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Experimental analysis and Investigation of Friction Stir Welding (FSW) on Aluminum Plates

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Abstract

The Friction Stir welding is the recent development in the solid state welding, to overcome the difficulties of the fusion base welding technology. In The Aerospace, Shipbuilding Automobile & railway, the Friction Stir Welding Technique is readily use nowadays. The Friction Stir Welding Technique was invented by the team of welding institute at UK in year 1991. Initially the attempt was made to join the Aluminium & its Alloys, Recently the research works are going on the various composite materials, Magnesium & its alloy & also for the Stainless Steel, etc. The Friction Stir Welding Techniques (FSW) gives the best joining efficiency & mechanical properties with less or negligible defect feel weld. It is also an environmental friendly process. The Aim of present work, to study the effect of various tool design & process parameter on quality of Friction Stir Welding of AA 6101 T6 alloy plate of 6mm thickness, was selected. The welding was carried out using by different tools: (1) Hexagonal pin with flat shoulder (2) Square pin with flat shoulder (3) Taper pin with flat shoulder (4) Plain cylindrical pin with flat shoulder. The Objectives of this process to study & investigation of welded Aluminum Plates and its properties like, Tensile Strength and hardness of welded Plates under heat treated tool and without heat treated tools.

Keywords: FSW; 6101T6 alloy, tool geometry; heat treatment, tensile strengths; hardness.

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1. INTRODUCTION

Friction stir welding (FSW) is a strong state, hot shear joining procedure in which a turning apparatus with a shoulder and ending in a threaded pin, moves along the butting surfaces of two inflexible rigid plates set on a support plate as appeared in Fig. 1. The shoulder reaches the top surface of the work–piece. Heat is created by contact at the shoulder and to a lesser degree at the pin surface, diminishes the material being welded. Serious plastic state is occurs and stream of this plasticized metal happens as the device is interpreted along the welding course. Material is transported from the front of the instrument to the trailing edge where it is compressed into a join. Although Fig. 1 shows a butt joint for illustration, other types of joints such as lap joints and fillet joints can also be fabricated by FSW.

The half plate where the heading of revolution is the same as that of welding is called them forward side, with the other side assigned just like the withdrawing side. This distinction can prompt asymmetry in heat transfer, material stream and the properties of the two sides of the weld; subsequently, the hardness of specific age hardened aluminum compounds has a tendency to be lower in the heat influenced zone on the withdrawing side, which then turns into the area of tensile crack in cross weld tests this is likewise the case for pure titanium.. Since its revelation in 1991, FSW has advanced as a procedure of decision in the standard joining of aluminum segments; its applications for joining troublesome metals and metals other than aluminium are developing yet at a slower pace. There have been broad advantages coming about because of the utilization of FSW in for instance, aviation, shipbuilding, car and railways. FSW includes complex communications between assortments of concurrent thermo mechanical procedures. The associations influence the warming and cooling rates, plastic deformation and flow, dynamic re-crystallization and the mechanical of the joint. A typical cross-section area of the FSW joint comprises of various zones.

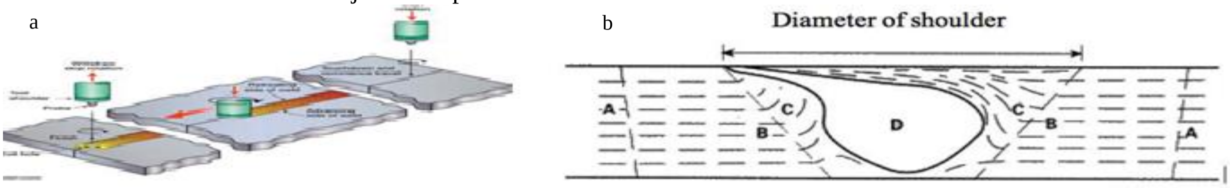


Fig.1. (a) Schematic illustration of the friction stir welding process (b) Schematic cross section of a FSW weld

Shown the fig. 1.b there is cross section of FSW weld four distinct zones (a) base metal, (B) heat–affected, (C) thermo mechanically affected and (D) stirred (nugget) zone. The role of welding parameters, tool design, the initial process modeling, and the microstructure and properties of the FSW joints have been reviewed previously. It is however a relatively new process and one which is evolving rapidly. As a result, a periodic critical duty of our appreciative of the welding process as well as the structure and properties of the welded materials is likely to be helpful.

2. Literature Review

L.V. Kamble, S.N. Soman, P.K. Brahmankar [1] designated apparatus outline and choice of procedure variables are basic issues in the utilization of this procedure. This paper handles the same issues for AA6101-T6 compound. The weld arranged by square pin profile would do well to mechanical properties and microstructure contrasted with the one arranged by hexagonal pin profile. Akos Meilinger, Imre Torok [2] designated the device must be meet a few essential necessities. From one perspective over the span of mixing the material flow conditions particularly influence the nature of the weld, so the apparatus geometry is critical. Various components must be considered for outlining the instrument of contact mix welding, so it is a genuinely muddled assignment. Since the apparatus has noteworthy burden, originators must pay consideration on material, surface quality and geometry of instruments. M.S.Srinivasa Rao, B.V. Ravi kumar and M. Manzoor Hussain [3] depicted in this study the weld attributes of AA6061-T6 Aluminum amalgam amid Friction Stir Welding (FSW) has been concentrated tentatively. The work has been done to study the malleable properties of the weldments like elasticity, hardness and estimations of temperature at different separations along the weld zone on the weldments. The variety in crest temperature opposite to the weld line at consistent rotational rate and steady welding rate. Variety of the nugget–zone temperature regarding time.

3. Material Selection

In this work the AA 6101 T6 Aluminum alloy was selected for friction stir welding with different tool rotation speed & welding speed i.e. 1070, 2720, 5440 rpm and 50, 78,120 mm/min respectively. The tool geometry selected was hexagonal pin, cylindrical pin, taper pin and square pin. The length of pin was 5.5mm and diameter of shoulder was 20 mm. For that composition shown in Table.1

Table 1. Composition of AA 6101 T6 Aluminum Alloy

Elements	Wt %
Al	99.89
Mg	0.6
Si	0.5

Fig.2 (a) AA6061T6 Specification size 180×50×6 mm & 160 gm (b) AA6061T6 Specification size 180×60×6 mm & 194 gm

4. Selection of tool for welding

4.1. Tool Material

The tool used in friction stir welding process is must be harder than the material which is to be weld. According to the literature review we are selected materials like H13 Tool steel & EN 24 Tool steel.

4.2. Tool Geometry

We are selected following different tool geometries having different tool pins:

1. Square pin tool (Material: EN 24 Tool Steel)
2. Hexagonal pin tool (Material: EN 24 Tool Steel
3. Taper pin tool (Material: EN 24 Tool Steel)
4. Cylindrical pin tool (Material: H13 Tool Steel)

Square Pin Tool (Material: En 24 Tool Steel)

a b

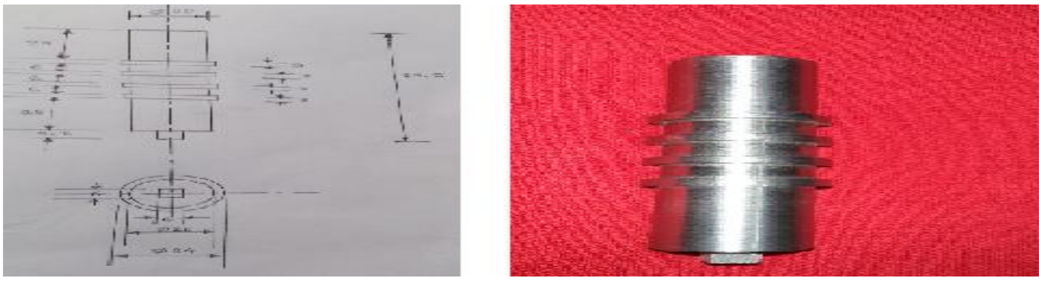


Fig.3.(a) tool geometry of square pin tool & (b)actual square pin tool

As shown in fig.3 Square pin tool for that dimension diameter is 32 mm, length is 100 mm; weight is 650 gm and tool weight 211 gm

Hexagonal Tool (Material: En 24 Tool Steel

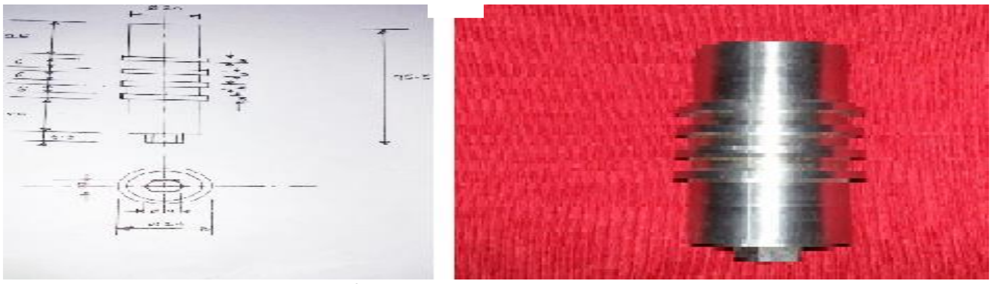


Fig.4. (a) tool geometry of Hexagonal pin tool & (b) actual Hexagonal pin tool

As shown in fig.4 hexagonal tool for that dimension diameter is 32 mm, length is 100 mm, weight is 650 gm and tool weight 214 gm.

Taper Pin Tool (Material: En 24 Tool Steel

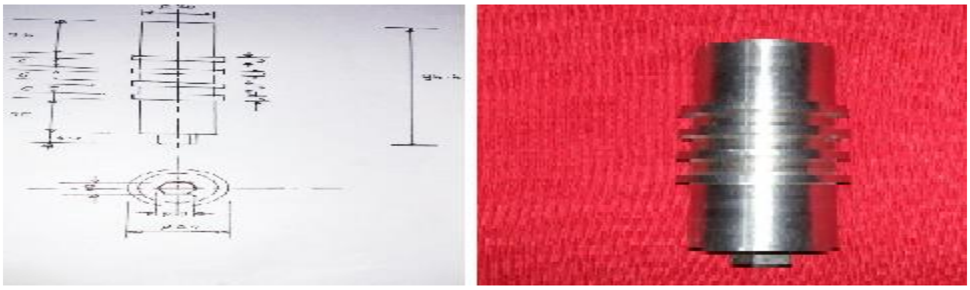


Fig.5.(a) tool geometry of taper pin tool & (b)actual Taper pin tool

As shown in fig.5 taper pin tool for that dimension diameter is 32 mm, length is 100 mm, weight is 650 gm and tool weight 212 gm

Cylindrical Pin Tool (Material: H13 Tool Steel)

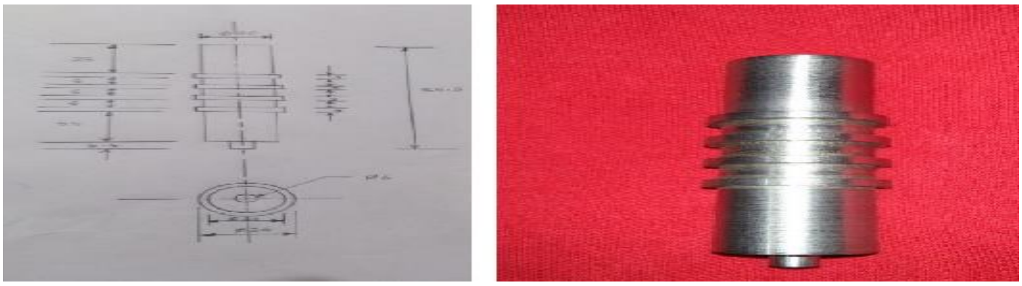


Fig.6.(a) tool geometry of cylindrical pin tool & (b) actual cylindrical pin tool

As shown in fig.6 cylindrical pin tool for that dimension diameter is 50 mm, length is 100 mm, weight is 1.6 kg and tool weight 210 gm.

4. Results and Discussion

4.1 Hardness of aluminium plates of grade AA6101-T6 & 6061-T6 welded by heat treated tools

Rockwell hardness of plate welded by non heat treated hexagonal pin tool

As shown in table 2 Experimental reading of Rockwell hardness of plate welded by non-heat treated hexagonal pin tool and table 3 Experimental reading of Rockwell hardness of plate welded by non-heat treated cylindrical pin tool

Table 2. Rockwell hardness of plate welded by non-heat treated hexagonal pin tool

Location	Hardness B- Scale
4A	53
3A	51
2A	49
1A	35
C	33
1R	34
2R	37
3R	42
4R	49
5R	52

Table 3. Rockwell hardness of plate welded by non-heat treated cylindrical pin tool

Location	Hardness B- Scale
4A	52
3A	49
2A	35
1A	31
C	27
1R	33
2R	36
3R	42
4R	45
5R	50

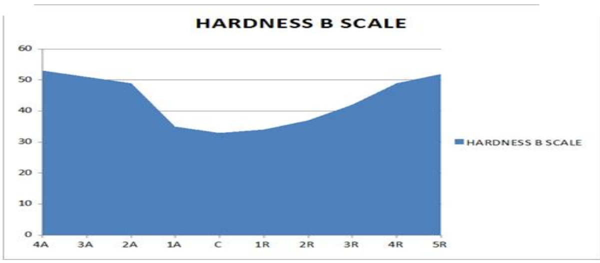
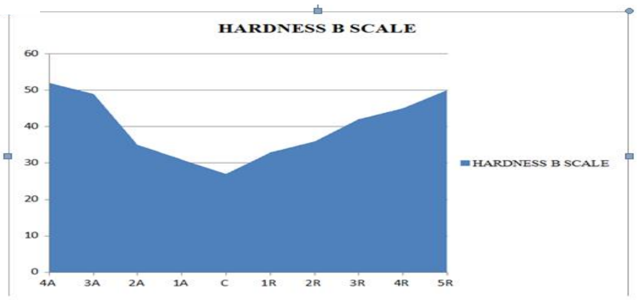


Fig 7. Location for hardness test of plates welded by non heat treated hexagonal pin tool

Rockwell hardness of plate welded by non heat treated cylindrical pin tool



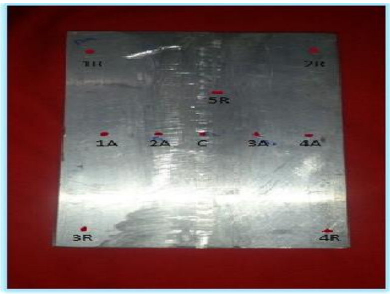


Fig 8. Location for hardness test of plates welded by non heat treated cylindrical pin tool

Rockwell hardness of plate welded by non heat treated square pin tool

As shown in table 4 Experimental reading of Rockwell hardness of plate welded by non-heat treated square pin tool and table 5 Experimental reading of Rockwell hardness of plate welded by non-heat treated Taper pin tool

Table 4 .Rockwell hardness of plate welded by non-heat treated square pin tool

Location	Hardness B-Scale
4A	49
3A	45
2A	35
1A	33
C	25
1R	33
2R	36
3R	42
4R	46
5R	50

Table 5. Rockwell hardness of plate welded by non-heat treated taper pin tool

Location	Hardness B-Scale
4A	48
3A	42
2A	39
1A	33
C	23
1R	35
2R	40
3R	42
4R	47
5R	50

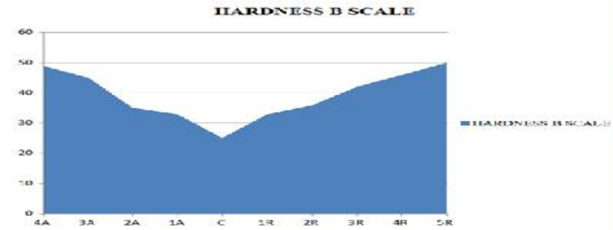
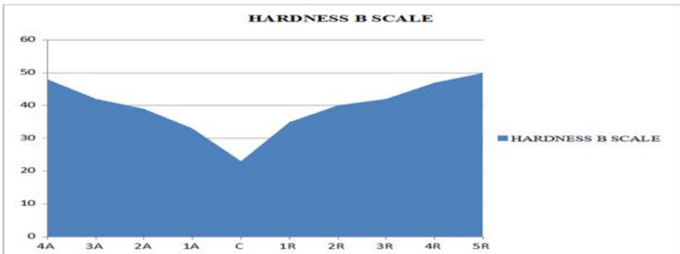


Fig 9. Location for hardness test of plates welded by non-heat treated square pin tool

Rockwell hardness of plate welded by non heat treated Taper pin tool



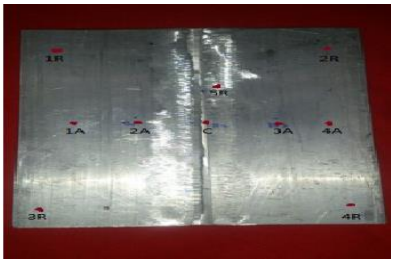
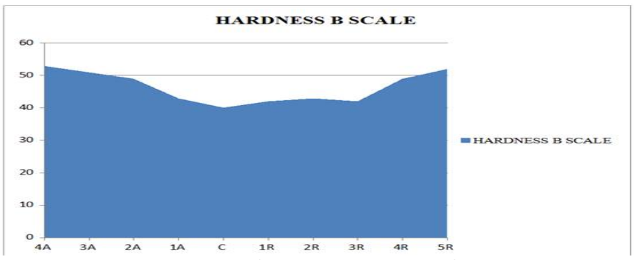


Fig 10. Location for hardness test of plates welded by non heat treated taper pin tool

4.2 Hardness of aluminium plates of grade AA6101-T6 & 6061-T6 welded by heat treated tool
Rockwell hardness of plate welded by heat treated hexagonal pin



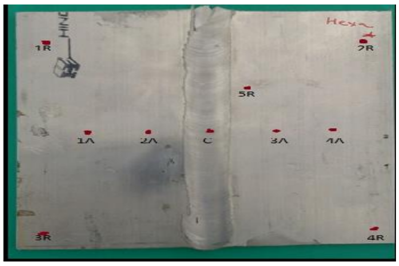


Fig 11. Location for hardness test of plates welded by heat treated Hexagonal pin tool

Rockwell hardness of plate welded by heat treated square pin

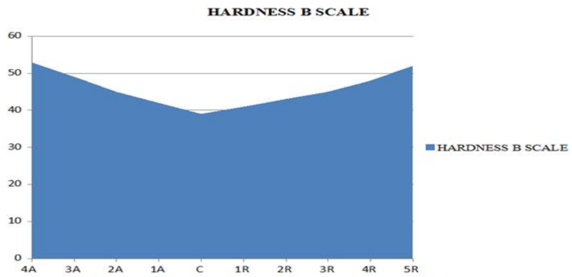
As shown in table 6 Experimental reading of Rockwell hardness of plate welded by heat treated hexagonal pin tool and table 7 Experimental reading of Rockwell hardness of plate welded by non-treated cylindrical pin tool

Table 6. Rockwell hardness of plate welded by heat treated hexagonal pin tool

Location	Hardness B-Scale
4A	53
3A	51
2A	49
1A	43
C	40
1R	42
2R	43
3R	42
4R	49
5R	52

Table 7.Rockwell hardness of plate welded by heat treated square pin tool

Location	Hardness B-Scale
4A	53
3A	51
2A	45
1A	42
C	38
1R	40
2R	43
3R	46
4R	49
5R	52



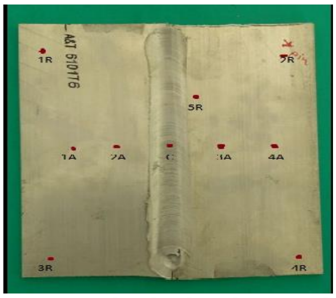


Fig 12. Location for hardness test of plates welded by heat treated cylindrical pin tool
Rockwell hardness of plate welded by heat treated cylindrical pin

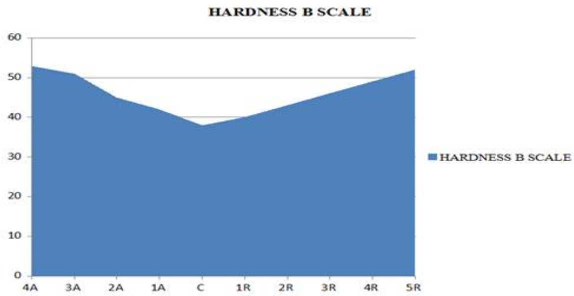
As shown in table 8 Experimental reading of Rockwell hardness of plate welded by heat treated square pin tool and table 9Experimental reading of Rockwell hardness of plate welded by heat treated Taper pin tool

Table 8.Rockwell hardness of plate welded by heat treated square pin tool

Location	Hardness B-Scale
4A	53
3A	49
2A	45
1A	42
C	39
1R	41
2R	43
3R	45
4R	48
5R	52

Table 9.Rockwell hardness of plate welded by heat treated Taper pin tool

Location	Hardness B-Scale
4A	53
3A	49
2A	45
1A	37
C	30
1R	35
2R	43
3R	45
4R	48
5R	52



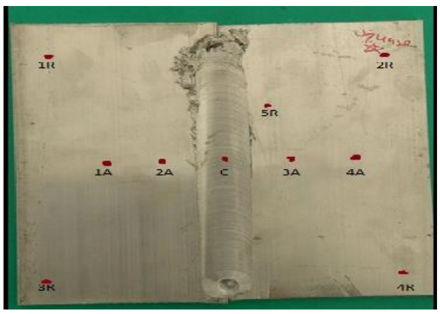
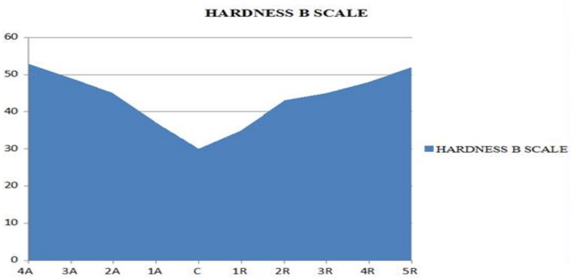


Fig 12. Location for hardness test of plates welded by heat treated square pin tool

Rockwell hardness of plate welded by heat treated Taper pin



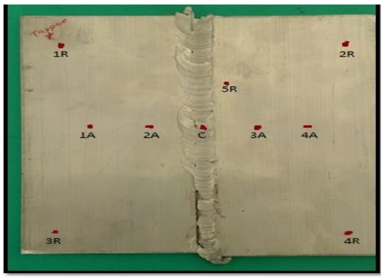


Fig 13. Location for hardness test of plates welded by heat treated taper pin tool

5. Conclusion

From the Rockwell hardness test it is observed that hardness of weld region of plate welded by hexagonal pin non heat treated tool compare to other plates welded by non heat treated tool is high which is 33 B scale. And hardness of weld region of plate welded by hexagonal pin heat treated tool compare to other plates welded by heat treated tool is high which is 40 B scale. The weld prepared by square pin heat treated as well as square pin non heat treated tool possess good mechanical properties

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