International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 01, January-2018

Effect of Tool Speed and Feed on Tensile Properties of Friction stir welded AA6063-T4 alloy

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Abstract—In present work friction stir welds (FSW) of 3 mm thick AA 6063-T4 aluminium alloy were prepared at different speeds and feeds. The welding parameters were considered in order to achieve non-defective welds. The welds produced were classified as ''hot welds" and ''cold welds". The cold welds, obtained with the minimum tool rotational speed and maximum traverse speed. Cold welds have improved mechanical properties relative to the hot welds that were in under match condition relative to the base material. The tensile strength and hardness properties are found by experiments at three different speeds and feeds. The results are analysed.

Keywords— FSW , Aluminum alloy , hot welds, cold welds, brinnels hardness, Tensile strength

I. INTRODUCTION

Friction stir welding (FSW) appears as a promisingly ecological weld method that enables to diminish material waste and to avoid radiation and harmful gas emissions usually associated with the fusion welding processes. Welding of non-ferrous materials like Aluminium, Magnesium, Copper etc, is difficult with the conventional welding processes as they are prone to oxidation effects. Hence we go for friction stir welding technique which makes use of a non-consumable welding tool to generate heat.
As the tool feed rate increasing the brinells hardness is increasing, the brinels hardness number is found along the weld zone [1] The FSW parameters are tool, lead edge, trailing edge, advanced side, retreating side, applied forces, weld speed, tool rotation. The FSW samples with low speed, feed can give high ultimate strength and high speed gives high hardness value [2]. Tool pin profile, Tool shoulder are also a considerable parameter [3] The hardness of the weld negget is lower than that of base metal, because of annealing effect during welding [4]. The mechanical properties of weldments are effected by tool pins, the welds done by threaded profiles have better mechanical properties than tapper tool [5] All processes parameters influences the temperature of weld. The increased speed of tool in rpm increases the peak temperature [6] The best temperatures of the welding for good mechanical properties can be found by simulation [7] The FSW can give excellent quality weld for aluminium alloys. For high temperature materials like magnesium, titanium, and steels FSW is a good method [8] Aluminium is an important metal which has multi functions in automobiles, aerospace, defence applications. The FSW is a method to join metals without losing their properties [9].The tensile strength is highly influenced by tool speed in rpm[10].The post weld treatments on the work pieces improves the mechanical properties weldment. The tensile tests on weld samples can be done ASTM E 08 [11]. In the hot weld a lower frictional heat input is given [12].

1.1 History of friction stir welding:

FSW is considered to be the most significant development in metal joining in a decade and is a ''green'' technology due to its energy efficiency, environment friendliness, and versatility. As compared to the conventional welding methods, FSW consumes considerably less energy.
The FSW process was patented at The Welding Institute (UK) in December 1991 and it has proven to be a very successful joining technology for aluminium alloys, nickel alloys and, more recently, for steels.

II.TYPES OF FRICTION STIR WELDING:

Based on rotational speeds the welds produced were classified as ''hot welds" and ''cold welds". The''hot" welds obtained with the maximum tool rotational speed and the minimum traverse speed and the "cold" welds obtained with the minimum tool rotational speed and maximum transverse speeds.

2.1 Hot Weld:

Experimental results showed that during friction stir welding of aluminium alloys recrystallization occurred at temperature range between 200^0C to 300^0C above tool rpm of 1120 and comparatively minimum feed values.

In the present work, welds in 3 mm thick sheets of the AA 6063-T4 aluminium alloy were performed with conical shoulder tool geometries.
Conical shoulder with a 8^0 Inclination cavity, 12 mm in diameter and 20 mm length with a cylindrical threaded probe diameter of 6mm and 2.85 mm length.

2.2 Cold Weld:

Cold welding is done below recrystallization temperature, that is lesser than hot welding temperatures, which is achieved at rotational speeds ranging from 710 to 1120 rpm at comparatively high weld feed values than hot welds.

2.3 Experimental work : In the present work a 3mm rolled AA6063-T4 aluminum alloy were cut in to required size (140mmX70mm) by power hack saw and milling machine. A square butt joint was prepared at various speeds. The initial joint arrangement was obtained by clamping rigidly on the bed from four sides using mechanical clamps, this set up avoids displacement and vibration of plates during welding.FSW were performed with two different tools. The chemical composition of this alloy is shown in
table 1.

Table 1 - Chemical Composition of the metal used (**AA 6063-T4**)

%	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
Min	0.20			.	45				
Max	0.6	0.35	0.05	0.1 0	0.9	0.1	0.1	0.1	Remaining

The welding tool was made of HSS having a much higher hardness and wear resistance is used. Fig. 1&2
shows the tools used for the experiment.

The tool geometry used in cold welds is a scrolled shoulder with 20 mm in diameter and 20 mm length having grooves in base surface of the shoulder with a cylindrical threaded probe of 6 mm diameter and 2.65 mm long. The probe length is less in this tool geometry than the hot weld because of the grooves provided at the base of the scrolled shoulder.

Fig:1Conical shouldered hot weld tool

Fig2: Scrolled shoulder base surface of cold weld tool

III.WELDING PROCEDURE:

IV.TESTING, OBSERVATION AND CALCULATIONS

Testing is carried on the weld specimens, the results obtained from which the optimum values of speed and feed are defined for the specimen having good weld and mechanical properties.

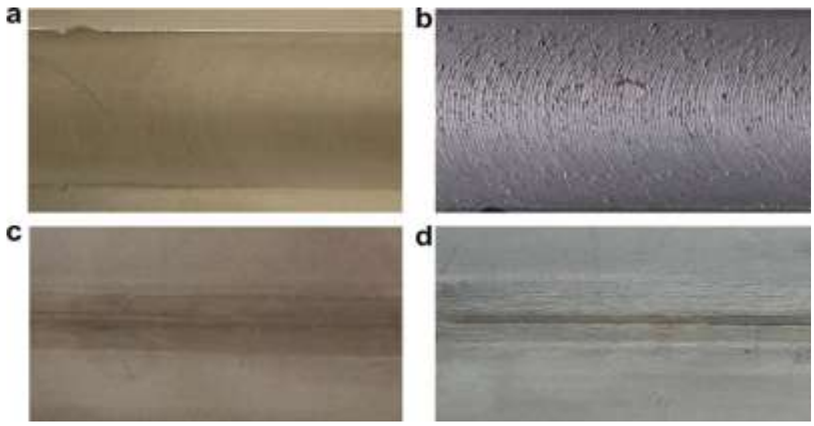

Fig 3. : Weld zones of cold and hot welds

a:900 r.p.m&125mm/min **b**:900r.p.m&160mm/min **c**:1400r.p.m&125mm/mim, **d**1400r.p.m&160mm/min
The weld obtained is tested for its different mechanical properties as:

1. Hardness test (Brinell)
2. Tensile strength test

4.1 .Brinell Hardness Test:

- Ball diameter : 10mm
- Max load capacity of machine : 30 KN
- Load applied : 5kN
- Brinell Hardness Microscope

The weld specimen is placed on the work table so that the weld nugget is exactly under the indentor and a load of 5kN is applied on the weld piece. Hardness values are measured on advancing side, retreating side and at the centre of the weld nugget and the average of these three readings are preferred for calculating hardness values (BHN). Brinels hardness number ASTM standard is ,ASTM E 10.

Table 2.1: BHN for Cold welds:

Cold welds (C)	Traverse speed(mm/min)	Rotational speed (rpm)	Indent diameter mm	Hardness BHN
C1	125	710	1.33	36.206
C2	160	900	1.349	35.657
C3	200	1120	1.31	37.4717

Table 2.2 BHN for hot welds:

Hot welds (H)	Traversespeed (mm/min)	Rotational speed(rpm)	Indent diameter mm	Hardness (BHN)
H1	100	1120	1.564	26.523
H2	125	1400	1.49	29.756
H3	160	1800	1.62	24.64

4.2. Tensile test: A universal testing machine was used to perform the tensile test of the specimens. The starting and ending portions of the weld were not used. The tensile specimens are prepared as per standard ASTM E8M and the same geometry which was used throughout the present study.

Fig:4.1Specimen before tension testing

Fig 4.2. Specimen after testing

Results obtained in Tensile Test are tabulated below:

Table 3.1.Cold weld tensile properties

Weld samples	**Speed (rpm)**	**feed (mm/min)**	**Yield stress(N/mm$^{2)}$**	**UltimateStrength (N/mm^2)**	**% elongation**
C1	700	125	100.27	127.54	10.18
C2	900	160	101.897	123.391	9.18
C3	1120	200	106.242	132.802	9.04

Table3.2. Hot Weld:tensile properties

Weld samples	Speed (rpm)	**Feed (mm/min)**	**Yield strength (N/mm^2)**	**Ultimate Strength (N/mm^2)**	**% of elongation**
H1	1120	100	73.594	88.151	3.36
H2	1400	125	73.331	96.467	3.16
H3	1800	160	66.053	82.765	4

V. RESULTS AND ANALYSIS

5.1. Hardness:

The hardness results obtained for hot and cold welds show large differences between their values. The values obtained for cold welds are better when compared to hot welds. The hardness of the cold welds are very close to the base metal hardness i.e (AA6063-T4) whereas the hardness for hot welds are very less i.e the values are much deviated from the base metal hardness. The hardness at the weld zone even depends on the weld speeds and feeds.

5.2. Tensile properties:

The maximum yield strength and ultimate tensile strength obtained in cold welds for the specimen **C3**106.242N/mm^{2}and 132.802N/mm^{2}respectively.

The maximum yield strength and ultimate tensile strength obtained in hot welds for the specimen **H2**73.331 N/mm^{2}and96.467N/mm^{2}respectively.

The data results are represnted in the 3D graphs , showing Speed , v/s feed, yield strenght, ultimate strenght , % of elongation both cold and hot welds.

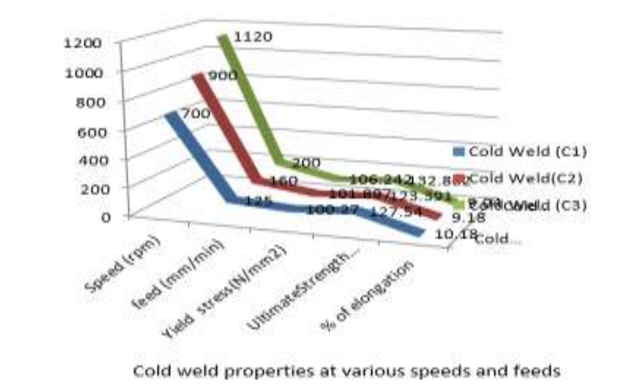

Fig.5.1Graph Shows Tensile properties of Cold Welds

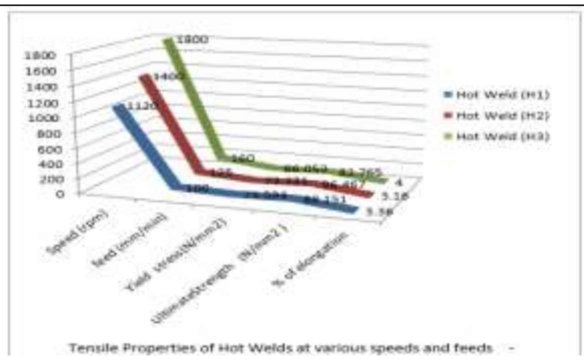

Fig.5.2.Graph Shows Tensile properties of Hot Welds

VI. CONCLUSIONS

The friction stir welding is found to be the best method for welding Aluminium metal. The FSW main parameters are the tool rotation, tool feed, tool shape. The heat, temperature developed between the tool and work piece melts and then solidifies, thus the FSW takes place. From the results obtained it has been analysed that for hot weld the better weld joint is achieved at 1400 rpm and 125 mm/min, whereas for cold welds the better weld joint is attained at rotational speed of 1120 rpm and welding speed of 200 mm/min. Compared to hot weld the cold weld obtained has more strength, nearer to the base metal properties.

REFERENCES

[1]. Prince Sainia, S.P.Tayala , Anish Kumara and Vikrant Kaushika "Experimental Study of Hardness by Friction Stir Welding of 6061-T6 Aluminium Pieces" International Journal of Current Engineering and Technology ISSN 2277–4106

[2]. T. Nancharaiah "Experimental Investigation of Mechanical Properties of Friction Stir Welded Butt Joint of Aluminum Alloy AA6061" IPASJ International Journal of Mechanical Engineering (IIJME) Web Site: http://www.ipasj.org/IIJME/IIJME.htmo Volume 5, Issue 8, August 2017 ISSN 2321-6441

[3]. Diljot Singh Sekhon , Er. Rajdeep Singh , Er. Nirmaljeet Singh Virk "A Review of Friction Stir Welding Process Parameters on Various Aluminium Alloys" International Journal of Innovative Research in Science, Engineering and Technology" ISSN(Online): 2319-8753 ISSN (Print): 2347-6710, DOI:10.15680/IJIRSET.2016.0608143 16750, Vol. 6, Issue 8, August 2017

[4]. N. Srirangarajalu, A. Rajadurai "Microstructure and mechanical behaviour of friction stir welded etp copper" La Metallurgia Italiana - n. 2 2016

[5]. Lam.Suvarna Raju, Adepu Kumar "Microstructure and Mechanical characterization of friction stir welded copper" International Journal of Advanced Trends in Computer Science and Engineering, Vol.2 , No.1, Pages : 640 – 643 (2013) Special Issue of ICACSE 2013 - Held on 7-8 January, 2013 in Lords Institute of Engineering and Technology, Hyderabad, ISSN 2278-3091

[6]. S.Rajendra Prasad, 2 Dr.Adepu Kumar, 3 Dr. Ch. Sridhar Reddy "Experimental Study on Temperature Evolution during Friction Stir Welding of 2014-T6 Aluminium alloy, StructureProperty Correlation " International Journal of Scientific & Engineering Research, Volume 7, Issue 6, June-2016 63 ISSN 2229-5518

[7] Khwaja Muzammil, R.D.Shelke "Review Paper on Friction Stir Welding of various Material" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 04 Issue: 01 | Jan -2017 www.irjet.net p-ISSN: 2395-0072

[8] Kaushal Kumar, Piyush Gulati, Akash Gupta andDinesh Kumar Shukla "a review of friction stir processing of Aluminium alloys using different types of reinforcements"International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue 7, July 2017, pp. 1638–1651, Article ID: IJMET_08_07_180"

[9].k. K. Ramachandran, n. Murugan, and s. Shashi kumar "Mechanical and microstructural Characterization of dissimilar friction stir welded butt joints" September 2015 / welding journal 291-s

[10]. D.Muruhganadam ,D.Raguram, L.K.Kumaraswami " Effect of post welding treatment on mechanical properties of joints in high strength alloys" Indian journal of engineering and material science ,Vol 22, August 2015, pp 381-388.

[11].Michael Hartmann, Stefan Böhm, and Sven Schüddekopf "Influence of Surface Roughness of Tools on the Friction Stir Welding Process" Journal of Welding and Joining, Vol. 32, No. 6.