work piece. Heat is therefore produced. Electrode melts due to the heat and molten filler metal falls on the heated joint.

• The arc may be produced between a continuously fed wire and the work. Continuous welding with coiled wire helps high metal depositions rate and high welding speed. The filler wire is generally connected to the positive polarity of DC source forming one of the electrodes. The work piece is connected to the negative polarity. The power source could be constant voltage DC power source, with electrode positive and it yields a stable arc and smooth metal transfer with least spatter for the entire current range.

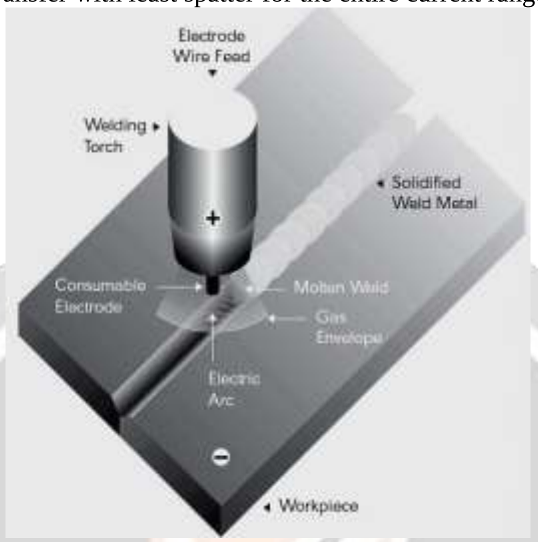


Fig.1 Basic working principle

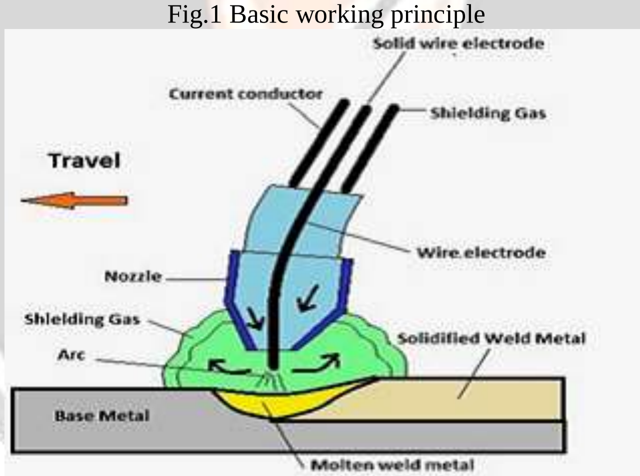


Fig.2 Schematic of GMAW

The gas shield around it does not ionized, which prevents weld against atmospheric co contamination and surface oxidation. Some torch has water cooling systems.MIG welding is also called Gas Metal Arc Welding. The filler metal is transmitted from electrode to joint by different methods. It is dependent on the current passing through the electrode and voltage.

- *GMAW / MIG welding applications*

MIG may be operated in semiautomatic, machine, or automatic modes. All commercially important applicable metals such as carbon steel, high-strength, low-alloy steel, and stainless steel, aluminum, copper, titanium, and nickel alloys can be welded in all positions with this process by choosing the appropriate shielding gas, electrode, and welding variables.

- *MIG Welding Effecting parameters*

Weld quality and weld deposition rate both are influenced very much by the various welding parameters and joint geometry. Essentially a welded joint can be produced by various combinations of welding parameters as well as joint geometries. These parameters are the process variables which control the weld deposition rate and weld quality. The weld bead geometry, depth of penetration and overall weld quality depends on the following operating variables.

• Electrode size, Welding current, Arc voltage
• Arc travel speed, Welding position
• Gas Flow rate, Shielding Gas composition
• Electrode extension (length of stick out)

- *Electrode Size:* The electrode diameter influences the weld bead configuration (such as the size), the depth of penetration, bead width and has a consequent effect on the travel speed of welding. As a general rule, for the same welding current (wire feed speed setting) the arc becomes more penetrating as the electrode diameter decreases. To get the maximum deposition rate at a given current, one should have the smallest wire possible that provides the necessary penetration of the weld. The larger electrode diameters create weld with less penetration but welder in width. The choice of the wire electrode diameter depends on the thickness of the work piece to be welded, the required weld penetration, the desired weld profile and deposition rate, the position of welding and the cost of electrode wire. Commonly used electrode sizes are (mm): 0.8, 1.0, 1.2, 1.6 and 2.4. Each size has a usable current range depending on wire composition and spray- type arc or short- circuiting arc is used. [7]
- *Welding Current:* The value of welding current used in MIG has the greatest effect on the deposition rate, the weld bead size, shape and penetration. In MIG welding, metals are generally welded with direct current polarity electrode positive (DCEP, opposite to TIG welding), because it provides the maximum heat input to the work and therefore a relatively deep penetration can be obtained. When all the other welding parameters are held constant, increasing the current will increase the depth and the width of the weld penetration and the size of the weld bead.
- *Welding Voltage:* The arc length (arc voltage) is one of the most important variables in MIG that must be held under control. When all the variables such as the electrode composition and sizes, the type of shielding gas and the welding technique are held constant, the arc length is directly related to the arc voltage. High and low voltages cause an unstable arc. Excessive voltage causes the formation of excessive spatter and porosity, in fillet welds it increases undercut and produces narrower beads with greater convexity, but an excessive low voltage may cause porosity and overlapping at the edges of the weld bead. And with constant voltage power source, the welding current increase when the electrode feeding rate is increased and decreased as the electrode speed is decreased, other factors remaining constant. This is a very important variable in MIG welding, mainly because it determines the type o metal transfer by influencing the rate of droplet transfer across the arc. The arc voltage to be used depends on base metal thickness, type of joint, electrode composition and size, shielding gas composition, welding position, type of weld and other factors.
- *Shielding Gas:* The primary function of shielding gas is to protect the arc and molten weld, pool from atmosphere oxygen and nitrogen. If not properly protected it forms oxides and nitrites and result in weld deficiencies such as porosity, slag inclusion and weld embrittlement. Thus the shielding gas and its flow rate have a substantial effect on the following: Arc characteristics, Mode of metal transfer, penetration and weld bead profile, speed of welding, cleaning of action, weld metal mechanical properties. Argon, helium and argon-helium mixtures are used in many applications for welding non-ferrous metals and alloys. Argon and Carbon dioxide are used in Carbon steel. [7]
- *Arc Travel Speed:* The travel speed is the rate at which the arc travels along the work- piece. It is controlled by the welder in semiautomatic welding and by the machine in automatic welding. The effects of the travel speed are just about similar to the effects of the arc voltage. The penetration is maximum at a certain value and decreases as the arc speed is varied. For a constant given current, slower travel speeds proportionally provide larger bead and higher heat input to the base metal because of the longer heating time. The high input increases the weld penetration and the weld metal deposit per unit length and consequently results in a wider bead contour. If the travel speed is too slow, unusual weld build-up occurs, which causes poor fusion, lower penetration, porosity, slag inclusions and a rough uneven bead. The travel speed, which is an important variable in MIG, just like the wire speed (current) and the arc voltage, is chosen by the operator according to the thickness of the metal being welded, the joint fit-up and welding position.

• Literature Review

- **UgurEsme etal,** studied an investigation of the effect andoptimization of welding parameters on the tensileshear strength in the resistance spot welding (RSW)process. The experimental studies were conductedunder varying electrode forces, welding currents,electrode diameters, and welding times.[2]

- **Anoop C A, Pawan Kumar etal**, studied use of taguchi method to design process parameters that optimize mechanical properties of weld specimen Aluminium alloy 7039 used in aircraft, automobiles, infantry combat vehicles and high speed trains. Process parameters of Pulsed GTAW setup considered are Pulse Current, Base current and Pulse Frequency Assigning process parameters to L-9 orthogonal array, experiments were conducted and optimization condition was obtained along with the identification of most influencing parameters using S/N analysis, mean response analysis and ANOVA[3]

- **Chang etal,** studied that the Taguchimethod as a powerful optimization tool for designing high quality systems that is based on orthogonal arrayexperiments with an optimum setting of process controlparameters.[4]

- **T. KURS¸UN etal,** studied medium-carbon steel (AISI 1030) plates of 10 mm thickness, were welded by using the synergic controlledpulsed (GMAW-P) and manual gas metal arc (GMAW) welding techniques. Constant wire feed speed, voltage, welding speedand gas flow rates and ASP316L austenitic stainless steel filler metal were used in thesetechniques. The interface appearances of the welded samples were examined by optical microscopy (OM), scanning electronmicroscopy (SEM), energy dispersive spectrometry (EDS) and X-Ray diffraction (X-RD). In order to determine mechanicalproperties of samples, the tensile, impact and microhardness tests were conducted. The GMAW-P joints of AISI 1030 steel couples showed superior tensile strength, less grain growth and narrower heat affected zone (HAZ) when compared withGMAW joints, and this was mainly due to lower heat input, fine fusion zone grain and higher fusion hardness.[5]

- **P. V. Gopal Krishna, K. Veladri and Syed Qasim Ali** Research on welding of materials like steel isstill critical and ongoing. K. Kishore, P. V. GopalKrishna, K. Veladri and Syed QasimAli[5] Researchon welding of materials like steel is still critical andongoing. [6]

- **SouravDatta, Ajay Biswas, Gautam Majumdar** Sensitivity Analysis has been carried out to check the case sensitiveness of relationimportance of different bead geometry parameters imposing predominant effect on the optimalparametric combination. [7]

- **P K Palani, Dr N Murugan, The DOE** using Taguchi approach cansignificantly reduce time required for experimentalinvestigations6-8. In this investigation, in the firststage, Taguchi's orthogonal arrays were usedtoconduct the experiments to find the contributions ofeach factor and to optimize the parameter settings.[8]AISI D2 and D3 tool steel materials are select for studying effect of process sequence on behavior of cryotreated cold work tool steel at different process cycles. The chemical composition of specimen (dia.10mm, Height 35mm) was analyzed in optical emission spectroscope (OES). The machine used for the analysis of raw material chemical composition was named as Spectrophoto Analyzer [AS 200(Switzerland)].

- OBJECTIVE

- By selecting optimized welding parameter , improving the tensile strength of pipe joints welded by using Gas metal arc welding
- To reduce the cracking
- To reduce the porosity due to improper welding parameter
- To improve welding fusion
- To avoid oxidation
- To improve appearance
- To improve welding quality

- GMAW Defects

Common weld defects include:

- Lack of fusion
- Lack of penetration or excess penetration
- Porosity
- Inclusions
- Cracking
- Undercut
- Lamellar tearing

Any of these defects are potentially disastorous as they can all give rise to high stress intensities which may result in sudden unexpected failure below the design load or in the case of cyclic loading, failure after fewer load cycles than predicted.

- *Types of Defects*

- *Fusion and penetration:* To achieve a good quality join it is essential that the fusion zone extends the full thickness of the sheets being joined. Thin sheet material can be joined with a single pass and a clean square edge will be a satisfactory basis for a join. However thicker material will normally need edges cut at a V angle and may need several passes to fill the V with weld metal. Where both sides are accessible one or more passes may be made along the reverse side to ensure the joint extends the full thickness of the metal. Lack of fusion results from too little heat input and / or too rapid traverse of the welding torch (gas or electric). Excess penetrations arises from to high a heat input and / or too slow transverse of the welding torch (gas or electric). Excess penetration - burning through - is more of a problem with thin sheet as a higher level of skill is needed to balance heat input and torch traverse when welding thin metal.
- *Porosity:* This occurs when gases are trapped in the solidifying weld metal. These may arise from damp consumables or metal or, from dirt, particularly oil or grease, on the metal in the vicinity of the weld. This can be avoided by ensuring all consumables are stored in dry conditions and work is carefully cleaned and degreased prior to welding.
- *Inclusions:* These can occur when several runs are made along a V join when joining thick plate using flux cored or flux coated rods and the slag covering a run is not totally removed after every run before the following run.
- *Cracking:* This can occur due just to thermal shrinkage or due to a combination of strain accompanying phase change and thermal shrinkage. In the case of welded stiff frames, a combination of poor design and inappropriate procedure may result in high residual stresses and cracking. Where alloy steels or steels with carbon content greater than about 0.2% are being welded, self cooling may be rapid enough to cause some (brittle) martensite to form. This will easily develop cracks. To prevent these problems a process of pre-heating in stages may be needed and after welding a slow controlled post cooling in stages will be required. This can greatly increase the cost of welded joins, but for high strength steels, such as those used in petrochemical plant and piping, there may well be no alternative.

Solidification Cracking: This is also called centreline or hot cracking. They are called hot cracks because they occur immediately after welds are completed and sometimes while the welds are being made. These defects, which are often caused by sulphur and phosphorus, are more likely to occur in higher carbon steels. Solidification cracks are normally distinguishable from other types of cracks by the following features:

- They occur only in the weld metal - although the parent metal is almost always the source of the low melting point contaminants associated with the cracking
- They normally appear in straight lines along the centreline of the weld bead, but may occasionally appear as transverse cracking
- Solidification cracks in the final crater may have a branching appearance
- As the cracks are 'open' they are visible to the naked eye

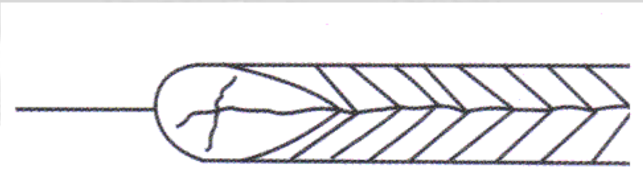


Fig.3 Centreline crack

A schematic diagram of a centreline crack is shown above on breaking open the weld the crack surface may have a blue appearance, showing the cracks formed while the metal was still hot. The cracks form at the solidification boundaries and are characteristically inter dendritic. There may be evidence of segregation associated with the solidification boundary.
The main cause of solidification cracking is that the weld bead in the final stage of solidification has insufficient strength to withstand the contraction stresses generated as the weld pool solidifies. Factors which increase the risk include:

- insufficient weld bead size or inappropriate shape
- welding under excessive restraint
- material properties - such as a high impurity content or a relatively large shrinkage on solidification

Joint design can have an influence on the level of residual stresses. Large gaps between conponents will increase the strain on the solidifying weld metal, especially if the depth of penetration is small. Hence weld beads with a small depth to width ratio, such as is formed when bridging a large wide gap with a thin bead, will be more susceptible to solidification cracking.

In steels, cracking is associated with impurities, particularly sulphur and phosphorus and is promoted by carbon, whereas manganese and sulphur can help to reduce the risk. To minimise the risk of cracking, fillers with low carbon and impurity levels and a relatively high manganese content are preferred. As a general rule, for carbon manganese steels, the total sulphur and phosphorus content should be no greater than 0.06%. However when welding a highly restrained joint using high strength steels, a combined level below 0.03% might be needed.

Weld metal composition is dominated by the filler and as this is usually cleaner than the metal being welded, cracking is less likely with low dilution processes such as MMA and MIG. Parent metal composition becomes more important with autogenous welding techniques, such as TIG with no filler.

Hydrogen induced cracking (HIC) - also referred to as hydrogen cracking or hydrogen assisted cracking, can occur in steels during manufacture, during fabrication or during service. When HIC occurs as a result of welding, the cracks are in the heat affected zone (HAZ) or in the weld metal itself.

Four requirements for HIC to occur are:

- Hydrogen be present, this may come from moisture in any flux or from other sources. It is absorbed by the weld pool and diffuses int o the HAZ.
- A HAZ microstructure susceptible to hydrogen cracking.
- Tensile stresses act on the weld
- The assembly has cooled to close to ambient - less than 150oC

HIC in the HAZ is often at the weld toe, but can be under the weld bead or at the weld root. In fillet welds cracks are normally parallel to the weld run but in butt welds cracks can be transverse to the welding direction.

- *Undercutting:* In this case the thickness of one (or both) of the sheets is reduced at the toe of the weld. This is due to incorrect settings / procedure. There is already a stress concentration at the toe of the weld and any undercut will reduce the strength of the join.
- *Lamellar tearing:* This is mainly a problem with low quality steels. It occurs in plate that has a low ductility in the through thickness direction, which is caused by non metallic inclusions, such as suphides and oxides that have been elongated during the rolling process. These inclusions mean that the plate can not tolerate the contraction stresses in the short transverse direction. Lamellar tearing can occur in both fillet and butt welds, but the most vulnerable joints are 'T' and corner joints, where the fusion boundary is parallel to the rolling plane. These problem can be overcome by using better quality steel, 'buttering' the weld area with a ductile material and possibly by redesigning the joint.

- *Inspection*

- *Detection Visual Inspection:* Prior to any welding, the materials should be visually inspected to see that they are clean, aligned correctly, machine settings, filler selection checked, etc.

As a first stage of inspection of all completed welds, visual inspected under good lighting should be carried out. A magnifying glass and straight edge may be used as a part of this process.

Undercutting can be detected with the naked eye and (provided there is access to the reverse side) excess penetration can often be visually detected.

- *Liquid Penetrant Inspection:* Serious cases of surface cracking can be detected by the naked eye but for most cases some type of aid is needed and the use of dye penetrant methods are quite efficient when used by a trained operator.

This procedure is as follows:

- Clean the surface of the weld and the weld vicinity
- Spray the surface with a liquid dye that has good penetrating properties
- Carefully wipe all the die off the surface
- Spray the surface with a white powder
- Any cracks will have trapped some die which will weep out and discolour the white coating and be clearly visible

- *X - Ray Inspection:* Sub-surface cracks and inclusions can be detected 'X' ray examination. This is expensive, but for safety critical joints - eg in submarines and nuclear power plants - 100% 'X' ray examination of welded joints will normally be carried out.

- *Ultrasonic Inspection:* Surface and sub-surface defects can also be detected by ultrasonic inspection. This involves directing a high frequency sound beam through the base metal and weld on a predictable path. When the beam strikes a discontinuity some of it is reflected beck. This reflected beam is received and amplified and processed and from the time delay, the location of a flaw estimated. Porosity, however, in the form of numerous gas bubbles causes a lot of low amplitude reflections which are difficult to separate from the background noise. Results from any ultrasonic inspection require skilled interpretation.
- *Magnetic Particle Inspection:* This process can be used to detect surface and slightly sub-surface cracks in Ferro-magnetic materials (it cannot therefore be used with austenitic stainless steels). The process involves placing a probe on each side of the area to be inspected and passing a high current between them. This produces a magnetic flux at right angles to the flow of the current. When these lines of force meet a discontinuity, such as a longitudinal crack, they are diverted and leak through the surface, creating magnetic poles or points of attraction. A magnetic powder dusted onto the surface will cling to the leakage area more than elsewhere, indicating the location of any discontinuities. This process may be carried out wet or dry, the wet process is more sensitive as finer particles may be used which can detect very small defects. Fluorescent powders can also be used to enhance sensitivity when used in conjunction with ultra violet illumination.

- *Welding Problems*

In much the same way that the automatic transmission has simplified the process of driving, Gas Metal Arc Welding (GMAW) has simplified the process of welding. Of all welding methods, GMAW is said to be one of the easiest to learn and perform. The main reason is because the power source does virtually all the work as it adjusts welding parameters to handle differing conditions; much like the sophisticated electronics of an automatic transmission.
Because less skill is required, many operators are able to GMA weld at an acceptable level with limited training. These same operators run into trouble, however, when they begin creating inferior welds and are unable to diagnose and correct their own problems. The guidelines listed below will help even inexperienced operators create high quality welds as well as offering tips for those who have been using the GMAW process for a number of years.
Most common welding problems fall into four categories:

- Weld porosity
- Improper weld bead profile
- Lack of fusion
- Faulty wire delivery related to equipment set-up and maintenance.
- *Weld Metal Porosity:*

Porosity Problem #1: Improper Surface Conditions
The most common cause of weld porosity is an improper surface condition of the metal. For example, oil, rust, paint or grease on the base metal may prevent proper weld penetration and hence lead to porosity. Welding processes that generate a slag such as Shielded Metal Arc Welding (SMAW) or Flux-Cored Arc Welding (FCAW) tend to tolerate surface contaminates better than GMAW since components found within the slag help to clean the metal's surface. In GMAW, the only contamination protection is provided by the elements which are alloyed into the wire.
Porosity Problem #2: Gas Coverage The second leading cause of porosity in welds is a problem with the shielding gas coverage. The GMAW process relies on the shielding gas to physically protect the weld puddle from the air and to act as an arc stabilizer. If the shielding gas is disturbed, there is a potential that air could
Porosity Problem#3: Base Metal Properties Another cause of weld porosity may be attributed simply to the chemistry of the base metal. For instance, the base metal may be extremely high in sulfur content.

- *Improper Weld Bead Profile:* If operators are experiencing a convex-shaped or concave-shaped bead, this may indicate a problem with heat input or technique.

Improper Bead Problem #1: Insufficient Heat Input
A convex or "ropy" bead indicates that the settings being used are too cold for the thickness of the material being welded. In other words, there is insufficient heat in the weld to enable it to penetrate into the base metal.
Improper Bead Problem #2: Technique A concave or convex-shaped bead may also be caused by using an improper welding technique. For example, a push or forehand technique tends to create a flatter bead shape than a pull or backhand technique.
Improper Bead Problem #3: Inadequate Work Cable
Problems with the work cable can result in inadequate voltage available at the arc. Evidence of a work cable problem would be improper bead shape or a hot work cable.

- *Lack of Fusion:* If the consumable has improperly adhered to the base metal, a lack of fusion may occur. Improper fusion creates a weak, low quality weld and may ultimately lead to structural problems in the finished product.

Lack of Fusion Problem: Cold Lapping in the Short Arc Transfer Process: In short arc transfer, the wire directly touches the weld pool and a short circuit in the system causes the end of the wire to melt and detach a droplet. This shorting happens 40 to 200 times per second. Fusion problems may occur when the metal in the weld pool is melted, but there is not enough energy left to fuse it to the base plate. In these cases, the weld will have a good appearance, but none of the metal has actually been joined together. Since lack of fusion is difficult to detect visually, it must be checked by dye-penetrant, ultrasonic or bend testing.

- *Faulty Wire Delivery:* If the wire is not feeding smoothly or if the operator is experiencing a chattering sound within the gun cable, there may be a problem with the wire delivery system. Most of the problems related to wire delivery are attributed to equipment set-up and maintenance.

Faulty Wire Delivery Problem #1: Contact Tip There is a tendency among operators to use oversized tips, which can lead to contact problems, inconsistencies in the arc, porosity and poor bead shape.

Faulty Wire Delivery Problem #2: Gun Liner A gun liner, like the contact tip, must be sized to the wire being fed through it. It also needs to be cleaned or replaced when wire is not being fed smoothly.

Faulty Wire Delivery Problem #3: Worn Out Gun Inside the gun are very fine strands of copper wire that will eventually break and wear out with time.

- *Remedy*

If the gun becomes extremely hot during use in one particular area, that is an indication that there is internal damage and it will need to be replaced. In addition, be certain that the gun is large enough for the application. Operators like to use small guns since they are easy on the hand, but if the gun is too small for the application, it will overheat.

Faulty Wire Delivery Problem #4: Drive Roll Drive rolls on the wire feeder periodically wear out and need to be replaced.

Faulty Wire Delivery Problem #5: Wire Coming off Reel and Tangling some wire feeding problems occur because the inertia from the wire reel causes it to coast after the gun trigger is released.

- Troubleshooting of GMAW

Today’s MIG welders have become so easy to use that when a weld doesn’t turn out as expected or the equipment starts acting differently, it can confuse the operator and leave him searching for an answer. This article will look at some of the most common equipment and technique issues that crop up and how to solve them. Consult your manual for your specific machine’s set up and operation. Many companies post their manuals on-line. Miller manuals as well as additional troubleshooting tips can be found at MillerWelds.com.

Equipment Issues: Often, the complaint is heard that a welder was working perfectly and then suddenly the operator started experiencing problems with arc stability, burnbacks or porosity in the weld. If this happens, after changing wire or gas, the new spool of wire or cylinder of gas should be checked first.

Shielding Gas: Make sure you’re using the right shielding gas. When welding steel, a 75% Ar – 25% CO_2 mixture is usually recommended. If you were to inadvertently use 100% argon on steel, the weld will have low penetration and produce excessive spatter. Similarly, if instead of using the 100% argon usually recommended for aluminum, you use a 75/25 mix, the weld will turn black, and you will observe tiny aluminum “BB’s” on the weld surface. Turning up the amperage to compensate will only cause melt-thru.

If you were achieving satisfactory welds before changing gas, use a cylinder you know to be good and see if that corrects the problem.

Electrode Wire: Exposed to moisture in the air or environment, welding wire not used for a period of time can develop an oxide layer. If feeding or arc instability problems occur after changing wire, examine the spool to make sure the wire is in good condition. If you’re not planning on using a spool of wire immediately, make sure to store it in a plastic bag in a dry environment, preferably with small packages of desiccant.

Wire feeding issues can affect performance; good welds require a consistent wire feed supply. One way to test if wire is feeding smoothly is to feed wire against a block of wood and watch for continuous smooth wire coil up, which implies there is no obstruction to wire feed. If the wire does not coil smoothly, there is a problem somewhere in the wire feed process.

Cable Liners: A kinked, worn, wrong size or partially plugged liner can easily lead to burnback or arc instability issues. Removable liners can be blown out with compressed air if dirty or replaced if worn or kinked.

Wire Feeder Drive Rolls: The drive rolls are designed to feed the electrode wire smoothly from the wire spool into the gun cable. However, if drive roll tension is set too tightly, the drive rolls not only can deform the wire (i.e., take on shape of drive roll grooves) – causing it to wear down the liner and contact tube – but also cause rough wire feeding, which can lead to arc instability or burnback. Too little tension can lead to wire slipping. Follow your owner's manual's instructions.

Wire Feeder Spool Brake: The electrode wire spool is mounted on a support arm equipped with a hub brake that prevents the spool from "free-wheeling" when the arc stops. Operators should set the brake with just enough tension to prevent freewheeling; too much tension will impede smooth wire feed through the drive rolls and gun cable, leading to arc instability, inconsistent wire feeding or burnback.

MIG Gun: Welders may find that issues with liners and contact tips are the source of most problems (arc instability, wire stubbing, burnback) related to the arc and electrode wire. Make sure that you match contact tip size with the wire size you're using. In addition, liners that are too small or too large can cause poor wire feeding. MIG guns are **never** intended to be used as a pry bar or hammer; abuse can damage the MIG gun's internal components and cause wire feed and shielding gas malfunctions.

Shielding Gas: Shielding gas protects the molten weld pool from the surrounding atmosphere, which would otherwise contaminate the weld. Figure 1 shows how the lack of shielding gas can cause porosity (pinholes) in the weld bead are formed in the face and weld interior in the absence of shielding gas. Check that there are no gas flow problems in the MIG gun (e.g., tear or hole in gas hose) and that the MIG gun o-rings are in good condition. Make sure the valve is turned on and supplying gas at the specified flow rate. If all of these checkpoints are O.K., determine if a fan or breeze is blowing away the flow of shielding gas around the arc.

Fig.4 **No Shielding Gas –** A lack of or inadequate shielding gas is easily identified by the porosity and (pinholes) in the face and interior of the weld.

Work Connection: Arc stumbling can occur if there is a poor connection between the workpiece or workbench and the welding machine output stud. Make sure the clamp is in good working condition and the work lead's cable lug is making good contact. Grind off rust or paint and ensure that the work clamp is connected as close to the work area as possible.

Voltage and Wire Feed Speed (WFS) Settings: Increasingly, welding equipment manufacturers are developing MIG welders that simplify parameter settings with automatic features. Miller's Auto-Set™, for example, enables users to set wire diameter and material thickness only¾then Auto-Set automatically sets WFS and voltage to achieve optimal welding results. In addition, most commercially available MIG welders today come with parameter charts that specify the proper voltage and WFS (amperage) settings for optimum welding performance. Manual setting is still available for broader applications, but the use of parameter charts is highly recommended and usually is available for download from provider web sites.

When manually setting parameters, here's what to look for:


Fig.5 **Voltage Too High:** Too much voltage is marked by poor arc control, inconsistent penetration, and a turbulent weld pool that fails to consistently penetrate the base material.

Fig.6 **Voltage Too Low –** Toolittle voltage results in poor arc starts, control and penetration. It also causes excessive spatter, a convex bead profile, and poor tie-in at the toes of the weld.

Fig.7 **Wire Feed Speed/Amperage Too High –** Setting the wire feed speed or amperage too high (depending on what type of machine you're using) can cause poor arc starts and lead to an excessively wide weld bead, burn-through and distortion.

Fig.8 **Wire Feed Speed/Amperage Too Low –** Anarrow, oftentimes convex bead with poor tie-in at the toes of the weld marks insufficient amperage.

Operator Issues

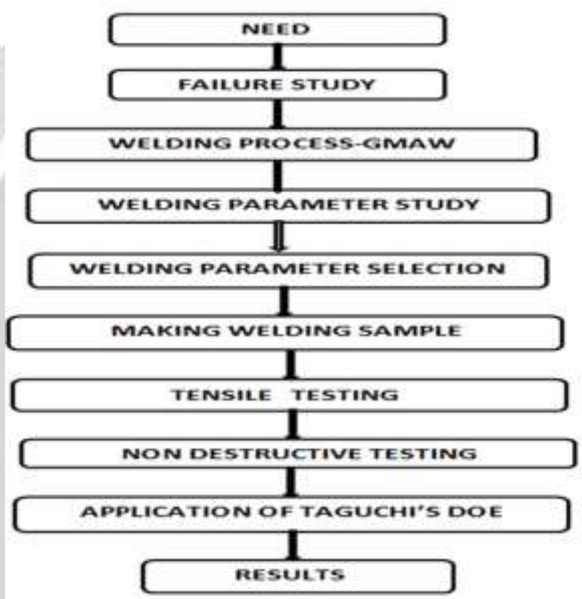
Operators are under complete control of travel speed and gun angle, so they can affect welding results with variations in their individual techniques.

Travel Speed: Excessively fast travel speed can lead to insufficient penetration because the arc does not stay in one place long enough to build up sufficient heat. This results in a narrow, convex bead with poor toe tie-in (Figure 7).

Too-slow travel speed may produce a large weld with excessive heat input resulting in heat distortion and possible burnthrough (See Figure 8). In most cases, proper travel speed is when the arc is on the leading edge of the puddle.

Gun Travel Angle: If your welds tend to have more spatter and less penetration and there is general arc instability, check your travel angle. Normal welding conditions in all positions specify a travel angle of 5 to 15 degrees for good weld puddle control. Excessive torch angle can cause limited penetration and

- Experimental Procedure



- *Material*

The material used for Gas metal arc welding (GMAW) is EN8 steel. The entire specimens were machined into the dimensions of 200mm long x 75mm x 10 mm thick. The details composition (weight %) of specimens is shown in TableI. This metal had very good welding characteristics and could be welded by all of the common welding techniques.

TABLE I

Chemical Composition of Base and Filler Metal (Weight %) Alloy

Material	C	Mn	Si	S(max)	P(max)	Cu(max)
AISI1040(EN-8)	0.40	0.75	0.25	0.05	0.04	-
ER 70S-6	0.19	1.63	0.98	0.025	0.025	0.025

Mechanical Properties

Tensile Strength -465 (N/mm2)

% Elongation-16% min

Hardness(HV) -201-255 BHN

- *WeldingMachine*

This sections provides the important specifications of the tool used in the welding process

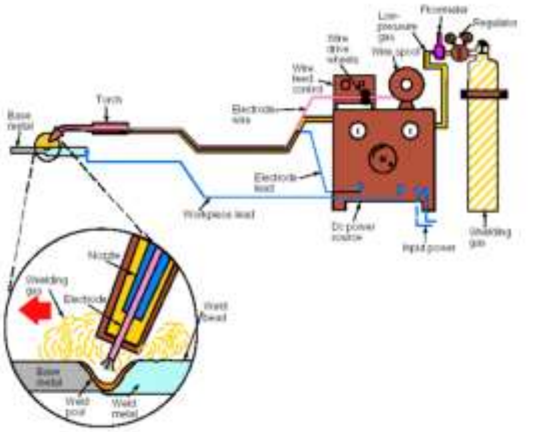


Fig.9 Gas Metal Arc Welding M/C

- *Welding Process Parameter Selection*

Based on literature review following is the range selected for three process parameter

TABLEII

Process parameter	Process Designation	Level 1	Level 2	Level 3
Welding Current(Amp)	A	180	210	240
Arc Voltage (volts)	B	24	27	30
Wire Feed Rate (m/min)	C	2	3	4

- EXPERIMENTAL WORK

- *Universal Testing Machine –Computerized*

Fig.10 Universal Testing Machine

Application:

Mechatronic Control System is a prominent manufacturer of Universal Testing Machine which is available in electronic and computerized functioning. This machine is used to test the tensile and compressive properties of material. The reason Universal Testing machine is named so because it can perform all the tests right from compression, bending to tension and examine the material in all mechanical properties. We offer these in grade of 10T, 20T, 40T, 60T and 100T.

Radiographic and ultrasonic weld inspection are the two most common methods of non-destructive testing (NDT) used to detect discontinuities within the internal structure of welds. The obvious advantage of both these methods of testing is their ability to help establish the weld's internal integrity without destroying the welded component. We shall briefly examine these two methods of non-destructive testing (NDT). We shall consider how they are used and what types of welding discontinuities they can be expected to find. We shall examine their advantages over other inspection methods and their limitations.

- *Radiographic Testing (RT)*

This method of weld testing makes use of X-rays, produced by an X-ray tube, or gamma rays, produced by a radioactive isotope. The basic principle of radiographic inspection of welds is the same as that for medical radiography. Penetrating radiation is passed through a solid object, in this case a weld rather that part of the human body, onto a photographic film, resulting in an image of the object's internal structure being deposited on the film. The amount of energy absorbed by the object depends on its thickness and density. Energy not absorbed by the object will cause exposure of the radiographic film. These areas will be dark when the film is developed. Areas of the film exposed to less energy remain lighter. Therefore, areas of the object where the thickness has been changed by discontinuities, such as porosity or cracks, will appear as dark outlines on the film. Inclusions of low density, such as slag, will appear as dark areas on the film while inclusions of high density, such as tungsten, will appear as light areas. All discontinuities are detected by viewing shape and variation in density of the processed film.

- *Ultrasonic Testing (UT)*

This method of testing makes use of mechanical vibrations similar to sound waves but of higher frequency. A beam of ultrasonic energy is directed into the object to be tested. This beam travels through the object with insignificant loss, except when it is intercepted and reflected by a discontinuity. The ultrasonic contact pulse reflection technique is used. This system uses a transducer that changes electrical energy into mechanical energy. The transducer is excited by a high-frequency voltage, which causes a crystal to vibrate mechanically. The crystal probe becomes the source of ultrasonic mechanical vibration. These vibrations are transmitted into the test piece through a coupling fluid, usually a film of oil, called a couplant. When the pulse of ultrasonic waves strikes a discontinuity in the test piece, it is reflected back to its point of origin. Thus the energy returns to the transducer. The transducer now serves as a receiver for the reflected energy. The initial signal or main bang, the returned echoes from the discontinuities, and the echo of the rear surface of the test piece are all displayed by a trace on the screen of a cathode-ray oscilloscope. The detection, location, and evaluation of discontinuities become possible because the velocity of sound through a given material is nearly constant, making distance measurement possible, and the relative amplitude of a reflected pulse is more or less proportional to the size of the reflector.

- Results And Discussion

Microscopic study

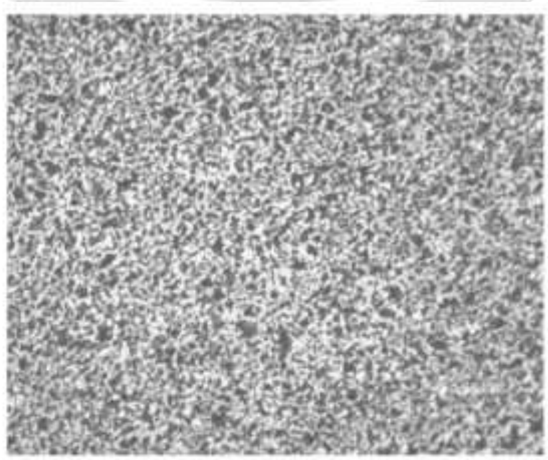


Fig.15 Microstructure of base metal

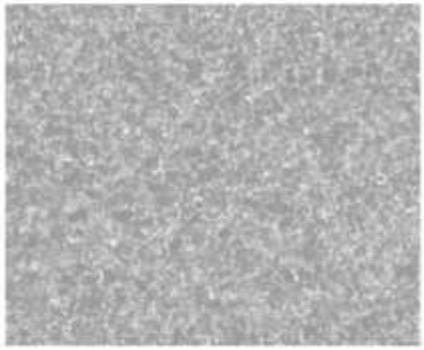


Fig.16 Microstructure of Heat Affected Zone

TABLE III
Experimental result for UTS and S/N ratio

welding current (amp)	**arc voltage (voltage)**	**wire feed rate (M/min)**	**tensile strength (Mpa)**	**S/N ratio**
180	24	2	255.500	48.1478
180	27	3	269.270	48.6038
180	30	4	375.130	51.4836
210	24	3	358.000	51.0777
210	27	4	395.750	51.9484
210	30	2	455.250	53.1650
240	24	4	218.875	46.8039
240	27	2	363.625	51.2131

TABLE IV
S/N response table for UTS

Level	**welding current (amp)**	**arc voltage (voltage)**	**wire feed rate (M/min)**
1	49.41	48.68	50.81
2	52.06	50.59	50.84
3	50.28	52.49	50.08
Delta	2.62	3.82	0.76
Rank	2	1	3

TABLE V
Result of annova for UTS

Symbol	**Parameter**	**DOF**	**Sum of sq.**	**Mean**	**F**	**%**
A	I	2	10.965	5.483	2.11	32.26
B	V	2	21.841	10.920	4.21	64.37
C	W	2	1.157	0.579	0.22	3.36
Error		2	5.191	2.595		0.01
Total		8	39.154			100

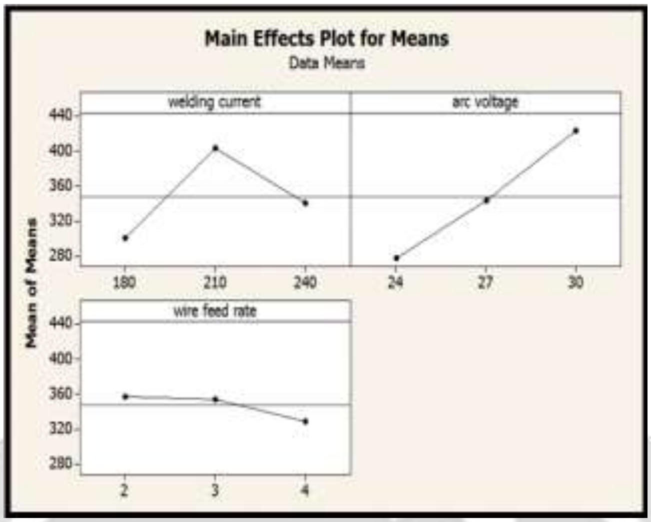


Fig.17 Main effect plot for means.

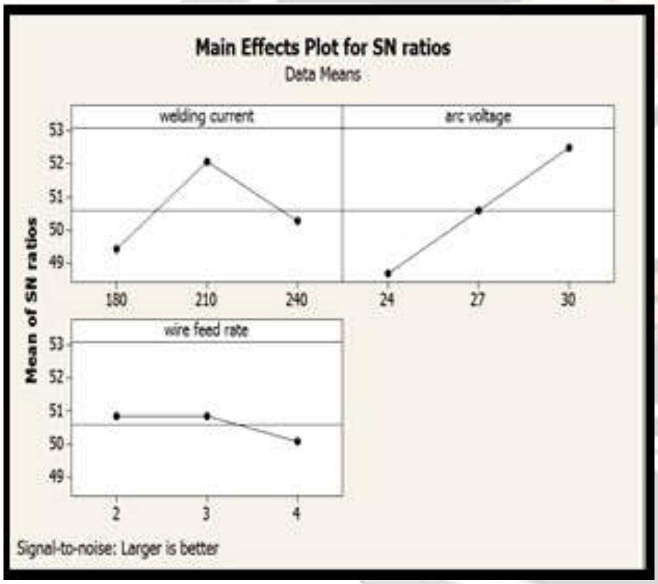


Fig.18 Main effect plot for SN ratios

- Conclusions

The following conclusions, from the experiential investigation can be made about the welding parameter and their influence on strength of weld and its quality From results of present experimental investigation and by doing Taguchi analysis the following conclusions are drawn

- Optimal Parameter are- A2B3C2 that are as follows

  Level 2 welding current 210 amp

  Level 3 arc voltage 30 volt

Level 2 wire feed rate 3 m/min

- From Annova analysis for UTS It is found that arc voltage has 64.37 % influence on tensile strength of welded joint

- Future scope

This study does not indicate for the other types of welding process as well as other types of welding process parameter. However one can pay attention to different material, filler material and applications in different areas.

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