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ANALYSING THE EFFECTS OF CYLINDRICAL TOOL GEOMETRY AND MECHANICAL PROPERTIES OFALUMINIUM 5052/6061 ALLOYS WELDED BY FRICTION STIR WELDING

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ABSTRACT

In the present experimental work, friction stir welding has been investigated with Al 6061 and Al 5052.To obtain the optimum condition, five rotational speeds (200, 400, 600, 800, 1000 rpm) and two traverse speeds (0.5 mm/sec, 0.7mm/sec) were considered. Friction Stir welding enhances the mechanical properties when welded with aluminium alloys. In FSW, the main influencing parameters are rotational speed, welding traversing speed and pressure.The observation from this experimental investigation is that the effect of rotational speed improves the mechanical properties of the welded joint.The mechanical properties such as tensile strength, hardness, impact and corrosion of weldment were studied. After carrying out the welding, the specimen was prepared as per ASTM standard. The optimal welding quality is found out by comparing the results attained from tensile testing, impact testing and by micro-hardness testing. The specimen welded at the rotational speed of 600 rpm and welding speed of 0.5mm/sec exhibited the highest ultimate tensile strength.

I. INTRODUCTION

Friction Stir Welding (FSW) has now become an important process in aerospace, shipbuilding, automobile industries and in many applications of commercial importance. Aluminium is the base material and elements like Mg, Zn, Cu, Ti, Si and Fe are the alloying elements which enhances the mechanical properties of

Aluminium alloys. FSW welding processes plays a major role in aerospace concepts for both the weight as well as cost of production of functional components [1-5].The basic concept of FSW is remarkably simple. Principally designed pin and shoulder is introduced into the adjoining edges of sheets. Dissimiar plates to be joined with non-consumable rotating tool is traversed along the line of joint A as shown in Figure.1.

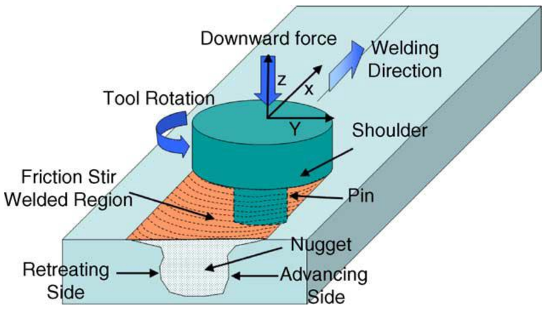

Figure.1.Principle of friction stir welding

The tool aids two primary purposes:

(a) Heating of work piece,

(b) Movement of material to produce the joint.

Friction between the tool and the work piece is accomplished by heating which results in work piece of plate to undergo plasticdeformation [6]. The localized heating tempers the material to be semi solid state around the pin and movement of material from the front of the pin to the back of the pin due to combination of tool rotation and translation. The Joint is formed in solid state at the end of this process. The mechanical performance of the welding depends specifically on the welding parameters such as rotational speed and traverse speed which influences welding strength of the joint [7-9]. Grain size, residual stresses, and strength of the weld influences tool deformation. Recently, many literatures have been studied to explore friction stir welded dissimilar Aluminum alloys and Aluminum based metal matrix composites.

The FSW of aluminum and its alloys has been commercialized and recent research interest is concentrated on joining dissimilar materials such as aluminum and copper. Aluminum is mainly preferred for its low cost, high corrosion resistance and high specific strength, while copper is mainly required for its superior electrical conductivity and its high thermal expansion. Such applications include switchgears and heat sinks, bus-bars, and many other applications are currently being developed. Friction stir welding process has been introduced for copper alloys and magnesium alloys. Aluminum alloy, AA6061 is widely essential in many evolving fields of aerospace industry and marine industry in the storage tanks, pipelines and construction of frame [10-14].

Recently, the work is being developed to explore the process for materials such as, nickel alloys, titanium alloys, steels, and molybdenum [15]. Rajkumar.V et. al. had investigated the characterizationoffrictionstirweldeddissimilarAluminium alloysAA5052andAA6061. AA5052 sheet lessened due to the vertical movement of the materials. By increasing the tool rotation speeds or by decreasing the tool traverse speeds, the amount of vertical transport is increased and hence the thickness of AA5052 is decreased when the heat input was either increased or decreased. Interface morphology and vertical movement of the material influenced joint strength of welded specimen.Sadeesh.P et al.had investigated that AA5052andAA6061arefrictionstirweldedviaspecifictooldesignandutilizing twodifferentoptimizedweldingparameters(constantspeedandvariablefeed). The outcome ofcharacterizationsofthemechanicalandmetallurgicalpropertieswiththeabove dissimilarcombinationtoevaluatetheperformanceandcharacteristicsoftheweldedjointsandresults were inferred. They used an array of process parameters to find out the mechanical strength of weld specimen of the dissimilar materials. They observed that the optimum conditions were a traveling speed of 61 mm/min and rotation speed of 1600 rpm. Their observations from the welded specimen for surface finish and plastic flow behaviour exhibited that the stirring effect was enhanced and number of defects were reduced when the traverse speed was decreased.Bhanumoorthy et al. had discussed that theeffectofmateriallocationsonthepropertiesoffrictionstirwelding(FSW)jointsoftwodissimilaraluminiumalloyswasinvestigatedbyexperiments.Theresultofthemicrostructural analysisrevealed thatthematerialadditionpatternsintheFSWjointsarefullydiversedependingonthepositionofthebasemetals.It was observed that for both combinations of material composition, AA5052-H32 revealed the lowest value of micro hardness in the heat-affected zone (HAZ), which clearly explained the reasons for the fracture of tensile test specimens at the 5052-H32 side.

This paper examines the study on characterizations of the mechanical performance with the above dissimilar welded joints and results were inferred.

II. MATERIALSAND METHODS

In this investigation, the dissimilar materials such as aluminium alloys 5052 and 6061 were welded using Friction stir welding technique and High carbon high chromium oil hardening steel was used as tool material Chemical compositions of the alloy materials are given in Table.1.

Table.1 Chemical compositions of Aluminium alloys

AA	Element	Mg	Si	Fe	Mn	Cu	Ni	Ti	Al
5052		2.8	0.25	0.4	0.1	0.1	-	-	Bal
6061		1.20	0.80	1.51	0.228	0.97	0.029	0.018	

III. FABRICATION METHOD

AA 5052 and AA 6061 aluminium alloys of thickness 6mm rolled plates were cut into needed sizes (100 x 50 mm) by power hacksaw. A square butt joint configuration was arranged to carry out the FSW joints. The initial joint configuration was obtained by securing the plates in position by means of mechanical clamps. The welded direction was normal to the rolling direction. Non consumable tool made up of chromium high carbon steel was used for the joining process. The aluminium alloy specimens were joined by varying rotational speed in five levels namely 200, 400, 600, 800, 1000rpm and traverse speed in two levels namely 0.5 mm/sec and 0.7mm/sec as shown in Figure.2.

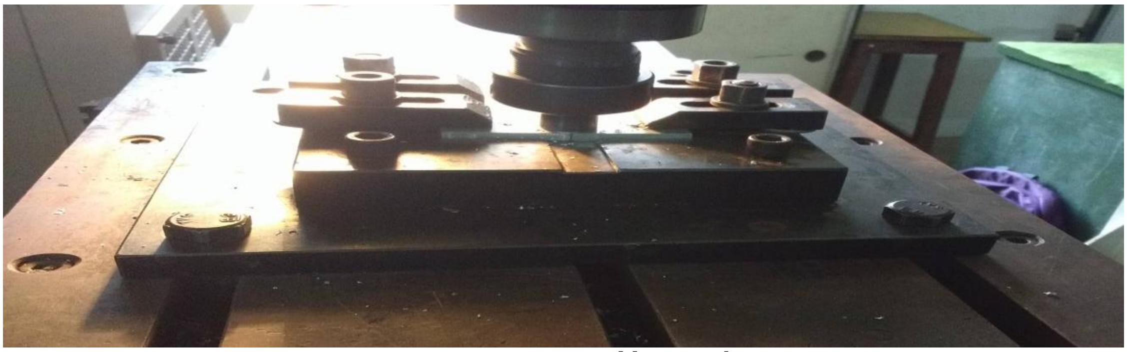

Figure.2. Friction stir welding machine

The tool used for fabricating the joints is made by high carbon and high chromium steel of base diameter 30mm with shoulder diameter as 40mm and with a cylindrical pin of diameter 5mm as shown in Figure.3. With the identified process parameters the joints were fabricated.

Figure.3. Tool material

IV. MECHANICAL TESTING

Tensile test and hardness tests were conducted on the welded plate using ASTM E8M-11 and ASTM E384 standard respectively. Welded joint was subjected to tensile load using Instron testing machine and Vickers hardness testers were used for carrying out hardness test on the welded region. Corrosion tests were carried out for 3 samples comprising AA 5052, 6061,AA5052/6061(combined).For each welded plate a set of 3 specimens were subjected to tensile and hardness test and the average value was taken. The prepared welded specimen is shown in Figure.4.

Figure.4. Welded specimen

V. RESULTS AND DISCUSSION

5.1. Tensile properties of the welded specimen

The tensile strength of the welded specimen was measured as per ASTM E8M-11 standard. A total of fifteen specimens, were welded at varying rotational speed and traverse speed based on above standard is prepared and tested. The experimental values obtained from the tensile testing of the welded specimens are shown in Figure.5. At a spindle rotation of 600 rpm at traverse speed of 0.5mm/sec, high ultimate tensile strength value of 184MPa is obtained and for other rotational speed of 200, 400, 800, and 1000 the ultimate tensile strength values were 146, 169, 171, and 151 respectively. On the contrary, at a spindle rotation of 1000rpm and for traverse speed of 0.7mm/sec the low ultimate tensile strength 149MPa is obtained. It is observed that the low traverse speed for given spindle rotation, it is possible to reach high UTS values. The tensile strength of the specimen was found to be better with weld made at a transfer speed of 0.5mm/sec and at the same time there was an increase in tensile strength. Uniform temperature distribution in the weld region is obtained by increasing rotational speed of the tool. When the rotational speed is increased beyond 600 rpm, undesirable property change is observed. At higher rotational speed distortion effects are found at the welded region. At rotational and traverse speed of 800 rpm and 0.5mm/sec, a better value of tensile strength 184 MPa is obtained. The tensile test specimen before test and after test is shown in Figure.6.

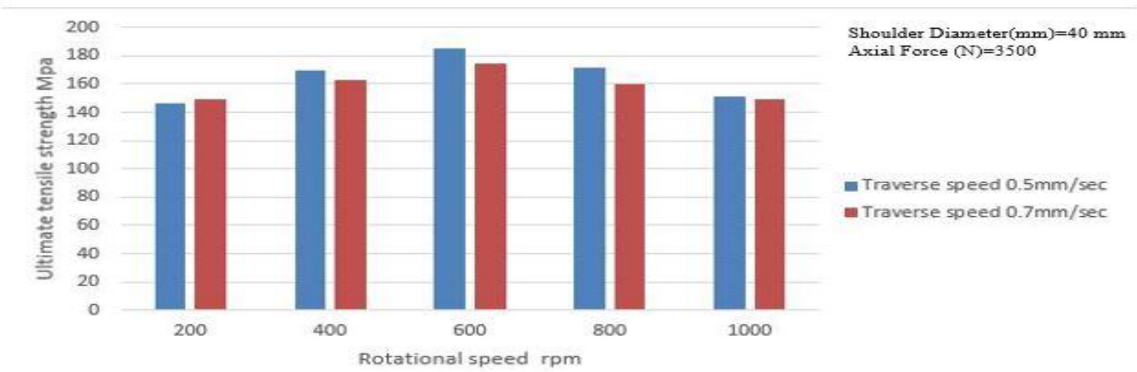

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Figure.5.Effect of Rotational Speed

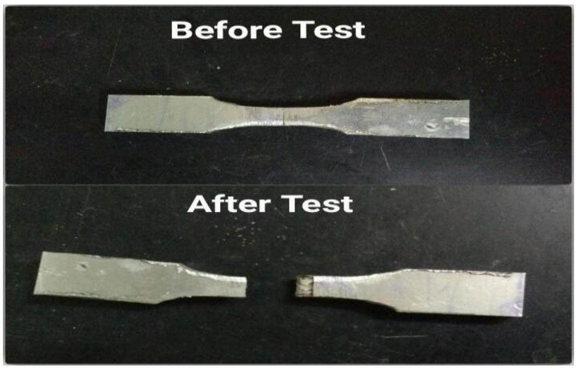

Figure.6.Tensile test specimen

5.2. Hardness properties of the welded specimen

The hardness of the welded specimen was measured using Vickers hardness scale. A total of fifteen specimens, welded at varying rotational speed and transfer speed were prepared and tested. The hardness was determined at five various positions in the welded region of the specimen and the average value was taken. The experimental values found from the hardness testing of the welded specimens were shown in Figure.7. The hardness of the specimen was found to increase with the increase in rotational speed and traverse speed and reached a maximum of 90 VHN at a rotational and traverse speed of 600 rpm and 0.5 mm/sec respectively. Beyond 600rpm, adverse effect was found on welded region. The increase in rotational speed at this critical limit resulted in decrease in hardness

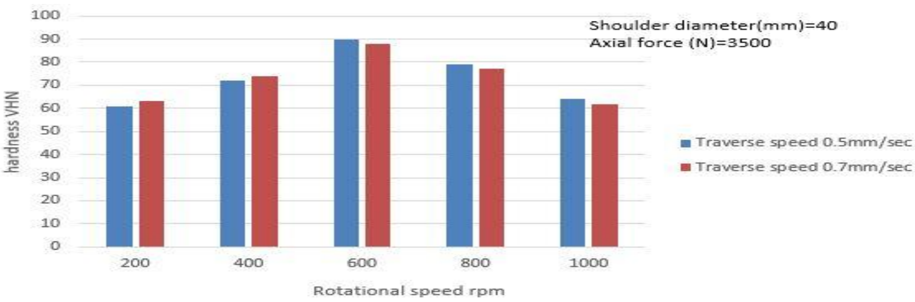

Figure.7. Effect of rotational speed on Hardness

5.3. Corrosion characterization

The corrosion samples with the size of 15×15×5 mm were machined in the transverse direction from the nugget zone. Corrosion behaviour of the welded joints was observedby means of corrosion immersion tests and electrochemical corrosion study. All specimen were ground with Sic emery papers of up to 2000 grit and finely polished with 0.5µm diamond powder, and then ultrasonically cleaned in alcohol for 5 min and dried in air.

Then the sample was immersed in the mixed solution of Na2SO4 + dilute H2SO4 (pH=5) at the ambient temperature (25 ℃). These solutions were prepared with A. R. grade chemicals and distilled water.

Table.2.Each specimen of corrosion potential and corrosion current

Sample	AA 5052	AA 6061	AA 5052/AA 6061
Corrosion potential/V	-1.0111	-1.0097	-1.0219
$I \times E^{-5}/A$	8.1461	6.2017	1.5873

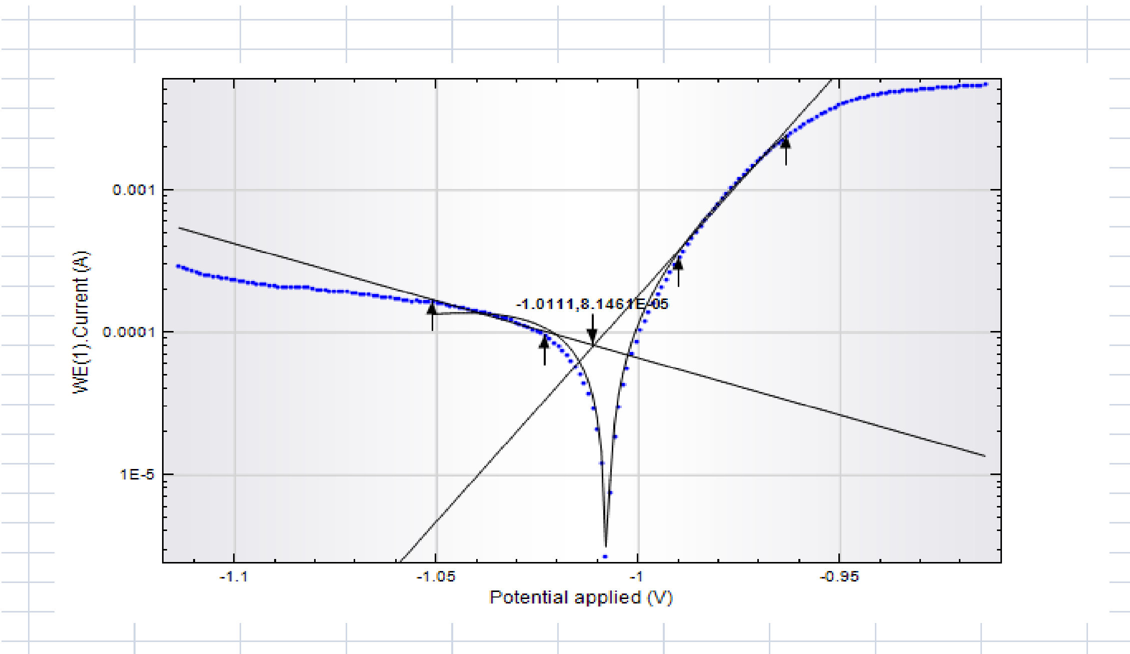

Figure 11. AA 5052

From the polarisation curve (Figure 11) it is noted that the material resist up to its optimum level when the potential reaches -1.0111. On further increasing the polarization the material start to lose its resistant level, if it continues further, atoms from the material side get dissolved on solution. The curve above -1.05 potential shows the corroded area of the component.

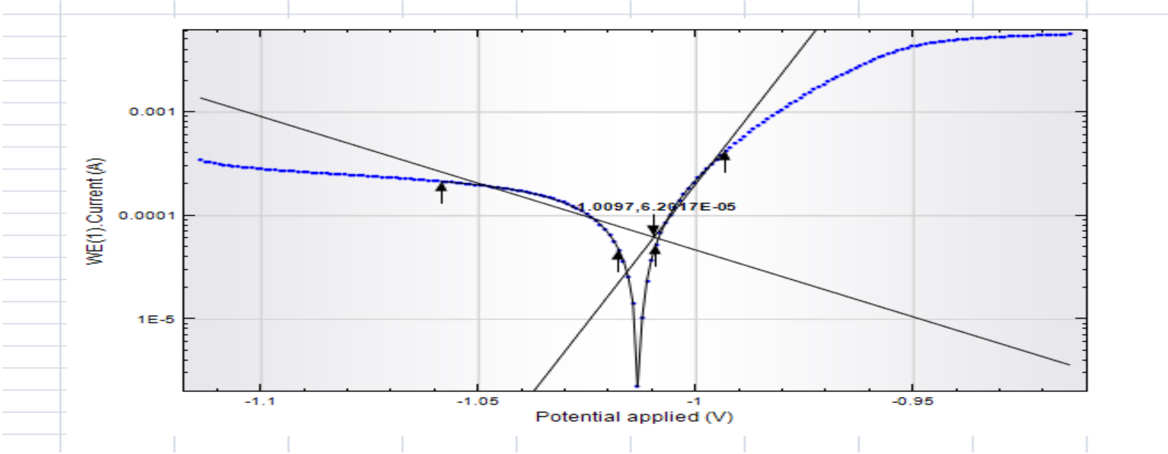

Figure 12. AA 6061

From the polarisation curve (Figure 12) it is noted that the material resist up to its optimum level when the potential reaches -1.0097. On further increasing the polarization the material start to lose its resistant level, if it continues further, over a time period polarization have constant and then atoms from the material side get dissolved on solution. The curve above -1.06 potential shows the corroded area of the component

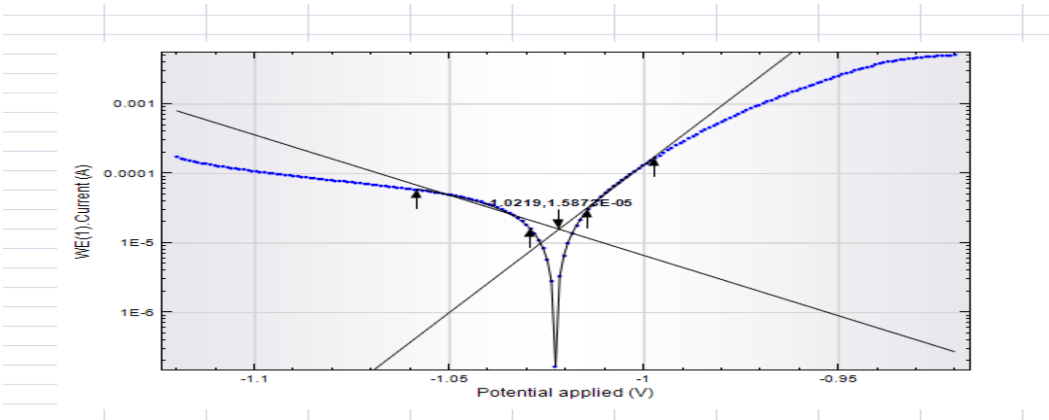

Figure 13. Both AA 5052 and 6061 (Joining By FSW)

From the polarisation curve (Figure 13) it is noted that the material resist up to its optimum level when the potential reaches -1.0219. On further increasing the polarization the material start to lose its resistant level, if it continues further, over a time period polarization have constant and then atoms from the material suddenly side get dissolved on solution. The curve above -1.06 potential shows the corroded area of the component.

The experimental analysis was performed for three different samples as shown in Figure.14. The sample1 was carried out for AA5052, Sample 2 for AA 6061, and sample 3 for AA5052/6061(combined). It is observed that the sample 3 has low corrosion rate.

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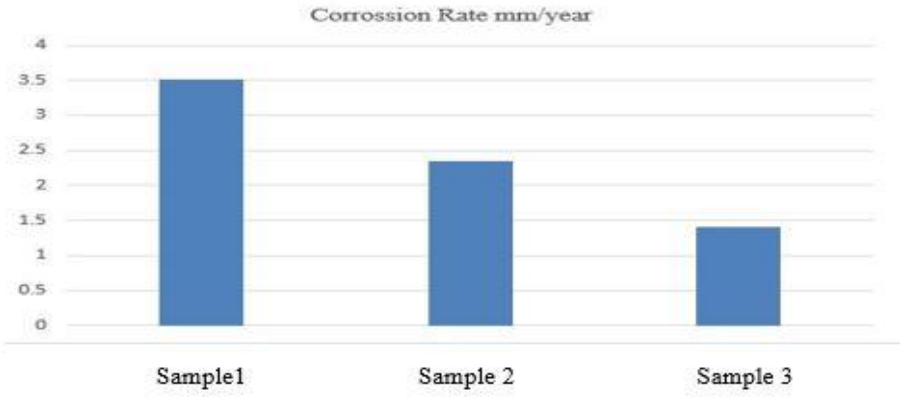

Figure.14.Corrosion Rate Analysis

VI. CONCLUSION

1. The welding parameter considered in this investigation was found to greatly influence the tensile and hardness properties of dissimilar aluminium alloys weld.
2. Friction stir welds between AA 5052 and AA 6061 Al alloys are reliable, promising, excellent weld ability and performance characteristics can be obtained.
3. Cylindrical threaded pin has showed excellent bond strength between both alloys (AA 5052 and AA 6061) via effective friction stir welding process.
4. The ultimate tensile strength of the joint increases with increase in rotational speed and decrease in traverse speed. It reaches maximum at rotational speed of 600rpm and traverse speed of 0.5mm/sec and then starts decreasing, same effect is also observed by varying the traverse speed of 0.7mm/sec.
5. The observation from the experimental analysis clearly indicates that the corrosion rate is lesser for sample 3(AA5052/6061 combined)
6. Either in the heat affected zone or in the weld joint, crack propogation has occurred. However, fracture occurred at the base material in all regions.
7. At spindle rotation speed of 600rpm and traverse speed of 0.5mm/sec,0.7mm/sec, both the specimen have exhibited nearly equal ultimate strength.
8. The mechanical and metallurgical characterizations have shown good agreement which is clearly evident from results obtained.

REFERENCES

[1]. Kumbhar, N.T., Sahoo, S.K., Samajdar, I., Dey, G.K., Bhanumurthy, K., 2011. Microstructure and micro textural studies of friction stir welded aluminium alloy 5052, Materials and Design 32,pp.1657–1666

[2].V.–X. Tran, J. Pan: 'Failure modes of friction stir spot welds in cross–tension specimens of dissimilar aluminium sheets', Science and Technology of Welding and Joining, 2010, 15, pp.286–292.

[3].R.S. Mishraa, Z.Y. Ma. "Friction stir welding and processing" Materials Science and Engineering" R 50 (2005) pp.1–78

[4].B.Supraja Reddy DR. B.Ram Gopal Reddy., "Effect of Tool Geometry and Process Parameters on Mechanical Properties and Micro Structure of Various dissimilar Aluminium Alloys Welded by Friction Stir Welding Review"International Journal of Engineering Technology, Management and Applied Sciences April 2015, Volume 3 Issue 4.pp. 2349-4476

[5].M. Dehghani *, A.Amadeh, S.A.A.Akbari Mousavi., "Investigations on the effects of friction stir welding parameters on intermetallic and defect formation in joining aluminum alloy to mild steel" Materials and Design 49 (2013) pp.433–441.

[6]. G.Bussu,P.E,irving.,"The role of residual stress and heat affected Zone properties on fatigue crank propogation in friction stir welded 2024-T351 aluminium alloys" international of fatigue 25,2003,pp 77-88

[7].Raj Kumar1, Vedant Singh."Friction Stir Welding Process Parameters of Aluminium Alloys 6xxx Series: A literature Survey". Volume-7, Issue-3, May-June 2017.pp.479-484

[8].S.Kailainathan, S.Kalyana Sundaram., "Influence of Friction Stir Welding Parameter on Mechanical Properties in Dissimilar (AA6063-AA8011) Aluminium Alloys" International Journal of Innovative Research in Science, Engineering and TechnologyVol. 3, Issue 8, August 2014.pp.2319-8753

[9].Sato, Y., Urata, M., Kokawa, H., Ikeda, K., 2003. "Hall–Petch relationship in friction stir welds of equal channel angular-pressed aluminium alloys" Material Science and Engineering 354 (1–2),
pp. 298–305.

[10].C.Elanchezhiana, B.Vijaya RamnathbParameter. "Optimization of Friction Stir Welding Of AA8011-6062 Using Mathematical Method". Procedia Engineering 97 (2014)pp.775 – 782

[11]. G. Elatharasana,V.S. Senthil Kumar."An experimental analysis and optimization of process parameter on friction stir welding of AA 6061-T6 aluminum alloy using RSM" Procedia Engineering 64 (2013) pp.1227 – 1234

[12]. Janak Singh1, O. S Bhatia."An experimental approach to study the effects of friction stir welding on 1050 h8 aluminium alloy" International Journal of Advanced Technology in Engineering and Science Volume No.03, Issue No. 05, May 2015,pp.2348 - 7550

[13]. Neeraj Kumar1, Ishu Monga., "An experimental investigation to find out the effect of different
pin profile tools on aa 6061 t6 and aa 2014 t4 with friction stir welding" International Journal For Technological Research In Engineering Volume 2, Issue 8, April-2015,pp.2347-4718

[14.].T. DebRoy and H. K. D. H. Bhadeshia.,"Friction stir welding of dissimilar alloys a perspective" Science and Technology of Welding and Joining2010, Vo15, No 4 pp. 286–292.

[15].Mahabunphachai, S., Koc, M.,"Investigations on forming of aluminum 5052 and 6061 sheet alloys at warm temperatures", Materials and Design 31, pp. 2422–2434.

[16]. N. T. Kumbhar and K. Bhanumurthy. "Friction Stir Welding of Al 5052 with Al 6061 Alloys" Journal of Metallurgy Volume 2012 (2012), Article ID 303756, pp.7