"EFFECT OF PROCESS AND TOOL PARAMETERS ON FRICTION STIR WELDINGEDGE JOINT OF ALUMINUM ALLOYS 6061"

VimalB patel[1]
[1] Asst.prof. in Mechanical department, Vadodara institute of engineering, Vadodara,india
Email: vml310@gmail.com,

Abstract- Friction stir welding procedure is utilized for joining material, for example, Aluminum ,copper ,magnesium and so on., It is aclean, environment-accommodating, and nonharmful process as it isccompanied by neither a circular segment arrangement and radiation nortoxic gas discharge. It has low warmth input and no weld finishing costs [1]. This paper examines about the utilization of Taguchi method for augmenting tensile strength of friction stir welded Al 6061 alloy. The impact of process parameters on rigidity of welded joints are assessed and signal to noise ratio of robust design. From this examination it is found that the joints manufactured at the apparatus rotational speed of 1600 rpm, welding rate of 14 mm/min, and pin length of 5mm. Influence on rigidity of the welded joints took after by spindle speed and pin length . We considered geometry of tool of the welding joint separated from other parameter like temperature, pressure. The impact of welding parameters on the greatest temperature improvement has been studied. In analysis we use AA6061 similar material for flow stress, temperature and pressure analysis with Hyper works 9.0.

***Keywords*-Friction Stir welding, AA6063,Flowstress,Temperature, Pressure, Viscosity, Hyper works 9.0**

I. INTRODUCTION

Friction Stir welding (FSW) innovation help joining aluminum sheets, without material preheating. The welding procedure happens by a rotating FSW tool. The apparatus works inside welded materials moving along their edges.The frictional heat created because of rubbing of shoulder and work piece material outcomes in plastic deformation and movement of material from propelling side to withdrawing side took after by arrangement of joint behind the tool appeared in figure1. As a result of nonappearance of complete melting, FSW offers a few focal points over the ordinary combination welding process. The points of interest are assembled as metallurgical favorable circumstances and ecological preferences. Metallurgical advantages incorporates great dimensional stability , repeatability, no loss of alloying components, phenomenal mechanical properties in the joint area because of recrystalization smaller scale structure in the stir zone. The procedure is a green one since it eliminates grinding wastages, no unsafe emissions, required just least surface cleaning [2].Due to the previously mentioned focal points the procedure keeps away from some typical welding defects, for example, loss of alloying components, solidification splitting and porosity [3]. The system has the constrained procedure parameters need to control to deliver the goodwelded joint. The most widely recognized process parameters are tool rotation speed, welding speed and and tool geometry [4].Because of the focal points FSW gives, it has discovered its place in numerous modern applications, for example, those in marine like angling vessels, expansive steel journey ships, and the Japanese quick ship "Ogasawara. In aviation like fuel tanks for unmanned Delta II and later Delta IV rockets [5], the maker Boeing and substantial fuel tank for the Space Shuttle, and the Eclipse 500 business fly . Erosion blend welding has been connected in rail, for example, the Japanese Shinkansenin car, for example, Mazda Rx-8 sports auto, hat and back entryways [6] and in lightweight defensively covered vehicles. Supplanting copper by aluminum has potential applications since comparative electric properties can be accomplished at a lower cost and a lower thickness . Going for supplanting copper with aluminum effectively, the welding of these two metals is a key issue to be fathomed. The welding of divergent materials is for the most part more troublesome than that of homogeneous materials. Brilliant Cu-Al different joint is difficult to be delivered by combination welding methods because of the huge contrast of melting points, fragile intermetallic mixes presence and break formation[7]. friction stir welding is the best answer for this joining. Constrained looks into have been done in this field.

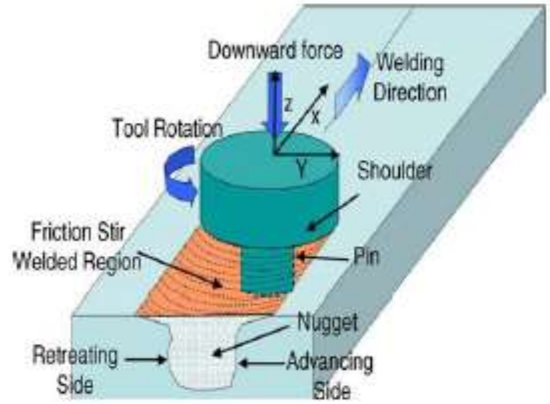

Fig.1:Schematic diagram of FSW

There are several processs parameter like Tool Rotation and Traverse speed , Tool geometry,welding force, Flow Of Material, Possible joint geometry and generation of heat flow. There are three tool speeds to be considered in friction-stir welding; how fast the tool rotates and how quickly it traverses the interface. These two parameters have significant significance and must be picked with care to guarantee an effective and proficient welding cycle. The relationship between the welding speeds and the heat input amid welding is complex in any case, when all is said in done, one might say that increasing the spindle speed or diminishing the welding speed will bring about a more hotter weld. The design of the tool is acritical component as a decent instrument can enhance both the quality of the weld and the most extreme conceivable welding speed. It is alluring that the tool material is adequately solid, tough and hard wearing, at the welding temperature.

The tool profile ought to be with the end goal that which makes less amount of flashes. It ought to likewise avert development of chips and the material ought to be all around infiltrated by instrument to shape the sound weld joint the shoulder diameter builds, the sticking torque, MT, increments, achieves a greatest value and then decreases. This conduct can be inspected, which indicates that two primary elements influence the estimation of the sticking torque. First,the strength of the material declines with increasing temperature because of an expansion in the shoulder measurement. Second, the area over which the torque is applioed increases with shoulder diameter.

For any welding process it is, in general, desirable to increase the travel speed and minimize the heat input as this will increase productivity and possibly reduce the impact of welding on the mechanical properties of the weld. At the same time it is necessary to ensure that the temperature around the tool is sufficiently high to permit adequate material flow and prevent flaws or tool fracture. When the traverse speed is increased, for a given heat input, there is less time for heat to conduct ahead of the tool and the thermal gradients are larger. At some point the speed will be so high that the material ahead of the tool will be too cold and the flow stress too high, to permit adequate material movement, resulting in flaws or tool fracture. If the ‘hot zone’ is too large then there is scope to increase the traverse speed and hence productivity.

II. LITERATURE SURVEY

Balasubramanian, et al [8] researches the impact of welding rate and tool pin profile on FSW zone arrangement in AA2219 aluminum combination. They found that the square pin profile apparatus at a welding speed 45.6mm/min, created mechanically stable and metallurgically imperfection free welds with maxium rigidity, higher hardness. Vivekanandan. P, et al [9] think about microstructure and hardness of aluminum 6035 and 8011. At the rotating speed 550rpm and welding speed 60mm/min, the fine grain are shaped at the focal point of the weld, because of element recrystallization, which result in higher tensile strength of 50N/mm2 with the most extreme hardness of 91HV. M. AbbasiGharacheh, et al [10]found that expansion in the proportion of rotational speed/transverse speed brings about development of huge weld nugget, in light of increment in heat inputeasioer material flow, hence likelihood of arrangement of deficient root entrance imperfection is decreased. A. C. S. Kumar, et al [11]focus on improvement of FSW parameters in various states of base material and the microstructures of the as-welded condition are compared and the post weld heat treated microstructures welded in tempered and T6 condition. The outcome demonstrate that in annealed condition tool rotation speed 800 rpm and welding speed 10 mm/min and 15 mm/min are the ideal parameters. The revolution speed 1000 rpm and welding speed 10 mm/min are the ideal parameters in "T6" condition. P. Cavaliere, et al [12] concentrate mechanical and microstructural properties of AA6082 joints. The material welded with the propelling pace of 115mm/min and settled turning velocities of 1600rpm showed the best fatigue properties and the higher fatigue limit. A. Kumar, et al [13] discover ideal mechanical properties of Al 6061-T6 combination and Mg AZ31B compound. The joint created utilizing rotational speed of 1120 rpm, a welding velocity of 40 mm/min, decrease thread pin profile, shoulder measurement of 18mm, (D/d)=3 demonstrates higher tensile properties. S. Rajakumar, et al [14] concentrate rigidity properties of AA7075-T6 joints delivered by friction stir welding. They found that the joint manufactured at a device rotational speed of 1400 rpm, welding rate of 60 mm/min, axial force of 8 kN, utilizing the apparatus with 15 mm shoulder diameter, 5 mm pin diameter, 45 HRc device hardness yielded higher strength properties. Prashant Prakash, et al [15] found that at rotational speed 1400rpm, welding speed 25 mm/min and pin length 5.7mm most extreme tensile strength is 182MPa, gives 60% joint effectiveness. Dr.Ayad M. Takhakh, et al [16] ideal outcome picked up at 80 mm/min weld speed and 1500 rpm rotational speed, the effectiveness spans to 89% of a ultimate tensile strength of the alloy 3003 H13. P. Bahemmat, et al [17] found that the joint is manufactured by fourflute pin profile at rotational speed of 800rpm have exhibited 90% ultimate and yield strength and the decreased tapered screw joint created at the rotational speed of 600rpm show 84% ultimate strength in AA2024 aluminum. Patil H S, et al [18] found that the joint manufactured utilizing tapered screw pin at welding velocity of 70mm/min shows superior tensile strength of 92.30% of base metal ultimate strength and % elongation of 27.58% in AA6082-0 aluminum.

Aluminum alloy 6061 is one of the most extensively used of the 6000 series aluminum alloys. It is a versatile heat treatable extruded alloy with medium to high strength capabilities. Alloy 6061 is known as a structural alloy. In plate form, 6061 is the alloy most commonly used for machining. Aluminum alloy 6061 is Goodtoughness,Good surface finish, Excellent corrosion resistance to atmospheric conditions, Good corrosionresistance to sea water, Can be anodized, GoodweldabilityGood workability, Widely available. This material is used for Air craft, Aero space component, Marine fitting Transport, Bicycleframes, Camera lenses, Driven shaft,Electrical fitting, Brake components, Valves, Coupling etc.

III. PROPERTIES OF WORK PIECE AND TOOL MATERIAL

The FSW have been completed by utilizing clapping fixture that permits the client to settle the two sheets (300mmx150mm) with plate of 5mm and 15mm to be welded on a CNC milling machine. Aluminum combination of 6061 arrangement was utilized as a part of this work which is a precipitation solidified, aluminum compound broadly utilized as a part of aviation applications because of its high strength. For the better welding reason and for legitimate arrangement, we are utilizing a M.S. backing plate on which we set the aluminum plate and its measurements are 300mm×150mm& 5mm thick. By the utilizing of thebacking plate we are getting great back pressure on welded plates. The properties of aluminum compound 6061 are appeared in Table 1 to 2

Table 1:Chemical composition of AA6061

Aluminum	Balance
Magnesium	0.8-1.2
Silicon	0.4-0.8
Iron	Maximum 0.7
Copper	0.15-0.40
Zinc	Maximum 0.25
Titanium	Maximum 0.15
Manganese	Maximum 0.15
Chromium	0.04-0.35
Others	0.05

Table:-2 Mechanical properties of AA6061

Ultimate Tensile Strength (MPa)	260-310
0.2% Proof Stress (MPa)	240-276
Brinell Hardness (500kg load, 10mm ball)	95-97
Elongation 50mm dia (%)	9-13
Co-Efficient of Thermal Expansion (20-100°C)	23.5×10^{-6} m/m.°C
Thermal Conductivity	173 W/m.K
Electrical Resistivity:	$3.7 – 4.0 \times 10^{-6}$ Ω.cm
Density	2.7 g/cm^3
Melting Point	Approx 580°C
Modulus of Elasticity	70-80 GPa
Poissons Ratio	0.33

Table 3:Tool properties(Steel 304)

Tensile strength,Ultimate (Mpa)	505
Shear Modulus(Gpa)	86
Modulus of elasticity(Gpa)	193-200
Poisson ratio	0.35
Young modulus(pa)	2.0E+11
Thermal conductivity(W/m.k)	16.2

Melting point(C^0)	1400-1455
Density(kg/m^3)	7870

Fig.1. Vertical CNC Milling Machine used for the FSW

Fig.2 Milling Machine attachment used for the FSW

These tool profiles are comprised of material SS 304. These profiles gives diverse properties of welded joints. Circular pin profile can be considered as multi edge cutting device, the hexagonal pin profile can be considered as six edge cutting device, the hexagonal pin profile can be considered as instrument with three cutting edges.

Fig.3Different geometry tool used for the FSW

Table:-4 Operating Parameters

Parameters	**I**	**II**	**III**
Rotational speed(RS)	1200	1400	1600
Feed(mm/min),WS	10	12	14

Depth of cut,PL	3	3	5

Table:-5L9 array

RS(rpm)	WS(mm/min)	PL (mm)	TS(tensile strength)MPA
1200	10	3	78
1200	12	3	88
1200	14	5	84
1400	10	3	115
1400	12	5	111
1400	14	3	105
1600	10	5	187
1600	12	3	168
1600	14	3	155

The graphical results showing temperatures, pressure, viscosity and flow stress distributions obtained by running the simulations on HyperWorks9.0 indicate the effects of varying welding parameters particularly welding speed (WS). At the constant value of 600 rpm (RS), The peak temperatures are found as maximum at the tool pin center.

1) Flow stress:-

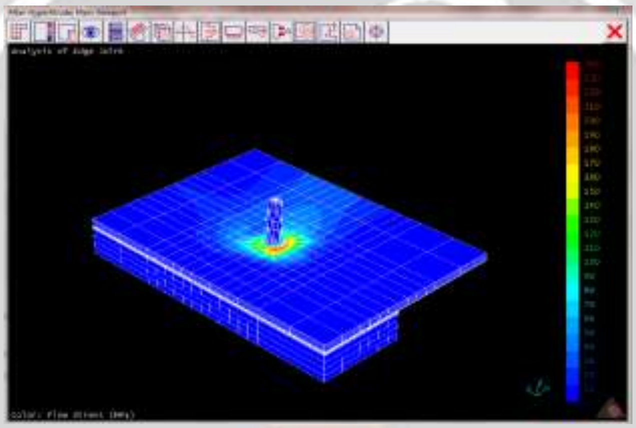

Figure 4: Flow stress at 600rpm

2) Temperature:-

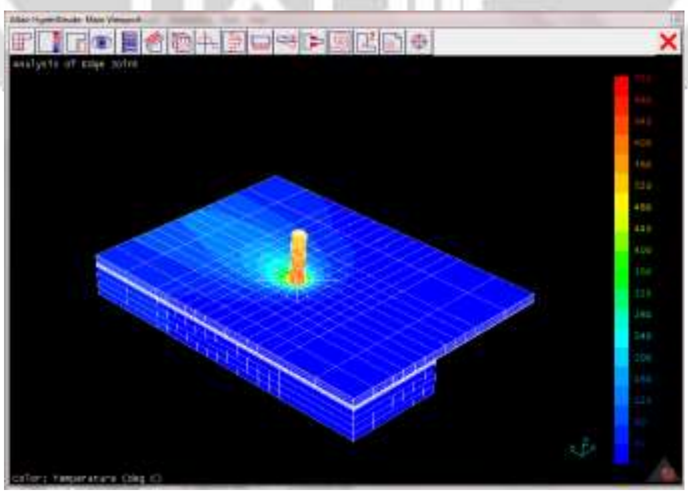

Figure 5: Temperature at 600rpm

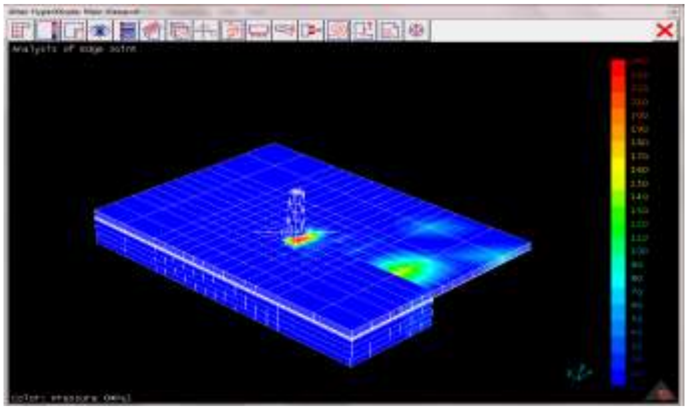

Figure 6: Pressure at 600rpm

3) Pressure:-

IV. RESULT TABLE

Table:-5Result table

Tool Speed(rpm)	600
Traverse Speed(mm/sec)	4.23
Flow Stress(Mpa)	233
Temperature(c°)	698
Pressure(Mpa)	238
Viscosity(pa-sec)	6.9635998e+11

V. RESULT ANALYSIS

The fundamental quality attributes considered in the present examination was tensile strength which portrays the nature of the FSW joints. Keeping in mind the end goal to get to the impact of welding parameters on the output response S/N ratio for every control variable were figured. The S/N ratio was utilized to investigation the test run results because it represents both average (mean) and variation (scatter) of the experimental results. The quantity of S/N ratios are accessible, for example, smaller the best, larger the best, nominal the best.

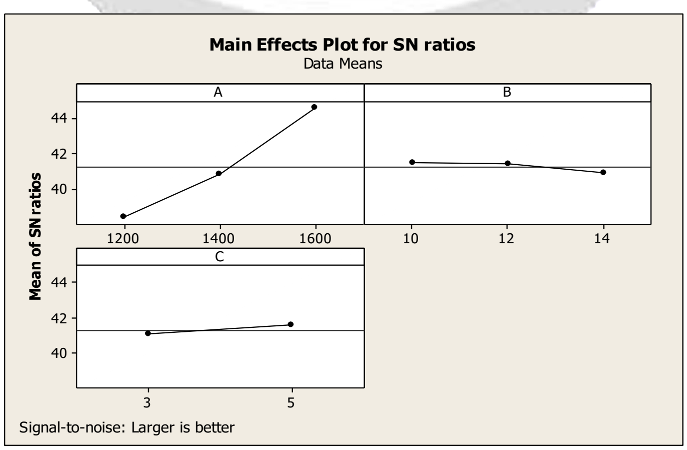

Fig.7. Main effect fpr S/N curve

Table:-6 Main effect for S/N curve

Level	A	B	C
1	38.41	41.5	41.11
2	40.85	41.43	41.61
3	44.58	40.91	
Delta	6.18	0.59	0.5
Rank	1	2	3

In light of the past information, ability and comprehension of the procedure the fitting S/N ratio was picked. The tensile strength of the joint made at a weld speed of 10 mm/min observed maximum. It is seen from Figure7 that for a fixed value of spindle speed an increment in WS, brought about an decrease of the TS. The weld zone is presented to frictional heating for a shorter time at higher WS, bringing about inadequate heating and poor plastic flow of the metal. Match with research Elangovan and Balasubramanian [19] that expanded WS brings about void-like imperfections in the joints that go about as stress raisers which influence the TS of the joint.

Fig.7 shows the main effects plot for S/N ratio indicating that the tensile strength is maximum when spindle speed, traverse feed, and pin lenght are at the level of 3, 1, 2 i.e. 1600rpm, 10 mm/min, 5mm respectively. From table 6 we conclude that spindle speed is most effective parameter to affect tensile strength og joint.

The TS of the considerable number of joints tried were noted to be lower t han the TS of the base materials. It is seen from Figure 7, that TS increments when the spindle speed is increased. The tensile strength of the joint made at a shaft speed of 1600 rpm was observed to be the most extreme. At low spindle speed, the material softening is not adequate because of low heat generation and in this manner, brings about insufficient blending of the materials. Henceforth the TS of the joints were observed to be low. Higher spindle speed generates more heat , and subsequently expands the mixing impact of the pin producing flash and forming tunnel defects. Comparative impact has been accounted for in their work by Elangovan and Balasubramanian [19].

VI. CONCLUTION

The optimum tool rotation speed and welding speed for joining AA6061 at 1600 rpm and 14 mm/min. Comparing the joint strength at different profiles we found that maximum weld strength 168.00 MPa with triangular tool profile and after that with hexagonal tool profile and least with circular tool profile.

Tool rotation speed was the major factor affecting the impact strength,Tool rotational speed of 1600 r.p.m, welding speed of 10 mm/min and pin length of 5 mm is the optimum.

At the constant value of 600 rpm (RS), The peak temperatures are found as maximum at the tool pin center.

For simulation AA6061 , If we are increasing the speed of tool than Flow stress, Pressure will decrease and Temperature will increase.

With increasing tool speed at constant traverse speed than Flow stress, Pressure will be decrease and Temperature, Viscosity will be increase.

During the simulation it is found thatpeak temperature of 698°C provides flow stress of 233MPa, pressure of 238Mpa and viscosity of 6.9635998e+11pa-sec as cylindrical pin profile at 600 RPM.

Simulations performed on computer software opens the new horizon of modeling friction stir welding process in virtual laboratory and help predict the mechanical properties of FSW-joints.

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