IMPROVEMENT OF MECHANICAL PROPERTIES OF ALUMINUM ALLOY 6061 –T6 WELD JOINT USING DC PULSED GAS TUNGSTEN ARC WELDING (PGTAW)

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ABSTRACT
The effect of DC pulsed GTAW method factors on mechanical properties of Aluminum alloys 6061–T6 is proves. Throbbed GTAW on the sheet having dimension of (200* 100* 5mm) is implemented at variable pulse current (150, 160, 170, 190) and constant frequency to get numerous connected joints by electrode type" ER4043 (Al Si_5) as a padding metallic and argon as protective gas and compared with base current GTAW welding at D C current at 90 amps. The welded pieces are examined by X-ray radiography. The welded joints were treated by heat, the joints heated for half an hour in the furnace to 150 C° then cooled in the air to release the residual stresses. Mechanical quality of the weld joints. Microstructural categorizations, Micro hardness, enduring stress are examined. Consequences exposed that a common decline of mechanical properties of TIG welded joints conveyed 34% analogies with parent metal while the PGTAW joined offers better mechanical qualities analogy with of TIG joined in reductions conveyed 8.4% analogies with original metal this is because of the microstructure variations through the joining method and compressive residual stress generation in the weld zones. It has been found that by PGTAW improved the mechanical properties of welded joints which rely on current parameters.
KEYWORDS :- GMAW, Pulsed current, Aluminum alloy, Microstructure, Mechanical properties

تحسين الخواص الميكانيكية لوصلات لحام من سبيكة المنيوم T6– 6061 بطريقة نبضات التيار المستمر للحام القوس الكهربائي بقطب التنكستن

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الخلاصة :-
دراسة لحام القوس الكهربائي باستخدام قطب التنكستن وتيار مستمر نبضي عند متغيرات مختلفة وغاز الأركون كحماية على الخواص الميكانيكية لسبيكة الالمنيوم6061-T6 . تم تحضير عدة صفائح بسمك (5) ملم لأعداد وصلات لحام تناكبيه بأبعاد (5*100*200) ملم وباستخدام سلك لحام ER- 4043 (Al-Si$_5$) كمعدن حشو تيار مستمر نبضي وبقيم (150,160,170,190،) امبير وبتردد ثابت وبعد الانتهاء من عمل وصلات اللحام من تم فحصها بواسطة جهاز X-ray radiography للتأكد من عدم وجود عيوب لحام ولغرض التخلص من اجهادات اللحام تم تسخين الوصلة في فرن كهربائي الى درجة 150 درجة مئوية لمدة نصف ساعه ثم التبريد بالهواء. واجري الفحص المجهري والصلادة المايكروية والاجهات المتبقية والخواص الميكانيكية .اظهرت النتائج انخفاضا في الخواص الميكانيكية للقطع الملحومة بالتيار المستمر لقطب التنكستن مقارنة مع العينات الغير ملحومة وبنسبة 34% للتغير الحاصل بالبنية المجهرية اثناء عملية اللحام وفي ومنطقة اللحام . ان عملية اللحام بتيار مستمر نبضي ساهمت في انخفاض الخواص الميكانيكية بنسبة 8.4 % مقارنة بالمعدن الاساس للعينات الملحومة وان عملية اللحام بتيار مستمر نبضي يعتمد بالدرجة الاساس على متغيرات اللحام من تيار ، تردد .

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INTODUCTION

Aluminum silicon –magnesium alloys 6061 –T6 is extensively applied in the manufacturing of car parts because of its high strength, admirable join ability and confrontation to corrosion. Its sedimentation hardened [Pawan Kumar1 ,2011]Pulsed gas tungsten arc welding (PGTAW) method is regularly used for joining of aluminum alloys [Wesley A. Salandro et al,2012] .The joining current (DC) is provided in shape of throbs. Throbbed current alternatives among little or setting level and highest level. The melting happened through highest current point; the pond of join hardens among throbs as the heat is degenerate in the work through the setting current point [Jenney, et al, 2001]. Throb method mutable are governing element for heat inside which in turn execute to grain refinement in melting region, breadth decrease of HAZ, separation of "alloying" elements, decreasing hot split sensibility and remaining stresses [M. Balasubramanian, et al,2008, R. Manti,2008].

Mechanical quality of joins are developed using current throbbing causes refinement in the melt region. Chief purpose of throbbing is to realize extreme infiltration deprived of additional in heat set up. The usage of great current throbs is to infiltrate profound at lesser current. Profound infiltration in throbbed current joining is manufactured using arc compression at top for extended periods adding to this argon – helium gas commixtures give sure benefits using growing heat input of the arc through joining. Argon is recognized for steady arch with well arc fire whereas helium offers greater thermal conductivity. There be present a linear connection among heat input of a join and extreme temperature at a specified space from the join focus line. It exhibits that throbbed arc joins are cooler and show fewer thermal deformation than conventional GTA joins of the similar infiltration [G. M. Reddy,2008]. The estimation of microstructure in join fusion region is affected using current throbbing and cyclic differences of power input into the weld pool triggering thermal oscillations. As a result this causes cyclic suspension in solidification method. Current throbbing also results in suspension differences of the arc for forces consequential in extra fluid flow which take down the temperature in front of the solidifying interface. Also, the temperature variations inherent in throbbed joining cause to a continual variation in the join pond extent and figure preferring development of novel grains. It is to be agreed that active heat input for unit size of join pond ought to be widely fewer throb current joins & therefore anticipating the rate join pond temperature select little [G. M. Reddy,1998].many research are studying the subject like [P. K. Baghela,2013] PTIG joining method from diverse viewpoint for diverse metals and alloys is appraising . Some significant PTIGW method factors and their influence on weld property are debated. The microstructure and metallurgical faults be subjected through joining method like sponginess, cracking, oxide impurities and loss of alloying elements are portrayed. Mechanical characteristic of joins like hardness, tensile and fatigue strength, and other significant structural quality are debated. Exposed the new development in PTIGW of diverse metals and alloys and to provide the foundation for resulting exploration. [S. Kumar,2009] studied the probability of joining greater thickness aluminum sheets of 6mm by DC pulse current at some gas flow 7 litre/min ,15 litre/min. tensile properties is best by throb current of 250 Amp and gas movement amount of 15 litre/min analogy through original current 200 Amp. It has also been saw that cut off strong point differs with alteration of throb current. Microstructural learns of join sediment appearances two distinct regions, co-axial dendrites nearby to melting streak and the very small equiaxed jot in the zone of join halfway point. [Senthil Kumar et.al , 2007] find that Tensile qualities of AA 6061 aluminum alloy is actualized and exist that to forecast the influence of throbbed current joining factors on tensile qualities by testing procedure is more suitable of joint this alloy . Test displays that top current and throb frequency are directly measured to the tensile qualities of the joined and exposed that origin current and throb on time is having contrariwise measured connection with the tensile qualities.

[Karunakara et. al 2011] study the influence of throbbed current on temperature distribution shapes and qualities of gas tungsten arc joined aluminum and its alloys connections and exist out that throbbed current joining method registers lesser top temperatures and lesser amount of remaining stresses analogy by means of settled current joining, which is greatly favorite for tinny sheet joining. Consequences more exposed that joint manufactured by gas tungsten arc joined aluminum alloy shows greater tensile qualities analogy with settled current joining method. Also clear that the build ing of finer grains produced by throbbed current is the chief cause for improved tensile and hardness qualities of the joints. In this paper Mechanical qualities and its influence on improvement of throbbed GTAW method factors on aluminum alloy 606 –T6 are actualize.

Experimental Technique

6061-T6 aluminum alloy plate of 5mm thickness are employing. **Table 1** reveals the chemical composition of the materials using ARL Spectrometer in the specialized institution of engineering industries of Industry ministry.

Joining Procedure

Sheets are prepared in dimensions (200*100*5) mm and by V angle 45° to get Butt PGTAW joining as shown in figure (1) using ER4043 as filler metal having diameter 3 mm where its chemical analyses are exposed in **Table (2)** .Welding process is employed using Automatic Throb GTAW Tri-ton 220 V AC/DC). The characteristic of join is founded on the procedure factors, like throb current in the extent of peak current (150,160,170.190) Amp respectively, pulse frequency of 90 Hz, pulse-on time 2 sec and argon as shielding gas20 lit/min. The connected pieces are examined by X-ray radiography. The joints heated for half an hour in furnace to 150 C° then cooled in the air to release welding stresses then all examinations are made.

Samples Preparation

Numerous samples are equipped from AA 6061-T6 weld joints for tensile test in dimensions according to ASTM 17500, as shown in Figure (2).

Samples Compiled

Samples for tensile test are divided into 6 groups as revealed in Tab. (3)**.**

Microstructure Test

Micro structural variations from join region to the original material are inspected with optical microscope. Samples are equipped for microstructure test containing wet grinding process using Sic paper at diverse jots of (220,320,500,800, and 1000). Brush up method is complete by diamond paste of extent (2μm) using exceptional brush up cloth. The specimens are purified using distilled water and alcohol and there dried out by dryer. Etching for the structure using Keller's reagent containing of 95 ml distill water, 2.5 ml HNO3, 1.5 ml HCl and 1 ml HF at that time it is washed with distill water then dried. The connected joint specimens and parent metal are tested using Nikon ME-600 computerized optical microscope supplied by means of a NIKON camera, the examined consequence is revealed in figure (3)**.**

Residual stress & macro hardness

X-ray diffraction $\sin^2\psi$ method is used to measure the remaining stresses. Using X-ray diffraction method, the strains are quantifying at specific diffraction angles and lattice planes where Bragg's law is achieving. Results are shown in Table (3) which exemplify compression having (-) signal

. macro hardness by Rockwell (B symbol) is used for hardness test Where three readings were taken in all welding zones and the average was adopted

Micro Hardness Test

Micro hardness test is implemented by the Vickers micro hardness apparatus with 200 gm load for 20 sec to quantity the hardness for specimens weld joint on a cross section vertical to the welding line The consequence is displayed in Fig. (4).

Tensile stress

Mechanical characteristic like strength and ductility are determined by tensile test of the specimens which manufactured in dimensions according to ASTM 17500, as shown in Figure (2) such as the ultimate tensile stress (UTS) yield strength (YS) and % elongation. Examine device smart sequence by preload value (N) 100 and pass head speed (mm/min) or rate. 20 is used. Extension lead the tested consequences are revealed in Table (5).

DISCUSSIONS

Figure (3A) demonstrate the micro structure of AA 6061-T6 original metal which perceived rough and elongated particles with regularly spread strengthening deposit of (Mg_2Si.) as shown by darken particles because of syndicate of existence alloying components "silicon& magnesium". The TIG method characterized by symbol Fig. (3, F) offer the lesser amount of reinforcement remains analogy to the original metal categorized symbol (fig.3A). As a result, the Strengthening of "(Mg2Si)" deposit is puny in tungsten inert gas and infusion area its comprise dendritic structure and this probably because of rapid joining heating of the original alloy and slow refrigerating of melted metal resulting in decreases of hardness, mechanical properties and increases in elongation Table (4,5).

From microstructures as shown in Figure3, it is see that samples (B,C,D,E) results in fine dendritic micro-structure analogy with sample (A,F) Consequently from the microstructural describe by PGTAW it is saw that the throb factors performance an significant part [14]in progress of fine micro-structure in fusion region and this be reflected on mechanical properties due to method table (5) ,Sample (C) give the best result in mechanical properties due to consequences in fine dendritic micro-structure analogy to other sample (B,D,E). and few compression residual stress , hardness Table (3) .Fig .(4) is perceived Lesser micro hard ness in the weld region for all specimens for the reason that of with little hardness of stuffing metal , rough dendritic solidified microstructure and inter dendritic separated phase. Micro hardness of HAZ is also lesser compared with the fusion region that perceived a greater significance accuracy understood. This rise in micro hardness because of the rapid cooling average veteran nearby the join zone, which abounds a wonderful filled solid solution. Through ensuing cooling and normal ageing phenomena actual acceptable sediment of Mg_2Si may have shaped nearby join area of heat effected zone (HAZ).

CONCLUSIONS

1-Throb current is having distinct influence on the numerous of the mechanical qualities.

2- Fine dendritic microstructure which obtained through PGTAW lead to in development of mechanical qualities.

3- Increasing in compression residual stress by increasing current pulses.

Table (1) the elemental composition analyses of AA6061-T6.

Elements wt%	Si	Fe	Cu	Mn	Mg	Cr	Zn	Al
Measured Value	0.6	0.4	0.3	0.12	1.0	0.2	0.18	Rem.
Standard Value	0.4-0.8	Max 0.7	0.15-0.4	Max 0.15	0.8-1.2	0.04-0.35	Max 0.25	Rem.

Table (2) Chemical analyses of the Filler Metal (Filer Wire ER 4043)

Element wt%	Si	Fe	Cu	Mn	Mg	Cr	Zn	Sn	Al
Actual value	5	0.4	0.1	0.08	0.06	0.25	0.15	0.15	93.44
Nominal value	4.5-6	< 0.6	< 0.3	< 0.15	< 0.2	-	< 0.1	-	Rem.

Table (3) Revealed the compiled of samples

Specimens symbols	Condition
A	As received
B	Welded pulse DC current of 150 amp&90 Hz
C	Welded pulse DC current of 160 amp&90 Hz
D	Welded pulse DC current of 170amp &90Hz
E	Welded pulse DC current of 190 amp&90 Hz
F	TIG Welded DC current of90 amp&20Hz

Table (4) Residual stresses & Macro hardness.

Specimens character	Remaining stress Mpa	Macro hardness kg/mm^2 (HR_B)
A	-18	100
B	-8.798	80
C	-13	78
D	-17	91
E	-33.794	91
F	-23.071	79

Table (5) Mechanical properties of 6061-T6 aluminum alloy base metal.

Mechanical properties	σu MPa	σy MPa	Elongation %	HR_B hardness(Kg/mm^2)
Max	335.71	296	11.8	95
Min	300-328	241-282	6-11	98

Table (6) Results of tensile properties for all specimens

Specimens symbol	σu MPa	σyMPa	σF MPa	Strain (ε)
A	350.45	295.3	200	10
B	285	153	143	10.66
C	294	168	147	10.88
D	286	263	143	9.8
E	267	162	134	9.84
F	118	101	89	10.48

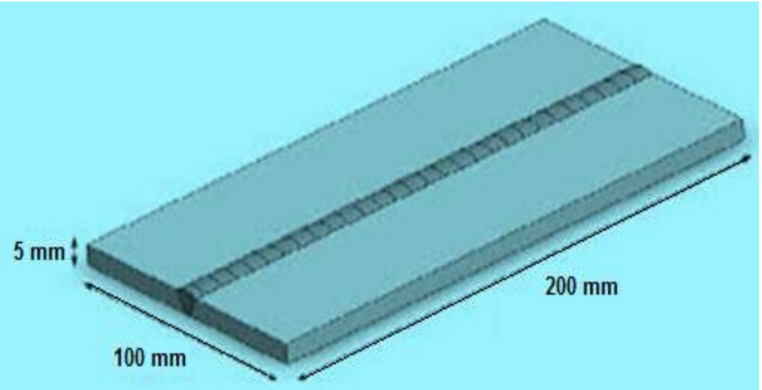

Figure (1) dimension of butt join

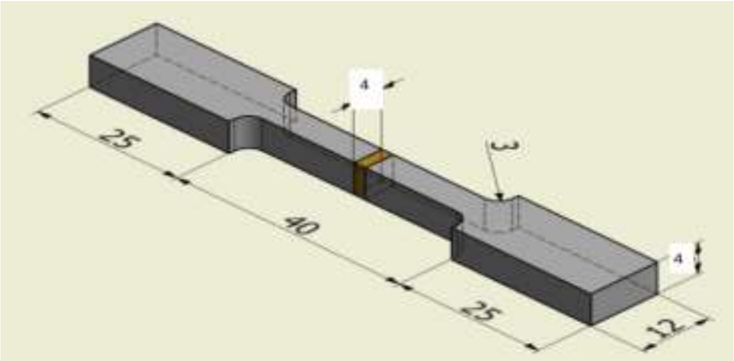

figure (2). dimension of tensile test specimen (in mm**)**

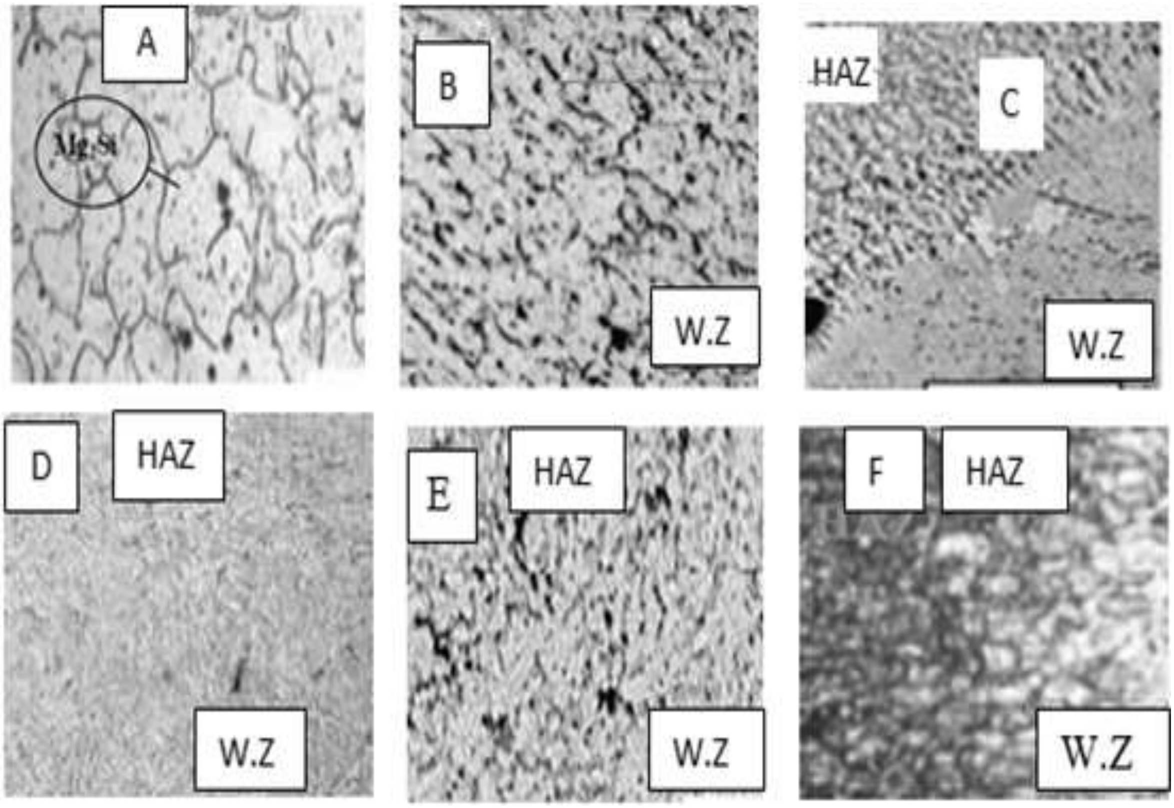

figure (3) microstructure of samples (40x)

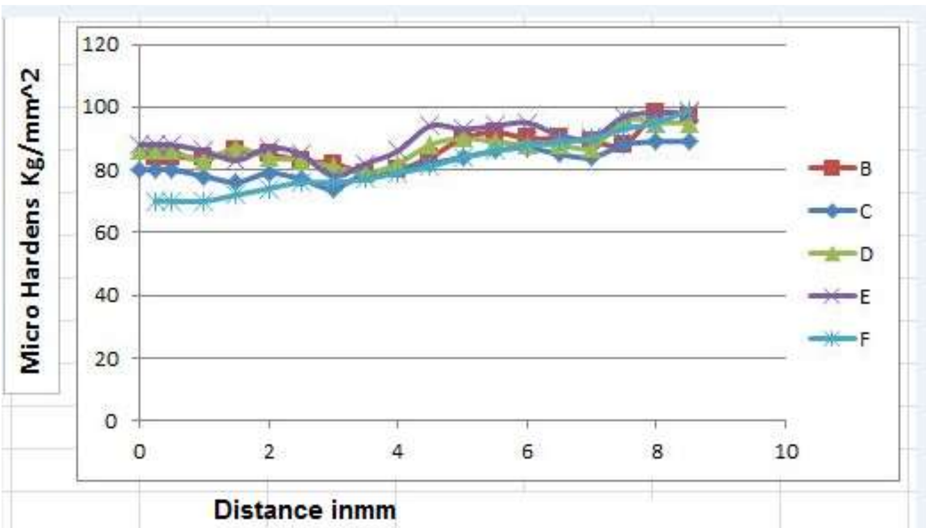

Figure (4) Micro hardness distribution for specimens.

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