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Experimental Investigation on AA6061 by Using Tungsten INERT Gas

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Abstract- Tungsten Inert Gas Welding process is generally used for welding of Aluminum alloys. GTAW process is generally preferred because it produces a very high quality weld. Distortion is the major problem in welding of thin sections. This distortion is controlled in pulsed and magnetic arc oscillation GTAW process. The metallurgical advantages of pulsed TIG welding are grain refinement in fusion zone, reduced width of HAZ, less distortion, control of segregation, reduced hot sensitivity and residual stresses. It was observed that Pulsed TIG Welding produces finer grain structure of weld metal than conventional TIG welding (without arc pulsation). The mechanical properties and microstructure characteristic of weld metal depends upon the microstructure of the weld. The microstructure of the weld depends upon pulsed parameters peck current, base current, pulse frequency, pulse duration. The objective of present project is to achieve better mechanical properties. So, controlling of pulsed parameter is needed in this investigation. An increase in the pulse frequency has been found to refine the grain structure of weld metal especially when welding is done using short pulse duration. Long pulse duration lowers the pulse frequency up to which refinement of constituents in weld metal takes place. Effect of the pulse frequency on the grain structure was found to be determined by pulse duration. For a given pulse frequency, long pulse duration produced a coarser structure than short pulse duration. An increase in the peak current coarsened the grain structure.

Keywords:- GTAW process, HAZ, TIG Welding etc.

I. INTRODUCTION

In the construction of pressure vessels and storage tanks, the weldability play unique role in selection of materials from the various candidate materials.

Aluminium fabrication is preferred when compared to other materials fabrication since it offers a considerable mass advantage to the extent of as high as 40 % to existing materials. Also repair procedures and methodology are easily to be adopted & hence it is highly recommended for aerospace applications. All aluminium alloys are not weldable due to the hot cracking during welding. The hot cracking is due to high solidification range (called a mushy zone) of the alloys. A few alloys are readily weldable and prominent alloys are AA 6061, AA 5053 and AA 2219. An alloy is a mixture or metallic solid solution composed of two or more elements. An alloy will contain one or more of the three: a solid solution of the elements (a single phase); a mixture of metallic phases (two or more solutions); an inter-metallic compound with no distinct boundary between the phases. Solid solution alloys give a single solid phase microstructure, while partial solutions give two or more phases that may or may not be homogeneous in distribution, depending on the thermal (heat treatment) history of the material. An inter-metallic compound will have another alloy or pure metal embedded within another pure metal. Alloys are

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used as their properties are superior to those of the pure component elements.

Examples of alloys are solder, brass, pewter, phosphor bronze and amalgam.

The alloy constituents are usually measured by mass. Alloys are usually classified as substitutional or interstitial alloys, depending on the atomic arrangement that forms the alloy. They can be further classified as homogeneous (consisting of a single phase), or heterogeneous (consisting of two or more phases) or intermetallic (where there is no distinct boundary between phases).

An alloy is a mixture of either pure or fairly pure chemical elements, which forms an impure substance (admixture) that retains the characteristics of a metal. An alloy is distinctive from an impure metal, such as wrought iron, in that, with an alloy, the added impurities are usually desirable and will typically have some useful benefit.

Alloys are made by mixing two or more elements; at least one of which being a metal. This is usually called the primary metal or the base metal, and the name of this metal may also be the name of the alloy. The other constituents may or may not be metals but, when mixed with the molten base, they will be soluble, dissolving into the mixture.

When the alloy cools and solidifies (crystallizes), its mechanical properties will often be quite different from those of its individual constituents. A metal that is normally very soft and malleable, such as aluminum, can be altered by alloying it with another soft metal, like copper. Although both metals are very soft and ductile, the resulting aluminum alloy will be much harder and stronger. Adding a small amount of non-metallic carbon to iron produces an alloy called steel.

1. Classification of Aluminium Alloys:

Aluminium alloys are classified in several ways, the most general according to their strengthening mechanisms. Some alloys are strengthened primarily by strain hardening. While others are strengthened by solution heat treatment and precipitation aging grouping of wrought aluminium alloys by strengthening method, major alloying element and relative strength is given in the Table.

Table 1. Wrought aluminium and aluminium alloy designation system.

Aluminium series	Type of alloy composition	Strengthening method
1XXX	Al	Cold working
2XXX	Al-Cu-Mg	Heat Treatment
3XXX	Al-Mn	Cold working
4XXX	Al-Si	Cold working
5XXX	Al-Mg	Heat treatment
6XXX	Al-Mg-Si	Heat treatment
7XXX	Al-Zn-Mg	Heat treatment
	Al-Zn-Mg-Cu	Heat treatment
8XXX	Al-Mg-Li-Cu	Heat treatment

Commercial aluminium products used in majority of structural applications are selected form 2xxx, 5xxx, 6xxx and 7xxx alloy groups, which offer medium to high strengths. 5xxx and 6xxx alloys offer a relatively high strength and good corrosion resistance. This study focuses on 2XXX, 5XXX and 6XXX series

Wrought Al-Mg-Si alloys can be divided into three groups. In the first group the total amount of magnesium and silicon does not exceed 1.5%. These elements are in a nearly balanced ratio or with a slight excess of silicon.

This easily extrudable alloy nominally contained 1.1% Mg_2Si and quench sensitivity is less. The second group nominally contains 1.5% or more magnesium & silicon and other additions such as 0.3% copper, which increases strength in T6 temper. The third group contains an amount of Mg_2Si overlapping the first two but with a substantial excess amount of silicon.

An excess of 0.2% silicon increases the strength of an alloy containing 0.8% Mg_2Si by about 70 MPa. Larger amounts of excess silicon are less beneficial. Excess magnesium however, is of benefit only at low Mg_2Si contents because magnesium lowers the solubility of Mg_2Si.

2. AA6061 Aluminium Alloy:
This is the least expensive and most versatile of the heat treatable aluminum alloys. It has most of the good qualities of aluminum.

It offers a range of good mechanical properties and good corrosion resistance. It can be fabricated by most of the commonly used techniques. In the annealed condition it has good workability.

3. Operation:

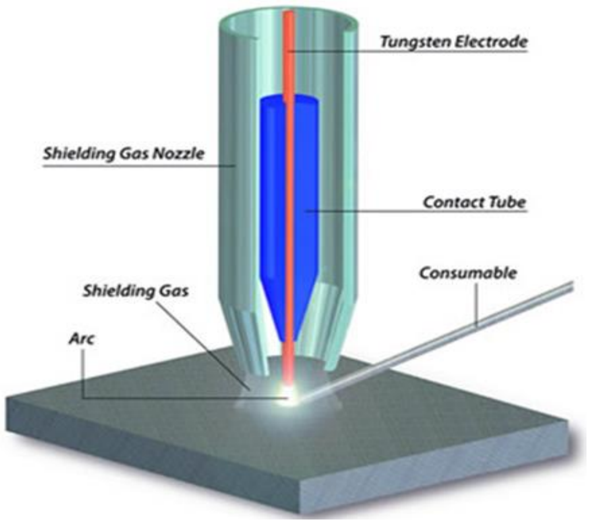


Fig 1. Working principle of TIG.

The process takes place by the formation of the electric arc between the electrode of welding torch and on the surface to be weld. The arc is the electric arc produced. To strike the welding arc.

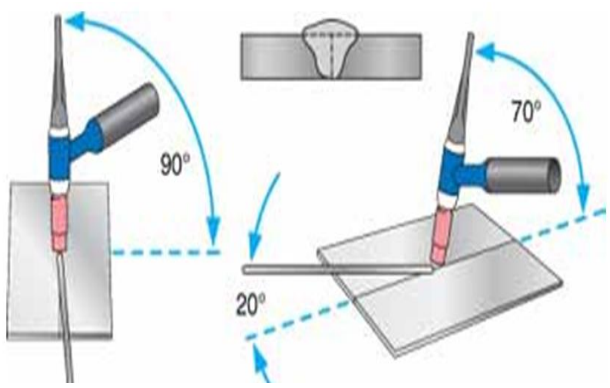


Fig 2. Holding position of torch for BUTT Joint.

II. LITERATURE REVIEW

Tungsten Inert Gas (TIG) Welding provides an effective manufacturing technique that enables the welding of the parts made of alloy materials with complicated geometry that is difficult to produce by conventional welding processes.

In the process after the Gas Tungsten Arc Welding has been done on AA6061 as base metal the following performances are done;

- Ultimate Tensile Strength
- Yield Strength and elongation
- Micro hardness different zones of welding (weld zone, fusion zone, heat affected zone)

III. RESEARCH METHODOLOGY

Artificial neural networks are nonlinear information (signal) processing devices, which are built from interconnected elementary processing devices called neurons.

The development of artificial neural network started 50 years ago. The paradigm of neural networks, began during the 1940s, promises to be a very important tool for studying the structure-function relationship of the human brain. Each computing unit, i.e. the artificial neuron in the neural network is based on the concept of an ideal neuron.

An ideal neuron is assumed to respond optimally to the applied inputs. However, experimental studies in neuron-physiology show that the response of a biological neuron appears random and only by averaging many observations it is possible to obtain predictable results. Inspired by this observation, some researchers have developed neural structures based on the concept of neural populations.

In the field of biology, electronics, computer science, mathematics and engineering, ANN is one of the most important research areas. ANN is a complicated system composed of numerous nerve cells. It is also a new type of computer system which is based on the primary understanding of the organization, structure, function and mechanism of the human brain.

Neural networks use hidden units to create internal representations of the input patterns. In fact, it has been shown that given enough hidden units, it is possible to approximate arbitrarily any function with a simple feed forward network. This result has encouraged people to use neural networks to solve many kinds of problems.

The inputs may be connected fully to the output units, but there is a chance that none of the input units and output units is connected with other input and output units respectively.

There is also a case where, the input units are connected with other input units and output units are connected with other output units. In a single layer network, the weights from one output unit do not influence the weights for other output units.

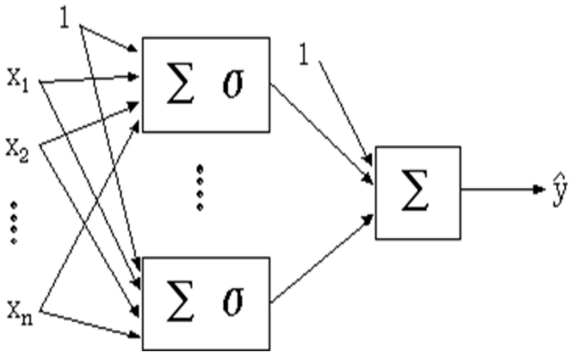


Fig 3. Single layer feed forward network.

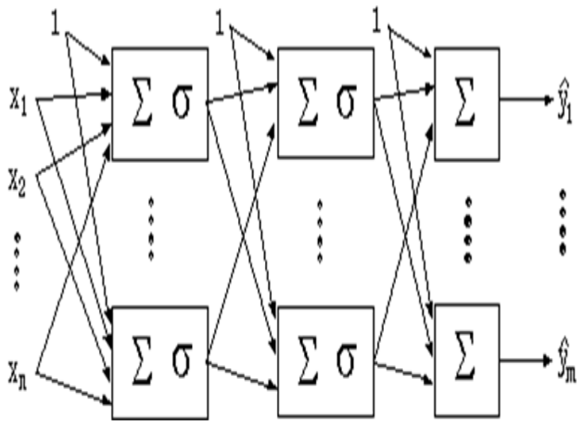


Fig 4. Multi layer feed forward network.

IV. EXPERIMENTAL INVESTIGATION

In order to achieve the desired aim, the present investigation has been planned in the following sequence:

- Selection of base material.
- Identifying the important Pulsed Current Tungsten Inert Gas welding parameters which are having Influence on grain refinement.
- Finding the upper and lower limits of the identified parameters.
- Design experimental condition and procedure.
- Preparation of material
- Conducting the experiments as per the design.
- Mechanical test
- Tensile test
- Microhardness test at different zones
- Microstructure analysis

1. Selection of Base Material:

The base material employed in this study is 4 mm thick Aluminum alloy (AA6061) welded with 4043 filler material. The chemical composition of the base material and filler material .

Table 2. Chemical composition (wt %) of base material and filler material.

Type of Material	Base metal (AA 6061)	Filler material (AA 4043)
Mg	0.85	0.05
Si	0.68	4.8
Cu	0.22	0.17
Cr	0.06	0.05
Mn	0.32	0.24
Zn	0.07	0.05
Ti	0.05	0.05
Al	Balance	Balance

Fig 5. TIG Welding Equipment.

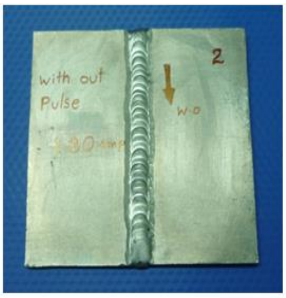
1.1 Machine Specifications:

Table 3. Specifications of Pulsed TIG welding machine.

Make	ESAB
Model	3000i
Setting range TIG AC/DC	4-300

2. Conducting the Experiments as Per the Design:

(1)



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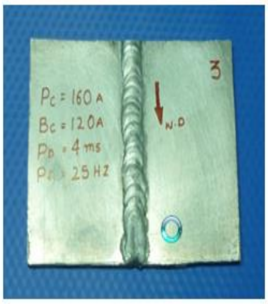

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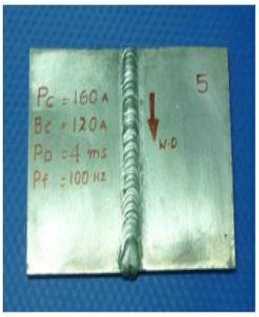


(5)

(6)

Fig 6. 1) Without pulse, 160 amp, 2) Without pulse, 180 amp,
3) Peak current 160 amp Base current 120 amp Pulse duration 4 ms Pulse frequency 25 Hz,
4) Peak current 160 amp Base current 120 amp Pulse duration 4 ms Pulse frequency 50 Hz,
5) Peak current 160 amp Base current 120 amp Pulse duration 4 ms Pulse frequency 100 Hz,
6) Peak current 180 amp Base current 120 amp Pulse duration 4 ms Pulse frequency 25 Hz.

The longitudinal weld and transverse weld testing configurations depicts the various weld orientation-working direction combinations in butt welded sheet and plate products. For dissimilar metal butt welding, joint efficiency is computed on the basis of the strength of the weakest member of the dissimilar couple. In this experiment we have tested in the transverse weld direction.

2.1 Tensile Specimen:

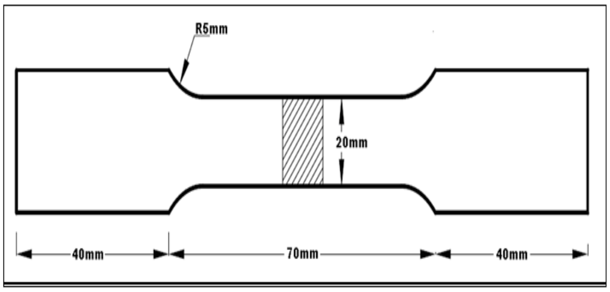


Fig 7. Tensile test standard sample.

V. NETWORK MODELLING

ANN is a multilayered architecture made up of one or more hidden layers placed between the input and output layers. Layers include several processing units known as neurons. They are connected with variable weights to be determined. In the network, each neuron receives total input from all of the neuron in the previous layer as;

$$\mathbf{Netj} = \sum_{\mathbf{j=0}}^{\mathbf{N}} \mathbf{WijXi}$$

Where, Netj is the total or net input and N is the number of inputs to the jth neuron in the hidden layer. Wij is the weight of the connection from the ith neuron in the forward layer to the jth neuron in the hidden layer and xi is the input from the ith neuron in the preceding layer. A neuron in the network produces its output (outj) by processing the net input through an activation (transfer) function f, such as log-sigmoid function.

1. ANN of Tensile Values:

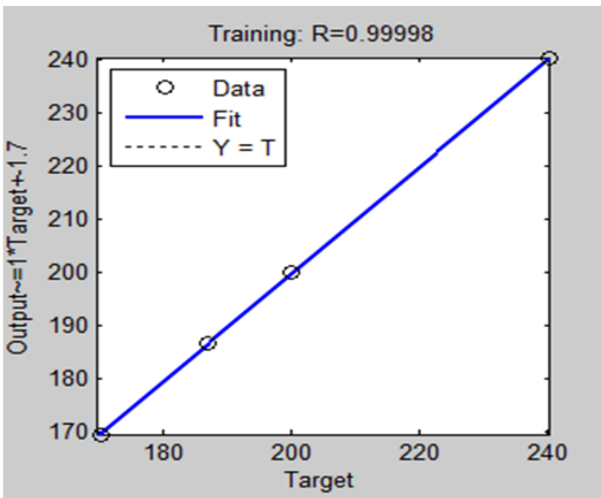


Fig 8. Training graph for tensile values.

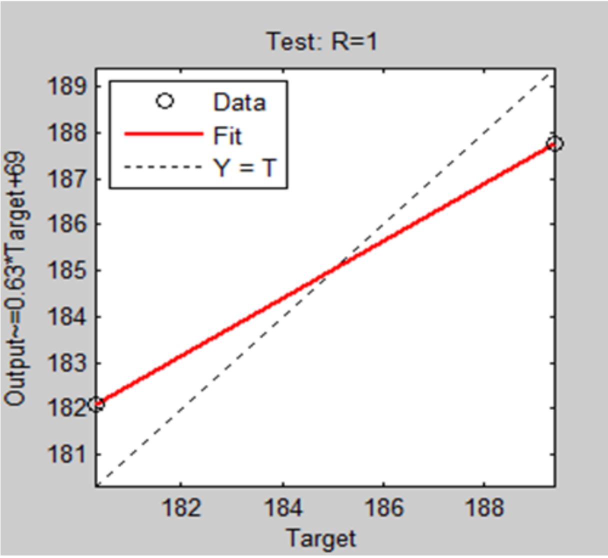


Fig 9. Validation graph for tensile values.

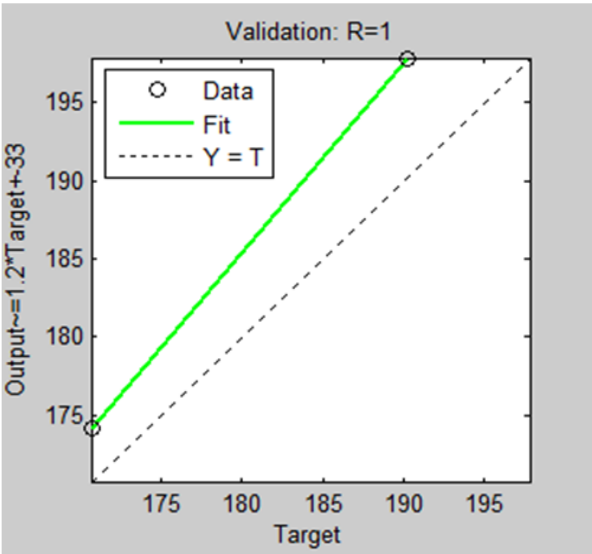


Fig 10. Testing graph for tensile values.

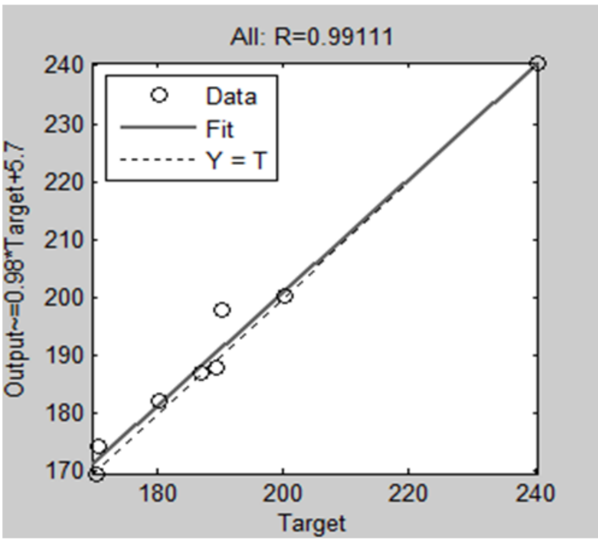


Fig 11. Regression Graph for tensile values.

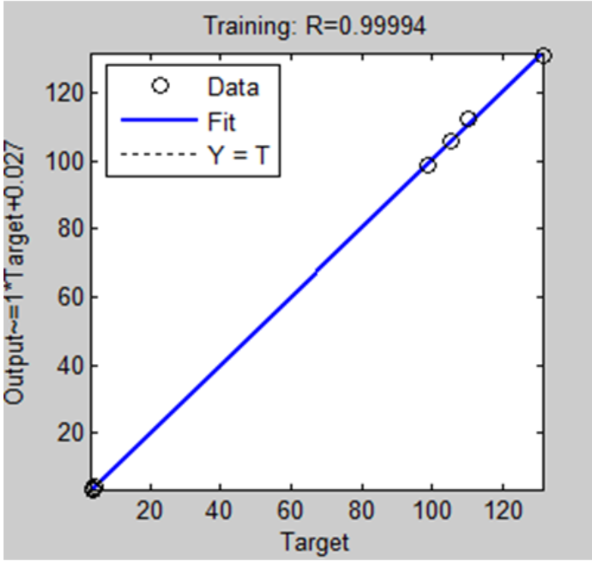


Fig 12. Training graph for yield point and elongation.

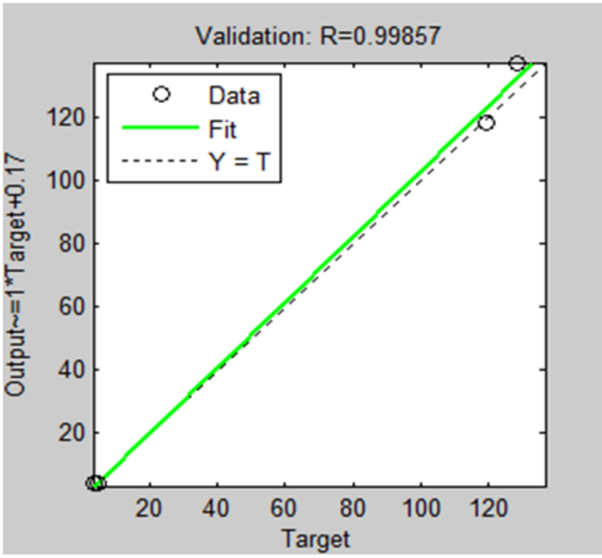


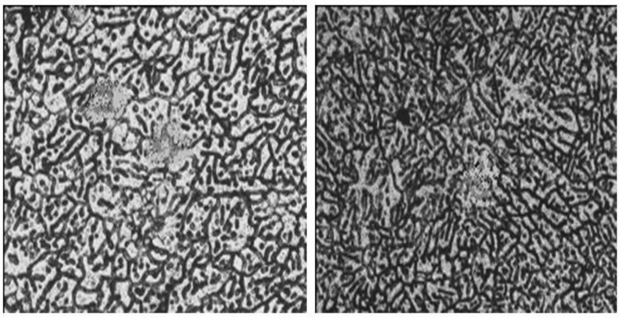
Fig 13. Validation graph for yield point and elongation.

VI. RESULTS AND DISCUSSION

The tensile strength of the weld metal produced using 160 A peak current for 4 ms pulse duration showed that increase in pulse frequency from 0 to 25 Hz decreases the tensile strength up to 170.2 N/mm2 followed by continuous increase in the tensile strength up to 100 Hz pulse frequency tensile strength is240.58 N/mm2.

The weld metal produced using 180 A for 6 ms pulse duration showed that increase in pulse frequency from 0 to 25 Hz increased the tensile strength upto 200.2 N/mm2 followed continuous decrease in the tensile strength 180.3 N/mm2 up to 100 Hz pulse frequency. Results showed that the effect of pulse frequency on the microhardness is determined by pulse duration and peak current.

The microhardness (HV100) of the weld metal produced using 160 A peak current for 4 ms pulse duration showed that increase in pulse frequency from 0 to 25 Hz decreases the microhardness up to 64.80 HV followed by continuous increase in the hardness 84.68 HV at 100 Hz pulse frequency.



(a) (b)

Fig 14. (a) Pulse frequency-50 Hz, (b) Pulse frequency-100Hz.

VII. CONCLUSIONS

Structure of weld metal especially when welding is done using short pulse duration of 4 ms. Increase in pulse frequency decreases the size of aluminum grains in the weld metal.

For a given pulse frequency 50-100 HZ with lower peak 160 Amp current by short pulse duration 4 ms produces fine grain structure. For a given pulse frequency 0-25-50-100 HZ with higher peak 180 Amp current by long pulse duration 6 ms produced coarser grain structure than short pulse duration 4ms. Longer pulse duration with higher peak 180 Amp current produces coarse grains.

The weld joint produced using 180 A for 6 ms pulse duration showed that increase in pulse frequency from 0 to 25 Hz decreased the hardness 68.31 HV,75.80 HV, 81.36 HV,79.46 HV at weld zone, at fusion zone, at HAZ. A continuous decrease in the hardness 67.50 HV,73.31,HV,79.46 HV up to 100 Hz pulse frequency. Maximum hardness obtained with peak current 160 Amp at 100 Hz pulse frequency by shorter pulse duration (4 ms). Peak current 180 Amp at given frequencies by long pulse duration (6 ms) produced lower microhardness of the weld metal.

The tensile strength of the weld metal produced using 160 A peak current for 4 ms pulse duration showed that increase in pulse frequency from 0 to 25 Hz decreases the tensile strength up to 170.2 N/mm2 followed by continuous increase in the tensile strength up to 100 Hz pulse frequency tensile strength is240.58 N/mm2.

The weld joint produced using 180 A for 6 ms pulse duration showed that increase in pulse frequency from 0 to 25 Hz decreased the strength up to 200.2 N/mm2 followed continuous decrease in the tensile strength up to170 N/ mm2 at 50 HZ frequency.

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