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Influence of Mx-Trivex, A-Skew, Three Flat Threaded and Concave Shouldered Mx-Triflute Tool Pin Profiles on Tensile Properties and Fractural Behaviour of AA 6082-T6 Weldments during Friction Stir Welding

K. Vijaya Krishna Varma, B. V. R Ravi Kumar, M. Venkata Ramana

Abstract: Friction Stir Welding (FSW) is a topical and propitious solid-state joining process producing economical and strengthened joints of age-hardened and heat-treatable Aluminium Alloy AA 6082-T6. Mechanical and fractural behaviour of weldments were investigated in order to find crack initiation and necking on the weld zone thereby perceiving the complete behaviour of fracture occurred near the weld zone. Weldments are fabricated by employing four tool pin profiles namely MX-TRIVEX, A-SKEW, Three flat threaded and Concave shouldered MX-TRIFLUTE tools at various rotational speeds 1000 rpm, 1200 rpm and 1400 rpm at single traverse speed 25 mm/min. EXCETEX-EX-40 CNC wire cut EDM with 0.25 mm brass wire diameter has been employed to perform the extraction of tensile test specimens from the weldments according to ASTM E8M-04 standard. Tensile test was performed on elctro-mechanically servo controlled TUE-C-200 (UTM machine) according to ASTM B557-16 standards Maximum Ultimate Tensile Strength (UTS) of 172.33 MPa (55.5% of base material) and 0.2% Yield Stress (YS) of 134.10 MPa (51.5% of base material) were obtained by using A-SKEW at 1400 rpm, 25 mm/min and maximum % Elongation (%El) of 11.33 (113.3% of base material) was obtained at MX-TRIVEX at 1000 rpm, 25 mm/min. Minimum UTS of 131.16 MPa (42.30% of base material) and 0.2% YS of 105.207 MPa (40.46% of base material)were obtained by using Concave shouldered MX-TRIFLUTE at 1400 rpm, 25 mm/min. Minimum % El of 5.42 (54.2% of base material) was obtained by using A-SKEW at 1000 rpm, 25 mm/min.

Keywords: Friction Stir Welding, Fracture behaviour, Fracture location, Tensile properties.

I. INTRODUCTION

FSW has relish global importance due to mere advantages over long-established joining methods.

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FSW technology boasts elimination of oxide disruption, cracking and reduced distortion in long length tailored FSW blanks with superlative mechanical properties in the weldments and heat affected zone thereby minimizing the formation of fumes, porosity, and material shrinkage as well green and energy efficient process compared to traditional fusion welds. During translational and rotational motion of weld ultra-fine recrystallized grain size are formed by adequate mixing and plunging of parent alloy [1]. Raghu babu et.al [2] optimized FSW parameters of AA 6082-T6 using Taguchi technique. In this experimentation, the Taguchi model was employed to find out influence of rpm and weld traverse speed on the welments. The results showed that at 1230 rpm and 170 mm/min weld defects are avoided. Marimuthu et.al [3] performed FSW on AA 6082-T6 at rotational speeds 660 rpm, 930 rpm, 1100 rpm, 1460 rpm and traverse speed of 0.5 and 0.83 mm/sec using circular threaded tool pin profile and obtained sound weldments at 930 rpm with 0.5 and 0.83 mm/sec traverse speeds. Pavan Kumar et.al [4] conducted FSW on AA 6082-T6 using three tool pin profiles triangle, square and hexagonal at process parameters like 1400 rpm and 90 mm/min and concluded that highest tensile strength of 116.47 MPa was obtained by hexagonal tool pin profile besides low tensile strength of 72.31 MPa was obtained by triangle tool pin profile. Fractography is used to study the type of fractures present on the weldment. Material failure occur due to distinct reasons, but fracture occurs in various modes like: wasp waist, cup-and-cone, shear lip, fatigue, rupture formed due bonding etc. Each fracture modes has their own fracture characteristic appearance. From the above literature review it is found that rotational speed 1400 rpm and low weld traverse speed gives optimum results during welding.

II. EXPERIMENTAL WORK

The base material used for experimentation is AA 6082-T6. The chemical composition analysis and mechanical properties of base material are shown in Tables I and II respectively. The hot rolled AA 6082-T6 blanks of 6 mm thickness were cut by chop saw and milling operation was performed to obtain final required size (300 ×80 mm) welding was performed on butt joint configuration using BAYGILL-KMT-1500 vertical milling machine (VMC) as shown in Fig. 1. Clamping of AA 6082-T6 for fabricating of weldments are shown in Fig. 2.

The FSW tools dimensions employed for fabrication of weldments are shown in Fig. 3 (a) A-SKEW, (b) MX-TRIVEX, (c) Three flat threaded respectively and (d) concave shouldered MX-TRIFLUTE.

Table- I: Chemical composition (wt%) of AA 6082 – T6

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
0.8	0.2	0.05	0.6	0.6	0.01	0.03	0.009	97.5

Table- II: Mechanical properties of AA 6082-T6

0.2% YS (MPa)	UTS (MPa)	%El
260	310	10

Fig. 1 BAYGILL KMT-1500 **Fig. 2 Clamping of AA6082**

Vertical milling machine -T6 plates

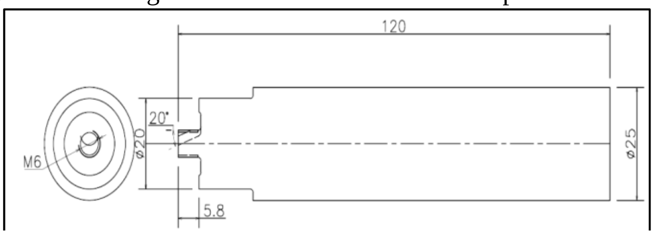


Fig. 3 (a) A-SKEW tool pin profile

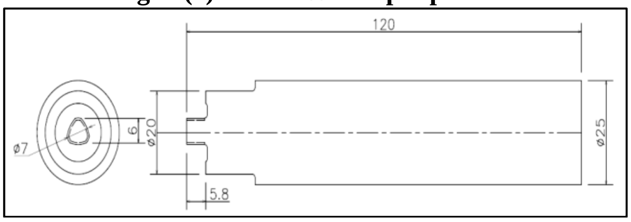


Fig. 3 (b) MX-TRIVEX tool pin profile

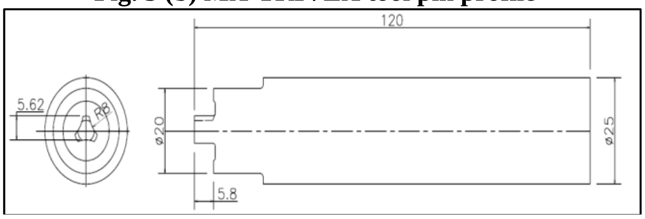


Fig. 3 (c) Three flat threaded tool pin profile

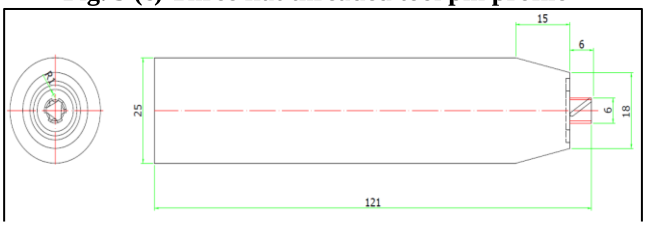


Fig. 3 (d) Concave shouldered MX-TRIFLUTE tool pin profile

Fig. 4 (a), (b), (c) shows the photographs of A-SKEW, MX-TRIVEX and Three flat threaded tools. Fig. 5 shows the photograph of concave shouldered MX-TRIFLUTE.

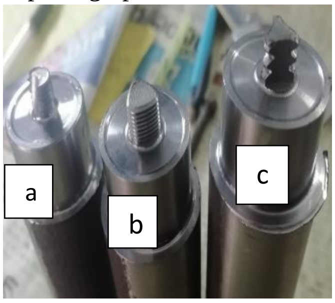


Fig. 4 (a) A-SKEW
4 (b) MX-TRIVEX
4 (c) Three flat threaded

Fig. 5 Concave shouldered MX-TRIFLUTE

Fig. 6 (a), (b) and (c) represents the joints fabricated using MX-TRIVEX tool pin profile at 1000 rpm, 1200 rpm and 1400 rpm respectively.

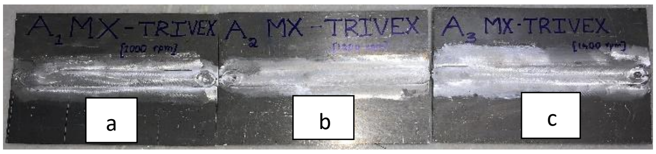


Fig. 6 (a) MX-TRIVEX at 1000 rpm, (b) MX-TRIVEX at 1200 rpm and (c) MX-TRIVEX at 1400 rpm

Fig. 7 (a), (b) and (c) represents the joints fabricated using A-SKEW tool pin profile at 1000 rpm, 1200 rpm and 1400 rpm respectively.

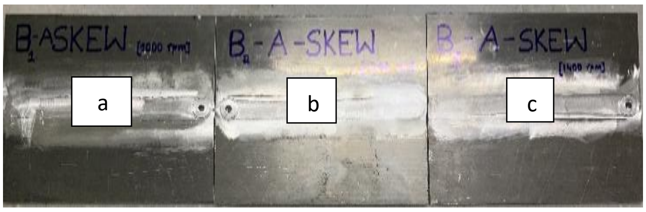


Fig. 7 (a) A-SKEW at 1000 rpm, (b) A-SKEW at 1200 rpm and (c) A-SKEW at 1400 rpm

Fig. 8 (a), (b) and (c) represents the joints fabricated using three flat threaded tool pin profile at 1000 rpm, 1200 rpm and 1400 rpm respectively.

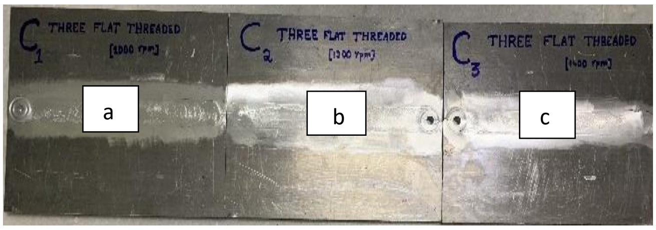


Fig. 8 (a) Three flat threaded at 1000 rpm, (b) Three flat threaded at 1200 rpm and (c) Three flat threaded at 1400 rpm

Fig. 9 (a), (b) and (c) represents the joints fabricated using concave shouldered MX-TRIFLUTE tool pin profile at 1000 rpm, 1200 rpm and 1400 rpm respectively.

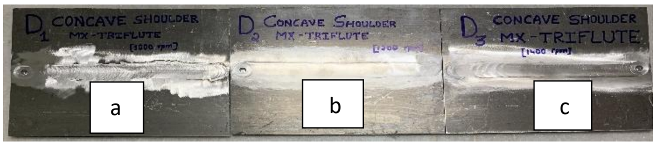


Fig. 9 (a) Concave shouldered MX-TRIFLUTE at 1000 rpm, (b) Concave shouldered MX-TRIFLUTE at 1200 rpm and (c) Concave shouldered MX-TRIFLUTE at 1400 rpm

As per ASTM E8M-04 standards, the tensile test specimen is prepared as shown in Fig. 10 using EXCETEX-EX-40 CNC wire cut EDM as shown in Fig. 11.

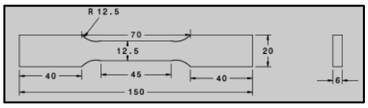


Fig. 10 Tensile test specimen

Fig. 11 EXCETEX-EX-40 CNC wire cut EDM

The tensile test specimens of MX-TRIVEX™, A-SKEW™ Three flat threaded and Concave shouldered MX-TRIFLUTE™ before performing mechanical test are shown in Fig. 12.

As per ASTM B557-16 standards, tensile test was performed on electro-mechanically controlled universal testing machine (UTM) at 150 kN (TUE make; C – SERVO - 200) as shown in Fig. 13. Gripping of tensile specimen in to the jaws is shown in Fig. 14.

Fig. 12 Tensile test specimens of tool pin profile before performing mechanical test

Fig.13 UTM machine specimens

Fig. 14 Gripping of tensile into the jaws

III. RESULTS AND DISCUSSIONS

A. TENSILE PROPERTIES:

The tensile test specimens after performing mechanical test are shown in Fig. 15 (a) and location of shear occurred on tensile specimen is shown in Fig. 15 (b) respectively.

Fig. 15 (a) Tensile test specimens after performing tensile test

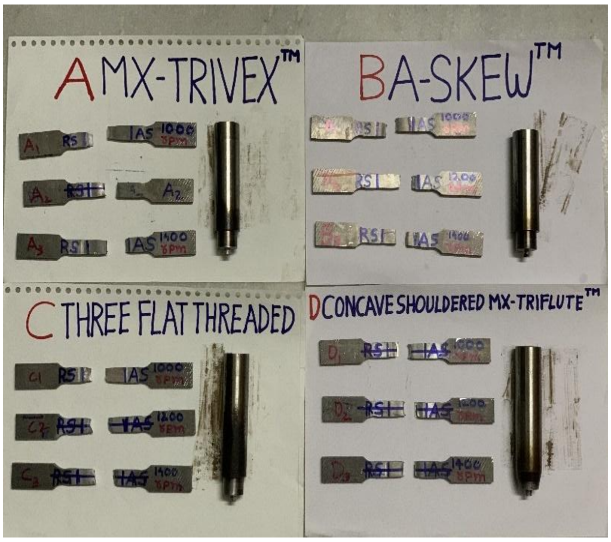


Fig. 15 (b) Location of shear occurred on tensile specimen

Tensile properties (UTS, 0.2% YS and %El) along with Failure locations of 6.0 mm thick 6082 Aluminium Alloy weldments for MX-TRIVEX, A-SKEW, Three flat threaded and Concave shouldered MX-TRIFLUTE are illustrated in Tables. IV, V, VI and VII respectively.

Table- IV: Failure locations of 6.0 mm thick 6082 Aluminium Alloy weldments of MX-TRIVEX FSW tool

Tool and Weld parameters	UTS (MPa)	0.2% YS (MPa)	%El	Failure location
MX-TRIVEX at 1000 rpm	134.3	127.4	11.3	Weld 

MX-TRIVEX at 1200 rpm	153.6	124.2	8.66	Weld 
MX-TRIVEX at 1400 rpm	161.1	131.1	7.4	Weld 

From the Table. IV MX-TRIVEX at 1000 rpm showed UTS of 134.3 MPa (43.3% of base material), 0.2% YS 127.4 MPa (49% of base material) and %El of 11.3 (113.3% of base material). MX-TRIVEX at 1200 rpm showed UTS of 153.6 MPa (49.5% of base material), 0.2% YS 124.2 MPa (47.7% of base material) and %El of 8.66 (86.6% of base material). MX-TRIVEX at 1400 rpm showed UTS of 161.1 MPa (51.9% of base material), 0.2% YS 131.1 (50.4% of base material) and %El of 7.4 (74% of base material). From the experimental results, higher UTS of 161.1 MPa (51.9% of base material), higher 0.2% YS of 131.1 MPa (50.4% of base material) is obtained 1400 rpm and higher %El of 11.3 (113.3% of base material) is obtained at 1000 rpm. Lower UTS of 134.3 MPa (43.3% of base material) is obtained 1000 rpm, lower 0.2% YS of 124.2 MPa (47.7% of base material) is obtained at 1200 rpm and lower %El of 7.4 (74% of base material) is obtained at 1400 rpm. Lower UTS and 0.2% YS is obtained at low rpm (1000 rpm) and low %El is obtained at higher rpm (1400).

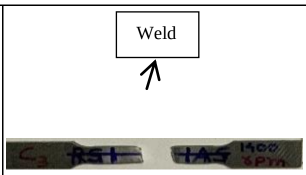
Table- V: Failure locations of 6.0 mm thick 6082 Aluminium Alloy weldments A-SKEW tensile properties

Tool and Weld parameters	UTS (MPa)	0.2% YS (MPa)	%El	Failure location
A-SKEW at 1000 rpm	142.4	111.7	5.4	Weld 
A-SKEW at 1200 rpm	172.3	134.1	10.3	Weld 
A-SKEW at 1400 rpm	133.9	164.4	7.0	Weld 

From the Table. V A-SKEW at 1000 rpm showed UTS of 142.4 MPa (45.9% of base material), 0.2% YS 111.7 MPa (42.9% of base material) and %El of 5.4 (54% of base material). A-SKEW at 1200 rpm showed UTS of 172.3 MPa (55.5% of base material), 0.2% YS 134.1 MPa (51.5% of base material) and %El of 10.3 (103% of base material). A-SKEW at 1400 rpm showed UTS of 133.9 MPa (43.19% of base material), 0.2% YS 164.4 (63.2% of base material) and %El of 7 (70% of base material). From the experimental results higher UTS of 172.3 MPa (55.5% of base material), %El of 10.3 (103% of base material) is obtained at 1200 rpm and higher 0.2% YS of 164.4 MPa (63.2% of base material) is obtained 1400 rpm. Besides Lower UTS of 133.9 MPa (43.1% of base material) is obtained at 1400 rpm, lower 0.2% YS of 111.7 MPa (42.9% of base material) is obtained at 1000 rpm and lower %El of 5.4 (54% of base material) is obtained at 1000 rpm.

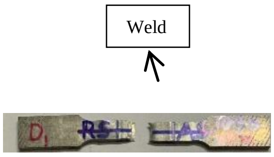
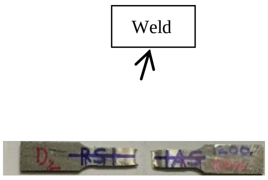
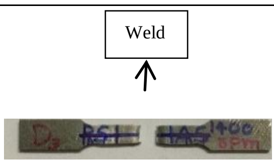
Table- VI: : Failure locations of 6.0 mm thick 6082 Aluminium Alloy weldments three flat threaded tensile properties

Tool and Weld parameters	UTS (MPa)	0.2% YS (MPa)	%El	Failure location 
Three flat threaded at 1000 rpm	171.4	131.9	9.6	Weld
Three flat threaded at 1200 rpm	163	129.4	9.6	Weld 

Three flat threaded at 1400 rpm	159.8	126.7	9.0	

From the Table. VI three flat threaded tool at 1000 rpm showed UTS of 171.4 MPa (55.2% of base material), 0.2% YS 131.9 MPa (50.7% of base material) and %El of 9.6 (96% of base material). Three flat threaded at 1200 rpm showed UTS of 163 MPa (52.5% of base material), 0.2% YS 129.4 MPa (49.7% of base material) and %El of 9.6 (96 % of base material). Three flat threaded at 1400 rpm showed UTS of 159.8 MPa (51.5% of base material), 0.2% YS 126.7 (48.7% of base material) and %El of 9.0% (90% of base material). From the above results we can observe that higher UTS of 171.4 MPa (55.2 % of base material), higher 0.2% YS of 131.9 MPa (50.7% of base material) %El of 9.6 (96% of base material) is obtained at 1000 rpm. Lower UTS of 159.8 MPa (51.5% of base material), lower 0.2% YS of 126.7 MPa (48.7% of base material) and lower %El of 9.0 (90% of base material) is obtained at 1400 rpm.

Table- VII : Failure locations of 6.0 mm thick 6082 Aluminium Alloy weldments concave shouldered MX-TRIFLUTE tensile properties

Tool and Weld parameters	UTS (MPa)	0.2% YS (MPa)	%El	Failure location
Concave shouldered MX-TRIFLUTE at 1000 rpm	145	119.8	6.4	
Concave shouldered MX-TRIFLUTE at 1200 rpm	147.6	117	6.8	
Concave shouldered MX-TRIFLUTE at 1400 rpm	131.1	105.2	7.0	

From the Table. VII concave shouldered MX-TRIFLUTE at 1000 rpm showed UTS of 145 MPa (46.7% of base material), 0.2% YS 119.8 MPa (46% of base material) and %El of 6.4 (64% of base material). Concave shouldered MX-TRIFLUTE at 1200 rpm showed UTS of 147.6 MPa (47.6% of base material), 0.2% YS 117 MPa (45% of base material) and %El of 6.8 (68% of base material). Concave shouldered MX-TRIFLUTE at 1400 rpm showed UTS of 131.1 MPa (42.2% of base material), 0.2% YS 105.2 (40.4% of base material) and %El of 7 (70% of base material). From the experimental results higher UTS of 147.6 MPa (47.6% of base material) is obtained at 1200 rpm , %El of 7.0 (70% of base material) is obtained at 1400 rpm and high 0.2% YS of 119.8 MPa (46% of base material) is obtained 1000 rpm . Lower UTS of 131.1 MPa (42.2% of base material) is, lower 0.2% YS of 105.2 MPa (40.4% of base material) is obtained at 1400 rpm and lower %El of 6.4 (64% of base material) is obtained at 1000 rpm.

B FRACTURE LOCATION, CHARCTERISTICS AND MECHANISM ON THE TENSILE SPECIMENS

Fig.16 represents the failure of material for MX-TRIVEX at 1000 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- ~ 45^0 shear lip (lower lip) occurred near Retreating side (RS) of the weld.
- ~ 45^0 shear lip (Upper lip) occurred near Advancing side (AS) of the weld.
- Quasi-cleavage fracture has been observed near the basal plane of RS.
- Tearing ridges in tensile direction was observed near Nugget zone (NZ) at AS side of the specimen.

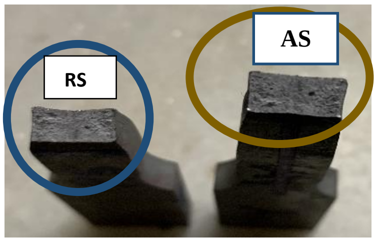


Fig. 16 Fracture of MX-TRIVEX tensile specimen at 1000 rpm

From the fracture observations, shear lip are formed due to acute deformation of material during the application of load.

Quasi-cleavage fracture phenomenon is mainly formed due to fracture arising on the surface leading to the formation of void coalescence initiating rupture across the slip band intersections.

Tearing ridges represents the direction of crack growth and used to identify localized crack initiation.

Fig.17 represents the failure of material for MX-TRIVEX at 1200 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- Cup-and-cone and Mode- III type of fracture was observed on the tensile test specimen.

- Failure occurred with lower lip at NZ forming dimple rupture resulting in the formation intrusions and shallow deep elongated dimples with sharp tearing ridges was observed on RS.
- Trans-granular fracture with fibrous pattern markings resulting in the formation of micro-pore aggregation of fracture was observed on AS.

From fracture observations, Cup-and-cone and Mode- III type of fracture occurs due acute shear applied on the specimen. Sharp tearing ridges and dimple rupture are formed due excessive void nucleation in the progressive stage. Trans-granular fracture occurs when prorogation of crack occurs along the direction of grains.

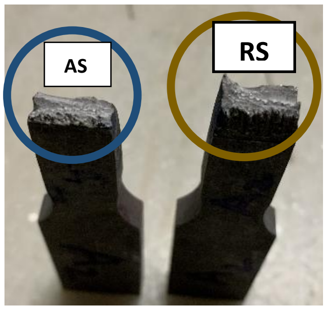


Fig. 17 Fracture of MX-TRIVEXtensile specimen at 1200 rpm

Fig.18 represents the failure of material for MX-TRIVEX at 1400 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- ~ 45^0 shear lip (lower lip) leading to formation of necking, fine equi-axed recrystallized grains, tearing edges at the end with river-like patterns forming cleavage on lower lip of AS.
- ~ 45^0 shear lip (lower lip) leading to formation of river like patterns, sharp tearing edges at the end with coarse bent recovered grains are formed on RS.

From the fractural observations, ductile shear has been observed on the specimens leading to formation of tearing edges and river-like patterns causing crack along the crystal planes thereby producing a series of connecting edges and plateaus.

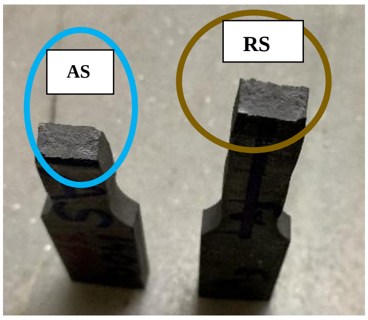


Fig. 18 Fracture of MX-TRIVEX tensile specimen at 1400 rpm

Fig. 19 represents the failure of material for A-SKEW at 1000 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- Cup-and-cone and Mode- III type of fracture was observed on the tensile test specimen.
- Lower lip with sharp tearing ridges at the end and crevious deep hole dimples was observed near NZ of RS.
- Lower lip with tearing edges at the end with flat facets comprising of coarse bent recovered grains was observed on AS.

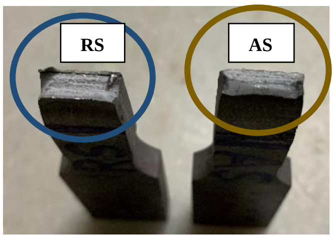


Fig. 19 Fracture of A-SKEW tensile specimen at 1000 rpm

From the fractural observations, shear lip angle represents the direction of acute shear stress thereby forming slip due to shear in the final stage of cracking.

Fig. 20 represents the failure of material for A-SKEW at 1200 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- Cup-and-cone and Mode- III type of fracture was observed on the tensile test specimen.
- Lower lip with sharp tearing ridges and deep shallow coarse elongated dimples with segregations was observed on RS.
- ~ 45^0 shear lip (lower lip) with river like patterns and strations was observed on AS.

From fractural observations, strations (concentric rings) mainly formed during crack propagation due to the formation of excessive void nucleation and variation of stress amplitude.

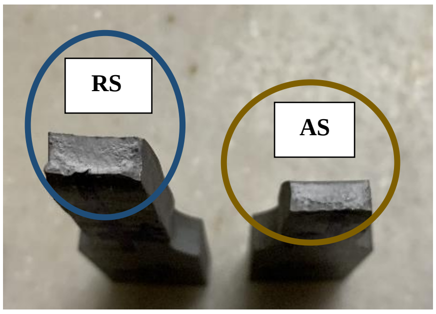


Fig. 20 Fracture of A-SKEW tensile specimen at 1200 rpm

Fig. 21 represents the failure of material for A-SKEW at 1400 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- Cup-and-cone and Mode- III type of fracture was observed on the tensile test specimen.
- Inter-granular fracture comprising of coarse dimples and micro-voids was observed on RS.
- Shallow elongated cavities comprising of coarse dimples with clamshell marks and voids formation was observed on AS.

From the fractural observations, clamshell marks are formed due to interruptions during crack propagation thereby crack propagation along the grain cross section boundaries.

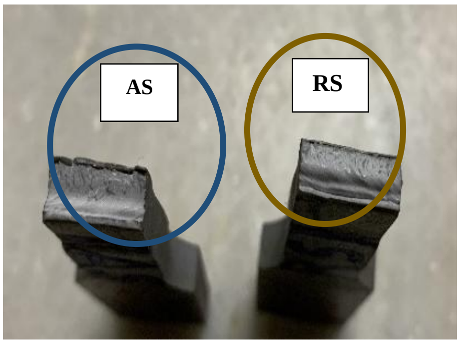


Fig. 21 Fracture of A-SKEW tensile specimen at 1400 rpm

Fig. 22 represents the failure of material for three flat threaded at 1000 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- ~ 45^0 shear lip (lower lip) bent near Thermo-mechanically affected zone forming irregular patterns with sharp tearing ridges and inter-granular fracture was observed on RS.
- ~ 45^0 shear lip (lower lip) with quasi-cleavage fracture and cervices was observed on AS.

From the fractural observations, quasi-cleavage fracture and cervices were observed due to propagation of crack occurs due to fragmentation of particle-lattice fracture.

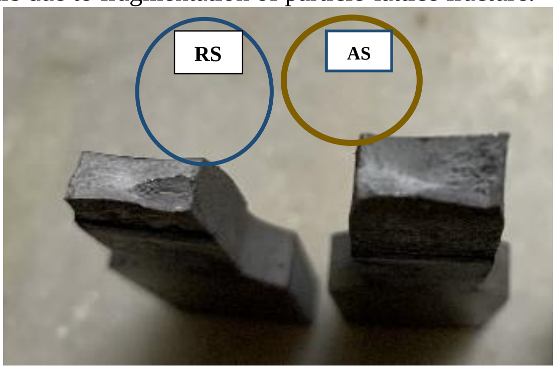


Fig. 22 Fracture of three flat threaded tensile specimen at 1000 rpm

Fig. 23 represents the failure of material for three flat threaded at 1200 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- Cup-and-cone fracture with deep shallow tearing edges and trans-granular fracture is observed on RS.
- Coarse-bent-recovered grains with fibrous little elongated dimples is observed on AS.

From the fractural observations, failure of specimen has been observed due to the crack propagation in the perpendicular direction of applied stress.

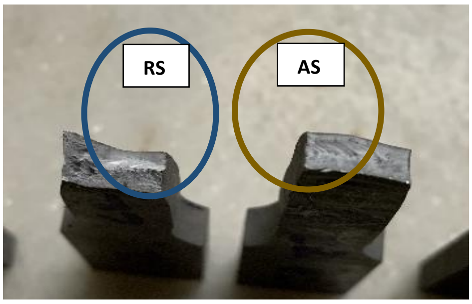


Fig. 23 Fracture of three flat threaded tensile specimen at 1200 rpm

Fig. 24 represents the failure of material for three flat threaded at 1400 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- ~ 45^0 shear lip (lower lip) comprising of sharp tearing ridges, clam shell patterns and coarse grains is observed on AS.
- Micro-pore aggregation fracture with flat facets and localized slip is observed on RS.

From the fractural observations, Micro-pore aggregation fracture with flat facets occurred due to inhomogeneous deformation formed due to acute critical stress.

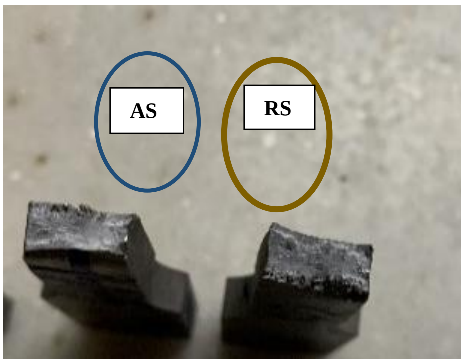


Fig. 24 Fracture of three flat threaded tensile specimen at 1400 rpm

Fig. 25 represents the failure of material for concave shouldered MX-TRIFLUTE at 1000 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- Cup-and-cone and Mode- III type of fracture was observed on the tensile test specimen.
- ~ 45^0 shear lip (lower lip) comprising of inter-granular fracture and irregular strirations was observed on RS.
- Shear fracture comprising of sharp tearing ridges with fine-equiaxed recrystallized grains was observed on AS.

From fractural observations, strirations (concentric rings) mainly formed during crack propagation due to the formation of excessive void nucleation and variation of stress amplitude

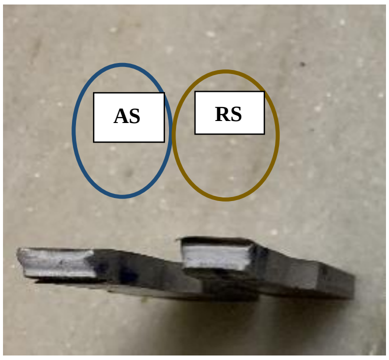


Fig. 25 Fracture of concave shouldered MX-TRIFLUTE tensile specimen at 1000 rpm

Fig. 26 represents the failure of material for concave shouldered MX-TRIFLUTE at 1200 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- ~ 45^0 shear lip (lower lip) with sharp tearing ridges and fine dimples was observed on RS.
- Localized slip with micro-pore aggregation fracture was observed on AS.

From the fractural observations, Micro-pore aggregation fracture occurred due to inhomogeneous deformation formed due to acute critical stress

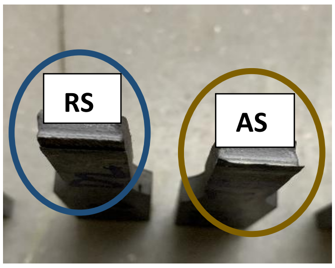


Fig. 26 Fracture of concave shouldered MX-TRIFLUTE tensile specimen at 1200 rpm

Fig. 27 represents the failure of material for concave shouldered MX-TRIFLUTE at 1400 rpm. Upon fractural examination of the material, the following are the observations made on the specimens:

- Sharp tearing ridges comprising of inter-granular fracture with fine strations was observed on RS.
- Localized slip with inter-granular fracture was observed on AS.

From fractural observations, strations (concentric rings) mainly formed during crack propagation due to the formation of excessive void nucleation and variation of stress amplitude [5].

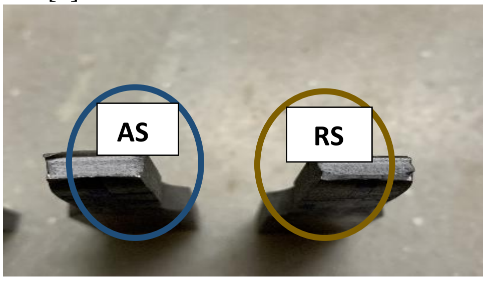


Fig. 27 Fracture of concave shouldered MX-TRIFLUTE tensile specimen at 1400 rpm

IV. CONCLUSIONS

The below are the conclusions drawn after investigating tensile and fracture behaviour of weldments:

- Weldment fabricated using A-SKEW at 1200 rpm and 25 mm/min traverse speed exhibited highest UTS of 172.33 MPa (55.5% of base material) and 0.2% YS of 134.1 MPa (51.5% of base material) respectively.
- Highest %El (11.3) i.e 113% of base material is obtained by using MX-TRIVEX at 1000 rpm and %El (10.3) 103% of base material is obtained by using A-SKEW at 1200 rpm.
- Ductile fracture with shear lip (lower lip), tearing ridges, coarse grains and voids were formed in most of the tensile test specimens.

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REFERENCES

1. Nikul Patel, Bhatt K.D, Vishal Mehta, “Influence of Tool Pin Profile and Welding Parameter on Tensile Strength of Magnesium Alloy AZ91 during FSW”, 3rd *International conference on Innovations in Automation and Mechatronics Engineering*, Elsevier, 2016, pp. 558 - 565.
2. Raghu Babu. G, Murti K. G. K. and Ranga Janardhana .G,” An Experimental Study On The Effect Of Welding Parameters On Mechanical And Microstructural Properties Of Aa 6082-T6 Friction Stir Welded Butt Joints ”, *ARPN Journal of Engineering and Applied Sciences*, Vol. 3, No. 5, Oct 2008, pp. 68 – 74.
3. Muthukrishnan. M and Marimuthu. K, “Some Studies on Mechanical Properties of Friction Stir Butt Welded Al-6082-T6 Plates ”, *IEEE*, 2010, pp. 269- 273.
4. Pavan Kumar Thimmaraju, Krishnaiah Arkanti, Chandra Mohan Reddy .G, Tilak K.B.G.,” Comparison of Microstructure and Mechanical Properties of friction Stir welding of Al 6082 aluminum alloy with different Tool Profiles”, *ICMRA*, 2016, pp. 4173 – 4181.
5. Raghu Nath. S, Balasubramanian .V, Malarvizhi. S, A.G Rao., “ Effect of welding processes on mechanical and microstructural characteristics of high strength low alloy naval grade steel joints”. Defence Technology, 2015, pp. 308-317.

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