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A comparative Study of Metal Inert Gas welding and Tungsten Inert Gas welding processes: A Review

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ABSTRACT

The existing technic which was used to the automated system included welding which was done by means of hand held welding gun. In comparison with a automated welding it is less accurate as well as precision. The process consumes more time and large number of workers for the production it's affected on production cost and profit margin. The automated method is proposed because fewer amounts of production and safety issue of the workers. Industrial implementations of the automated process increase productivity, profit margin, safety .Different conventional, automated welding process are introduced here. The various welding parameters such as welding speed, voltage and gas flow rate varies on material and the effects of these parameters on weld bead geometry such as penetration, width & height. The MIG welding parameters are the most important factors affecting the quality, productivity and cost of welding. These welding parameters are welding current, welding voltage, Gas flow rate, wire feed rate, etc. Today, GMAW is the most common industrial welding process, preferred for its versatility, speed and the relative ease of adapting the process of automation. Tungsten inert gas (TIG) welding and Metal inert gas (MIG) are the most popular gas shielding arc welding processes used in many industrial fields. Other arc welding processes have limited quality when they are compared to TIG welding processes.

***Keywords: MIG welding, TIG Welding, Welding Parameters*.**

I.INTRODUCTION

Welding is a fabrication or sculptural process that joins material usually metals or thermoplastics by causing of coalescence. This is done by melting the work piece and adding a filler material to form a pool of molten metal that cools to become a strong joint with pressure sometimes used in conjunction with heat or by itself to produce the weld. Welding is one of the most essential and inescapable process used for major fabrication process in the Manufacturing industries. Various types of Welding process are like Shield metal Arc Welding (SMAW), Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), Flux Cored Arc Welding (FCAW) and Submerged Arc Welding (SAW). Manual welding continuous to play a significant role in welding application for several reasons. Human tends to more adaptable to variation in the welding process so need a skilled workers who known about welding parameters to adjust and how to keep the welding process under control. With an international shortage of skilled welders and concerns about exposure of personnel to welding hazards it is appropriate to consider how joining processes can be simplified and automated. Since the beginning, welding is a process that depends on the welder skills. This relation is so direct that the classification, according to the application methods, is based on the degree of control of the activities related to welding that depends on the human interference. These application methods are classified as manual, semi-automatic, mechanized, automatic, and robotic and with adaptive control, according to American Welding Society (AWS).

Now days welding finds wide spread applications in almost all branches of engineering industry. the increasing need to improve occupational health and safety both in the workshop and general environment, pressure to improve productivity and reduce cost and the need to maintain joint integrity in critical structures. It is extensively mostly employed in fabrication and steel industry, framework, railways, wagons, furniture automobile bodies, ship building and nuclear [1].Due to the constant increase in the application of welding in every aspects of manufacturing, it has to be constantly improved, experimented and upgraded. Now in the presence of modern technologies and increasing demands of quality of products, every manufacturing process must be improved and innovated. The shortage of skilled welders has been highlighted in the media; for example The Wall Street journal reviewed the problem in 2006 [1] indicating a major shortage of welders and escalating weekly earnings. The same article claimed that on current estimates demand for skilled welders in the USA will outstrip supply by 200000 by 2010. This is by no means an isolated problem; it has been reported as an international problem in countries such as Japan, and Australia as well as in Western Europe. There is believed to be a link between the perceived OH&S hazards associated with welding and the ability to recruit new welding personnel. OH&S is an issue which must be addressed due to our moral responsibility to welders and society in general as well as the recent and sometimes ill conceived spate of litigation which often exploits our lack of technical knowledge concerning the physical effects of welding hazards. In terms of cost and productivity it is known that in most common welding operations (on plain carbon steel) labor accounts for 70 to 80% of the total welding cost. Since labor costs are escalating, and will inevitably do so even in developing economies, total fabrication costs will increase accordingly. Productivity improvements are difficult to envisage in such a labor intensive, highly skilled and OH&S affected environment [5]. Automated welding implementation required for:

□ Reduce skill requirements
□ Improve OH&S
□ Improve productivity
□ Reduce cost
□ Improve quality

Gas metal arc welding (GMAW), sometimes referred to by its subtypes metal inert gas (MIG) welding or metal active gas (MAG) welding, is a welding process in which an electric arc forms between a consumable wire electrode and the work piece metal(s), which heats the work piece metal(s), causing them to melt and join.

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Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from contaminants in the air. The process can be semi-automatic or automatic. A constant voltage, direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used. There are four primary methods of metal transfer in GMAW, called globular, short-circuiting, spray, and pulsed-spray. Arc welding is a technique to melt and join different materials that is widely used in the industry. The gas tungsten arc welding (GTAW) process is sometimes referred to as TIG, or heliarc. The term TlG is short for tungsten inert gas welding. Under the correct welding conditions, the tungsten electrode does not melt and is considered to be non consumable [6]. To make a weld, either the edges of the metal must melt and flow together by themselves or filler metal must be added directly into the molten pool. Filler metal is added by dipping the end of a filler rod into the leading edge of the molten weld pool. Most metals oxidize rapidly in their molten state. In Germany this method is called WIG welding, the W meaning wolfram.TIG welding is the international standardized designation for this welding method. Although most other welding processes are faster and less expensive, the clean, neat, slag-free welds GTAW produces are used because of their appearance and ease of finishing. TIG welding is a welding process that uses a power source, a shielding gas and a TIG hand piece. An electric arc is then created between the tungsten electrode and the work piece. The tungsten and the welding zone are protected from the surrounding air by a gas shield (inert gas). There are number of parameters affecting on the welding so they must be selected carefully which are improving the quality of welding.[7]

II.TYPES OF WELDING PROCESSES

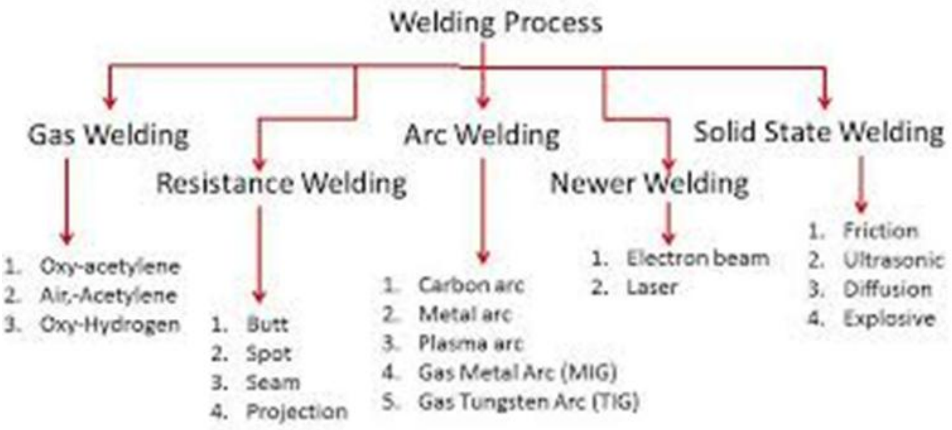

Fig. 1 Welding process

III.ARC WELDING PROCESSES

Arc welding includes several different subtypes and for the sake of simplicity but mostly common types are MIG (Metal inert Gas), also known as GMAW (Gas Metal Arc Welding) and TIG (Tungsten Inert Gas) also referred to as GTAW (Gas Tungsten Arc Welding) welding. The primarily main difference between MIG and TIG , the MIG welding utilizes continuously feeding wire and TIG requires the use of long welding rod that are slowly fed into the weld puddle as shows in the chart below both are considered excellent choices and each has advantages and suitability profile varies between application An arc is moved along the line of weld as circular seams by the motion of an automatic welding machine or of the object itself. [2].If the machine is structurally joined with the travelling mechanism, it is called self propelled, but it moves directly on the surface of the object or along the light removable track laid on the object, it is then called welding tractor. Flexible hose

Table No. 1. Difference between MIG and TIG welding

Types	MIG (Metal Inert Gas)	TIG (Tungsten Inert Gas)
Basics	Utilizes a consumable welding wire	Utilizes a non consumable welding wire
	Requires one of the shielding gasses to protect the weld pool e.g. Argon, carbon dioxide, helium or oxygen.	Requires one of the shielding gasses to protect the weld pool e.g. Argon, helium hydrogen or nitrogen
Metals used	Thin and medium thickness metals as like a aluminium,mild steel and stainless steel can generally be used on other non-ferrous metals and alloy	Mild steel, stainless steel, copper, nickel can be used in a certain applications
Electrode feeding	Electrode is feeded continuously from a wire reel	It does not require electrode feed
Power used	DC with reverse polarity is used.	It can use both A.C and D.C
Filler metal	Filler metal is compulsory used.	Filler metal may or may not be used.
Suitability	It can weld up to 40 mm thick metal sheet	Metal thickness is limited about 5 mm.
Advantages	1. Faster production than TIG welding and still produce high quality welds 2. Stable arc 3.Low spatter 4.Good weld bead appearance 5.Can be used in every position	1. Low spatter 2. Easy pose weld clean up 3. Adjustable filler metal independent of arc 4. Precise and clean looking welds 5. Slower production but more flexible in terms of suitable application

semi-automatic types of machines are very popular. In these the electrode wire is fed from the mechanism along the flexible hose to a holder in the welder's hand. Instead of a flux, protective gases such as argon or carbon dioxide and also gaseous mixture are used. However, because of metal spraying in this case, the current and welding speed are lower than when welding under a flux. Automatic welding using a non-fusible tungsten electrode in protective gases usually argon, is also known. In addition to a wire with a solid cross section a so – called power electrode is also filled with iron power alloyed with flux forming component.

3.1 Difference between MIG Welding and TIG Welding:

IV. MIG WELDING

4.1 a) Principle:

MIG works on same principle of TIG or arc welding. It works on basic principle of heat generation due to electric arc. This heat is further used to melt consumable electrode and base plate metal which solidify together and makes a strong joint. The shielded gases are also supplied through nozzle which protects the weld zone from other reactive gases. This gives good surface finish and a stronger joint.

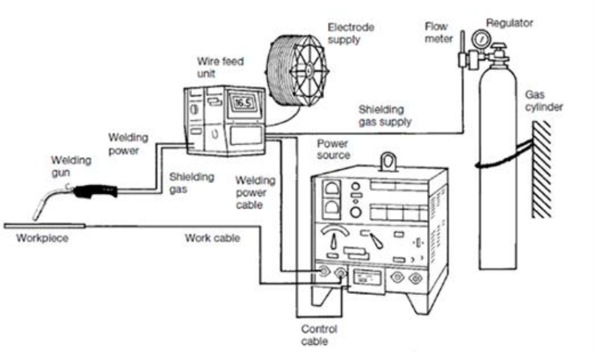

Fig.2 MIG Welding Set-up[6]

b) Power Source:

In this type of welding process, a DC power supply is used with reverse polarity. Reverse polarity means the electrode or in case of MIG welding electrode wire is connected positive terminal and work piece to negative terminal. It is due to principle of electric circuit which state that 70% of heat is always on positive side. So reverse polarity ensures that the maximum amount of heat liberate at tool side which melt the filler metal in proper way. Straight polarity can cause unstable arc that result into large spatter. The power source consist a power supply, a transformer, a rectifier which change AC into DC and some electronic controls which control the current supply according to weld requirement.

c) Wire Feeder System:

MIG welding needs continuous consumable electrode supply for welding two plates. This consumable electrode used in form of wire. These wire is continuously supplied by wire feed mechanism or system. It controls the speed of the wire and also pushes the wire form welding torch to welding area. These are available in different shapes and sizes. It consist a wire pool holder, a driving motor, a set of driving rollers and wire feed controls. The wire feed speed is directly control the current supply through power supply. If the wire feeding speed is high, it required more current in welding zone to produce proper heat for melting of it.

d) Welding Torch:

This torch is slightly different as used in TIG welding. In this torch there is a mechanism which holds the wire and supplies it continuously with the help of wire feed. The front end of the torch is fitted with a nozzle. The nozzle is used to supply inert gases. These gases form a shielding area around the weld zone and protect it from oxidization. The welding torch is air cooled or water cooled according to the requirement. For high current supplied, the torch is water cooled and for low supply it is air cooled.

e) **Shielding Gases:**

The primary function of shielding gases is to protect weld area from other reactive gases like oxygen etc. which can affect the strength of welding joint. These shielding gases are also form plasma which helps in welding. The choice of gas is depend on the welding material. Mostly argon, helium and other inert gases are used as shielding gases.

f) Regulators:

As the name implies, they are used to regulate the flow of inert gases from the cylinder. The inert gases are filled into cylinder at high pressure. These gases cannot be used at this pressure so a regulator is used between the gases supply which lower down the gases pressure according to welding requirements.

4.2 Working:

Its working can be summarized as follow.

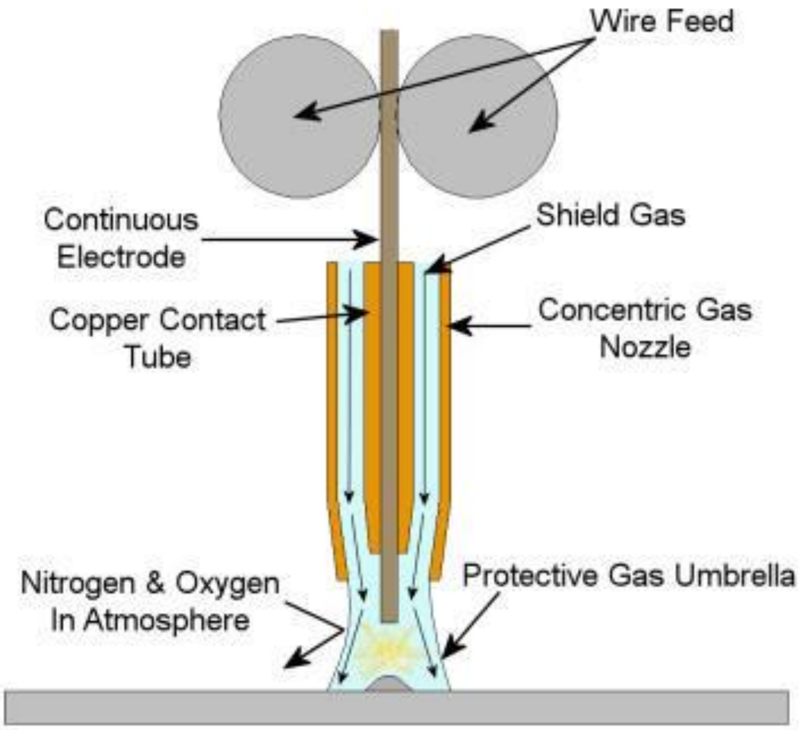

Fig. 3 Working of MIG Welding

- First, a high voltage current is change into DC current supply with high current at low voltage. This current passes though welding electrode.
- A consumable wire is used as electrode. The electrode is connected to the negative terminal and work piece from positive terminal.
- A fine intense arc will generate between electrode and work piece due to power supply. This arc used to produce heat which melts the electrode and the base metal. Mostly electrode is made by the base metal for making uniform joint.
- This arc is well shielded by shielding gases. These gases protect the weld form other reactive gases which can damage the strength of welding joint.
- This electrode travels continuously on welding area for making proper weld joint. The angle of the direction of travel should be kept between 10-15 degree. For fillet joints the angle should be 45 degree.

4.3 Applications:

- MIG is best suited for fabrication of sheet metal.
- Generally all available metals can be weld through this process.

- It can be used for deep groove welding.

4.4 Advantages and Disadvantages:

a) Advantages:

- It provide higher deposition rate.
- It is faster comparing to arc welding because it supply filler material continuously.
- It produce clean weld with better quality.
- There is no slag formation.
- Minimize weld defects.
- This welding produces very little slag.
- It can be used to make deep groove weld.
- It can be easily automated.

b) Disadvantages:

- It cannot be used for welding in difficult to reach portions.
- Higher initial or setup cost.
- It cannot be used for outdoor work because wind can cause damage of gas shield.
- It required high skilled labor.

V. TIG WELDING

5.1 Principle of TIG Welding:

TIG welding, an arc is maintained between a tungsten electrode and the work piece in an inert atmosphere (Ar, He, or Ar-He mixture). Depending on the weld preparation and the work-piece thickness, it is possible to work with or without filler. The filler can be introduced manually or automatically with regarding to types of process. The process itself can be manual, partly mechanized, fully mechanized or automatic. [10]

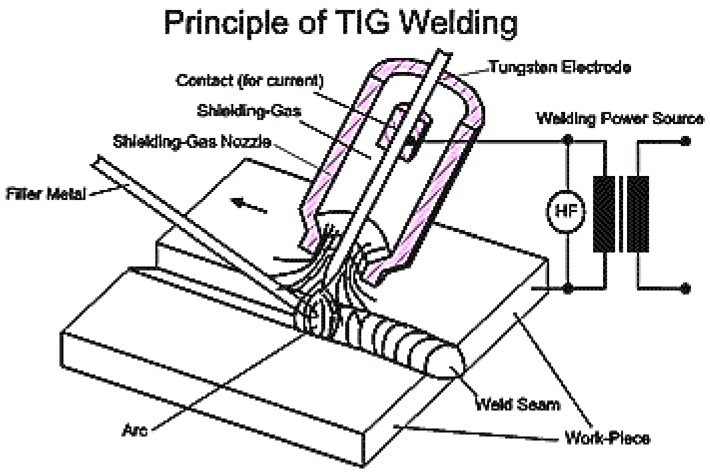

Fig.4 Working Principle of TIG Welding

The welding power source delivers direct or alternating current. By means of a gas nozzle the shielding gas is lead to the welding zone where it replaces the atmospheric air. TIG welding differs from the other arc welding processes by the fact that the electrode is not consumed like the electrodes in other processes such as MIG/MAG.

5.2 Manual TIG:

This process can be used for relatively thin components, small or circular welds. Depending on the weld preparation and the work piece thickness, it is possible to work with or without filler. The filler can be introduced manually or half mechanically without current or only half mechanically under current.

Compact and light TIG welding machines (less than 20kg) are available on the market. Easy to use, and to carry, they are ideal for small and localized repairs of commercial vehicles (breach in the skin of a tank, etc…).

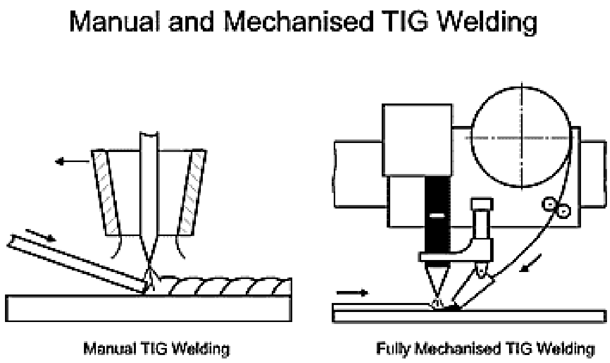

Fig.5 The manual and fully mechanized TIG welding processes.[4]

5.3 Automatic TIG Welding

Here, the welding torch is automatically guided, and if filler is used, it is fed automatically from a reel.

This process is attractive for large production runs, i.e. for vehicle manufacturers, especially when there is no access to the back of the weld. There is also a TIG version where helium is used as shielding gas, which helps to achieve a high temperature in the arc. Here, direct current with straight polarity is used instead of alternative current. Thickness from 0.2 up to 10 mm can be welded. This process is strictly for automatic welding.[4]

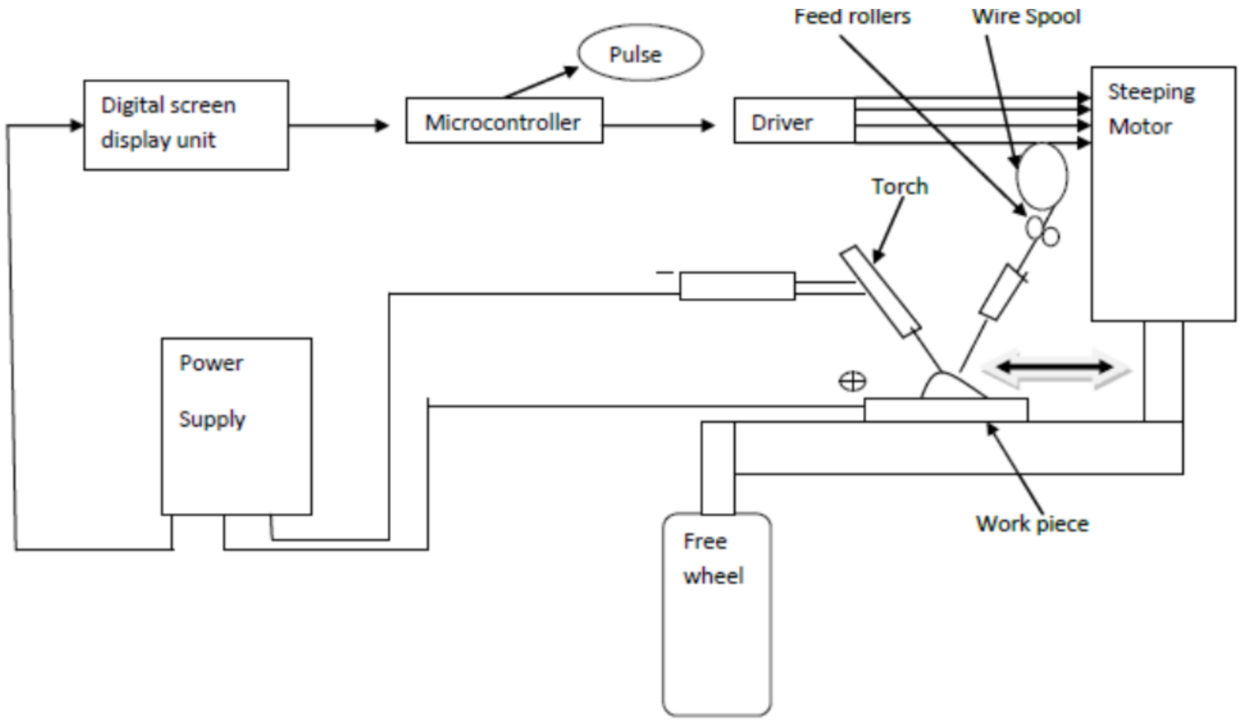

Fig.6 Automatic TIG welding Set-up

5.4 Advantages, applications and material used

a) Advantages

- It provides a concentrated heating of the work piece.
- It provides an effective protection of the weld pool by an inert shielding gas.
- It can be independent of filler material.

- The filler materials do not need to be finely, prepared if only the alloying is all right.
- There is no need for after treatment of the weld as no slag or spatters are produced
- Places of difficult access can be welded.

b) Areas of application

TIG welding is often used for jobs that demand high quality welding such as for instance:

- The offshore industry
- Combined heat and power plants
- The petrochemical industry
- The food industry
- The chemical industry
- The nuclear industry

c) Materials for TIG welding

- Welding of thin materials in stainless steels
- Aluminum
- Nickel
- Nickel alloys

VI. PARAMETERS AFFECTED ON WELDING

It is important to consider various aspects while selecting suitable type of welding parameters for developing weld joints in order to produce good welding or high quality weld also skilled persons are required. The welding parameters are chosen by the welders or the engineers based on the experimental trails and error methods. The weld geometry depends on the welding parameters, it is very important to study the essentiality of the welding parameters and its adverse and direct effect on the weld bead geometry. [1]

a) Welding current: The value of welding current used in MIG has the greatest effect on the deposition rate, the weld bead size, shape and the 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. Ease of arc initiation and maintenance needed even with low current. 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. If the current is too high, the size of the weld bead is large and the excessive deep penetration that wastes the filler metal causes burn-through and undercut. Too high or too low welding current also affects the mechanical properties of the weld metal and the tensile strength. The ductility is reduced and porosity, excessive oxides and impurities can be seen in the weld metal.

b) Welding Voltage: The arc length 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. In MIG the arc voltage has a decided effect upon the penetration, the bead reinforcement and bead width. By increasing the arc voltage the weld bead becomes flatter and wider, the penetration increases until an optimum value of the voltage is reached, at which time it begins to decrease. High and low voltages cause an unstable arc. Excessive voltage causes the formation of excessive spatter Low voltage produces narrower beads with greater convexity (high crown), but an excessive low voltage may cause porosity and overlapping at the edges of the weld bead.

c) 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. Increasing the travel speed shows opposite effects: Less weld metal gets deposited with lower heat input that produces a narrower bead with less penetration. Excessively high speeds cause high spatter and undercutting and the beads show an irregular form because of very little weld metal deposit per unit length of weld. 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 design, joint fit-up and welding position.

d) Electrode Size: The electrode diameter influences the weld bead configuration (such as the size), the depth of penetration, bead reinforcement and 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. A larger electrode in general requires a higher minimum current for the same characteristics. 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 welds with less penetration but wider in width. The choice of the wire electrode diameter depends on the thickness of the work-piece to be welded, the required weld penetration. For many purposes small diameter wires are good for thin sections and for welding in vertical and overhead positions. Large diameter wires are desirable for heavy sections and hard surfacing and built-up works with low current applications because of less weld penetration.

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