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Investigation of Microstructure and Mechanical Properties of TIG and MIG Welding Using Aluminium Alloy

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ABSTRACT

TIG (Tungsten Inert Gas) welding and MIG (Metal Inert Gas) welding are well known welding techniques, that are using in industries in current age. Aluminium is the most commonly used material in all industries. Aluminum is the second material in case of annual consumption after steel. Pure aluminum melts at 660^{0}C, and its alloys at slightly lower temperature. The crystal structure of aluminum is FCC, and it is very ductile material. In this paper the study is done on which welding technique (TIG or MIG) is best for the aluminium alloy. The comparison is done on the basis of microstructure and mechanical properties of the welded joint of TIG and MIG welding on aluminium alloy. It was observed that TIG welding has better in Tensile strength, hardness, impact strength and microstructure compared to MIG for used aluminium alloy.

KEY WORDS: TIG, MIG, A-6061.

1. INTRODUCTION:

Welding is a process where coalescence is produced by application of heat. There are many types of welding existing to weld different metals. Aluminium is on second number in terms of annual consumption however steel have first position. The market value of aluminium increasing at very fast rate, welding of aluminium also became a major consideration in industries. There are a number of techniques for joining the aluminium alloys. The selection of welding process depends on various factors, which influence the joining of the material a lot. These factors are material and geometry of the parts to be joined, requirement of joint strength, type of joint, number of parts to be joined, appeal for the aesthetic look of the joint and service conditions like moisture, temperature, inert atmosphere and corrosion.

Compared with steel, aluminum has a third the modulus of elasticity, weighs a third as much, and cost about three times as much per pound. Its coefficient of expansion is twice that of steel, a disadvantageous characteristic and the cause of warping during fusion welding **(Patton, 1967)**.

Table 1.1 Physical and Mechanical properties of aluminum (Varley, 1970)

Property	Purity				
	99.999%	99.99%	99.8%	99.5%	99.0%
Melting point, ^{0}C		660.2			657
Boiling point, ^{0}C		(2480)			
Latent heat of fusion, cal/g		94.6			93.0
Specific heat at 100^{0}C, cal/g		0.2226			0.2297
Density at 20^{0}C	2.70	2.70	2.70	2.71	2.71

Electrical resistivity Ω-cm at 20^0C	2.63	2.68	2.74	2.80	2.87
Temperature coefficient of resistivity		0.0042	0.0042	0.0041	0.0040
Coefficient of thermal expansion × 10^6 (20^0-100^0C)		23.86	23.5	23.5	23.5
Thermal conductivity, c.g.s units at 100^0C		0.57	0.56	0.55	0.54
Reflectivity (total)		90%	89%	86%	
Modulus of elasticity, lb/in^2 × 10^{-6}		9.9			10.0
Tensile strength, tons/in^2		3.8	4.4	5.2	5.8
Brinell hardness, P/D^2=5		15	19	21	22

TUNGSTEN INERT GAS (TIG) WELDING:

In the tungsten inert gas welding process, the arc is maintained between a non consumable tungsten electrode and a work piece in a protective inert gas atmosphere. Figure 1.2 shows the real processes.

Filler material is used externally for the joining of the work pieces. Normally, a DC arc is used with tungsten as the negative pole (DCEN). This is not possible for metals, such as aluminum and magnesium, where the oxide layer persists if the work piece is used as the anode. This layer prevents the formation of the weld pool. The mobile cathode spot can disperse the oxide layer but excessive heat is generated at the tungsten electrode if this is used as the anode.

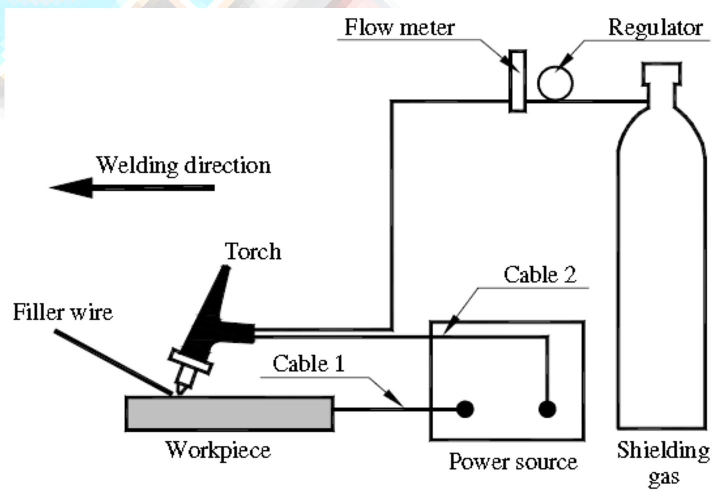
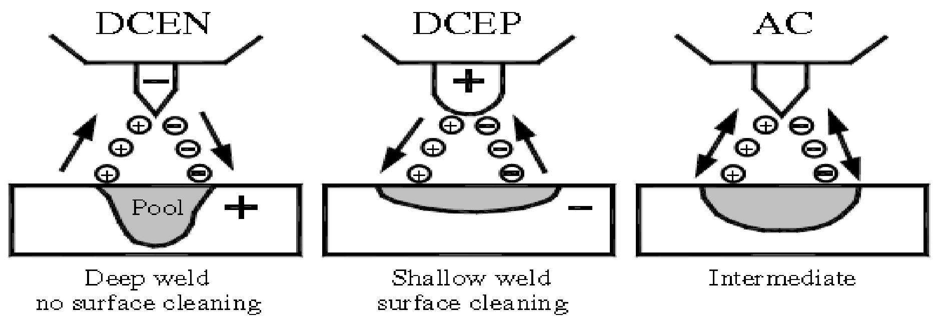


Fig. 1.2 TIG welding process

Hence, AC arc is used for such materials. To avoid the melting of the electrode, thorium or zirconium is added to the tungsten (to increase the melting point). Argon is most commonly used to provide the inert atmosphere. Nitrogen is sometimes used for welding copper. To prevent the possible little contamination, an argon deoxidant is added to the filler **(Ghosh and Mallik, 2005).**

Direct polarity is the most commonly employed in GTAW. This effect produces a high heat in the work piece and therefore gives a good penetration and a relatively narrow weld shape. When alternating current is used, is possible to obtain a good combination of oxides elimination (cleanliness) and penetration. This polarity is the most employed to weld aluminum alloys **(Ambriz and Mayagoitia, 2011)**. The polarity system used in the TIG welding process is shown in Fig. 1.3.



(a) (b) (c)

Fig. 1.3 Polarity in TIG welding process

2. METAL INERT GAS (MIG) WELDING:

In MIG welding process the arc is maintained between a consumable electrode and the work piece in an inert gas atmosphere. The coiled electrode wire is fed by drive rolls as it melts away at the tip. Except for aluminum, a DC source is used with the consumable electrode as the positive terminal. For welding steel, a shielding is provided by CO_2 for lowest cost. Normally, a high current density in the electrode (of the order of 10,000 amp/cm^2) is used so that projected types of metal transfer results. The welding current is in the range 100-300 amp. The process is primarily meant for thick plates and fillet welds. Fig.1.4 shows the main process **(Ghosh and Mallik, 2005).** MIG welding process is one of the most employed to weld aluminum alloys.

There are three basics metal transfer in MIG welding process: Globular transfer, Spray transfer and Short-circuiting transfer. In the globular transfer, metal drops are larger than the diameter of the electrode, they travel through the plasma gas and are highly influenced by the gravity force.

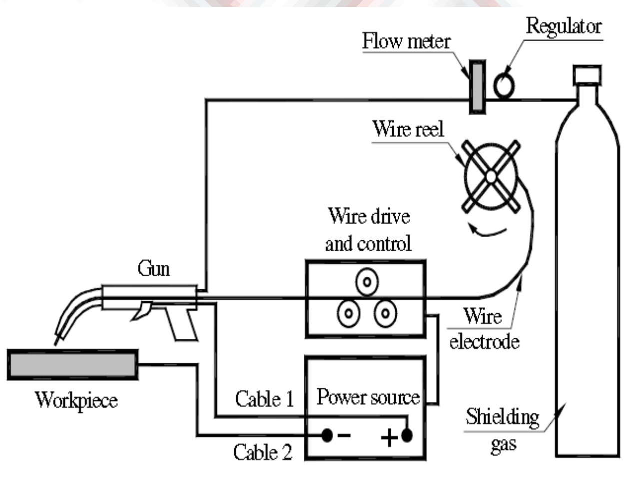


Fig. 1.4 MIG welding process

On the other hand, spray transfer occurs at higher current levels, the metal droplets travel through the arc under the influence of an electromagnetic force at a higher frequency than in the globular transfer mode.

In short-circuiting transfer, the molten metal at the electrode tip is transferred from the electrode to the weld pool when it touches the pool surface, that is, when short-circuiting occurs. Figure 1.5, shows the typical range of current for some wire diameters **(Ambriz and Mayagoitia, 2011)**.

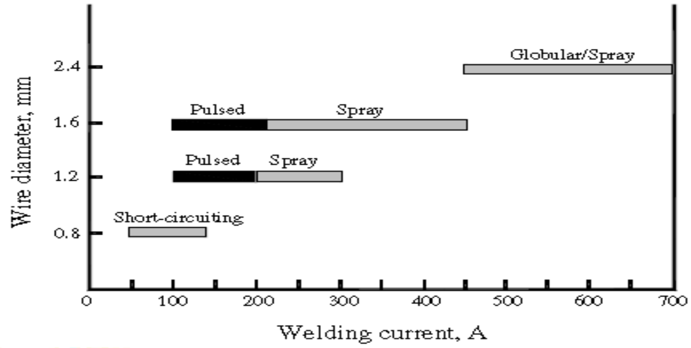


Fig. 1.5 Typical welding current ranges for wire diameter and welding current

3. MATERIALS AND METHOD:

This section mainly deals with experimental details and material used in this investigation work, like welding technique, specimen size and testing conditions etc. Aluminium alloy AA6061 (Al-Mg-Si) is the most widely used medium strength aluminium alloy, and has gathered wide acceptance in the fabrication of light weight structures **(Balasubramanian et al., 2007).**

The Extruded form of aluminium alloy AA6061 is used in the present investigation. It is heat treated up to 300^{0}C. It was in the sheet form having thickness 6 mm and width 50 mm. Chemical compositions and physical properties are given in Table 1.6 and 1.7 respectively.

Table 1.6 Chemical composition of aluminium alloy AA6061

Mg	**Si**	**Fe**	**Cu**	**Cr**	**Mn**	**Zn**	**Ti**	**Al**
0.63	0.42	0.42	0.12	0.19	0.05	0.08	0.02	Bal.

Table 1.7 Physical properties of aluminium alloy AA6061

Density(g/cm^3)	**Melting Point(^{0}C)**	**Modulus of Elasticity(GPa)**	**Poison Ratio**
2.7	600	70-80	0.33

The principle alloying elements in AA6061 are Magnesium and Silicon. Magnesium is introduced in aluminium alloys to increase strength, and recrystalization temperature, allowing the alloy to maintain its strength at high temperatures.

Table 1.8 Mechanical properties of aluminum alloy AA6061

Yield Strength (MPa)	**Ultimate Strength (MPa)**	**Elongation (%)**	**Reduction in cross sectional area (%)**	**Hardness (HRB)**
280	310	16	11	65

In this investigation hardness test, impact test (Izod), tensile test and SEM tests has been done on the welding joint joined by TIG and MIG. The actual joined material is shown in figure 1.9:

Fig. 1.9 Actual look of TIG and MIG joints

4. RESULT AND CONCLUSION:

In this investigation tensile testing has been done on UTM, hardness testing has been done on Brinell hardness tester, impact testing (Izod) has been done on impact testing machine.

Impact strength is the measurement of energy absorbing capacity of the material. Impact is a sudden load, which is applied on the work piece having a V notch. Two types of impact tests are performed here to know the impact strength of the welds made by TIG and MIG.

Fig. 1.10 MIG and TIG weld specimen after Izod test

Table 1.11 Summary of Impact test

Welds/Material	Energy Absorbed (Joule) Izod	Effect
BM	114.72	NO BREAK
TIG	134.31	BREAK
MIG	132.33	BREAK

The hardness of the weld metal is measured with the help of the Rockwell hardness testing machine at B grade (HRB) and the values of the hardness in the weld region is shown in the following Table 1.12.

Table 1.12 Hardness of the weld region

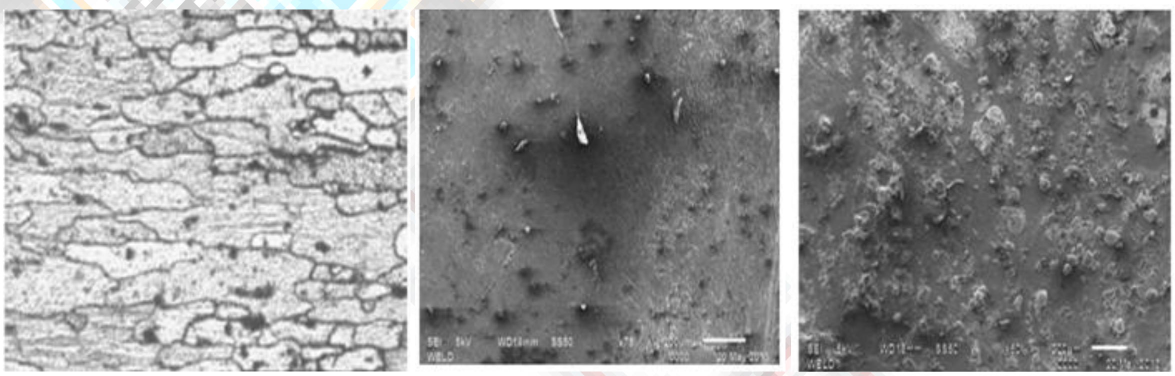
Type of Welding	Hardness of weld region (HRB)
TIG	43
MIG	39

Different types of tensile properties of welded aluminium alloy AA6061 were evaluated such as yield strength, ultimate tensile strength, percentage elongation and joint efficiency. For each condition three specimens were tested and the average properties of the welded joints are taken, these properties are shown in the following Table 1.13.

Table 1.13 Tensile properties of welded joints

Type of Joint	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Elongation (%)	Joint Efficiency (%)
TIG	170	200	10.1	64.3
MIG	140	160	7.2	51.2

In this study the microstructure of each and every joint has been examined at different locations of the joint. But it is found the joint mainly break/failed at the fusion zone, hence only the microstructure of the weld fusion zone is studied. The weld fusion zone microstructures of different welding processes are shown in the Fig. 1.14



(a) BM (b) TIG (c) MIG

Fig. 1.14 Microstructure of weld zone at 200μm scale

5. CONCLUSION:

After the welding by TIG and MIG mechanical properties and microstructure of welds have been tested and following conclusions can be drawn:

1. The impact strength of TIG joints is higher than that of the MIG joints.
2. It is found that hardness in weld metal region is less than that of the BM. The maximum hardness is found in TIG and the minimum hardness is found in MIG welded joint. The hardness pattern in the weld region in two welding processes is like, TIG > MIG.
3. In case of TIG the microstructure is very fine and equiaxed, having uniformly distributed grains with strengthening precipitates as compared to MIG welding processes in which dendritic grain structures is found. Because of fine grain structure the TIG joint possesses good tensile and mechanical properties than that of the MIG welding processes.

On the basis of the above discussion it can be elaborate that the TIG is the best suitable welding process to join aluminium alloy AA6061 as compared to MIG welding processes.

REFERENCES:

1. **Abbasi, K. Alam, S. and Khan, M. I. 2012.** An experimental study on the effect of MIG welding parameters on weld-bead shape characteristics. Engineering Science and Technology: An International Journal (ESTIJ). Vol. 2. pp 599-602.
2. **Advance Welding Society (AWS). 1996.** Welding Hand book. Vol. 3. pp 232-235.
3. **Akula, D. R. 2007.** Characterization of Mechanical properties and study of microstructures of friction stir welded joints fabricated from similar and dissimilar alloys of aluminum. Thesis, MS.
4. **Chavda, S. P. Desai, J. V. and Patel T. M. 2014.** A review on optimization of MIG welding parameter using Taguchi's DOE method. International Journal of Engineering and Management Research. Vol. 4. pp 16-21.
5. **Devakumar, D. and Jabaraj, D. B. 2014**. Research on gas tungsten arc welding of stainless steel-An overview. International Journal of Scientific & Engineering Research. Vol. 5. pp 1612-1618.
6. **Funderburk, R. S. 1999.** Key Concepts in Welding Engineering. Welding Innovation.Vol. XVI.
7. **Ghosh, A. and Mallik, A.K. 2005.** Manufacturing Scince. 23rd ed. New Delhi. Eastern western press pvt. Ltd. p 319.
8. **Gupta, K. M. 2008.** Material Science. 3rd ed. Delhi. Umesh Publications.
9. **Hamilton,C. Dymek, S. Blicharski, M. 2007.** Mechanical properties of Al 6101-T6 welds by friction stir welding and metal inert gas welding. Archives of metallurgy and materials. Vol. 52. pp 67-72.
10. **Hashemi, S. 2006.** Foundations of materials science and engineering.4th ed. McGraw- Hill, ISBN 007-125690-3
11. **Hegmann, W. 1982.** Aluminum workshop practice. 4th ed. Aluminum Verlag. pp 24-25.
12. **Khanna, O. P. 2009.** A text book of welding technology. 19th ed. New Delhi. Dhanpat rai publications. pp 412-414.
13. **Kumar, A. Gautam, S. S. and Kumar, A. 2014.** Heat input and joint efficiency of three welding processes TIG, MIG and FSW using AA6061. International Journal of Mechanical Engineering and Robotics Research. Vol. 1. pp 89-94.
14. **Maggiolino, Stefano and Schmid, Chiara. 2008.** Corrosion resistance in FSW and in MIG welding techniques of AA6XXX. Journal of materials processing technology. Vol. 197. pp 237–240.
15. **Munoz, C. Ruckert, G. Huneau, B. Sauvage, X. Marya, S. 2004.** Comparison of TIG welded and friction stir welded Al-4.5 Mg-0.26 Sc alloy. Journal of Material Process Technology. Vol. 152. pp 97-105.
16. **Munoza, A. Cabello. Ruckert, G. Huneau, B. Sauvage, X. Marya, S. 2008.** Comparison of TIG welded and friction stir welded Al–4.5Mg–0.26Sc alloy. Journal of materials processing technology. Vol. 197. pp 337–343.
17. **Patton, W. J. 1967.** The science and practice of welding. 4th ed. New Jersey. Prentice-Hall, Inc Englewood Cliffs. p 111.
18. **Prakash, J. Tewari, S.P. and Srivastava, B. K. 2012.** Shielding gas for welding of aluminium alloys by TIG/MIG welding-A review. International Journal of Modern Engineering Research (IJMER). Vol. 1. pp 690-699.