Effect of Shoulder Diameter and Pin Profile on Mechanical Properties of Al 6061 Alloy Processed By Friction Stir Processing

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Abstract— **The aim of this experiment was to improve the mechanical properties of 6061 aluminium alloys by friction stir processing (FSP), a solid-state technique for micro structural modification using the heat from a friction and stirring. The Aluminium alloy 6061 is widely used in the fabrication of lightweight structures with high strength-to-weight ratio and good corrosion resistance. Welding is main fabrication method of 6061 alloy for manufacturing various engineering components. Friction stir welding (FSW) is a recently developed solid state welding process to overcome the problems encountered in fusion welding. This process uses a non-consumable tool to generate frictional heat on the abutting surfaces. The welding parameters, such as tool pin profile,rotational speed, welding speed and axial force, play major role in determining the micro structure and corrosion resistance of welded joint. In this work a central composite design with two different speeds, traverse speeds and Four tools has been used to minimize the experimental conditions.**

***Index Terms*— Friction Stir Processing, Shoulder Diameter, Pin Profile, Rotational Speed and Traverse Speed**

I. INTRODUCTION

Friction stir processing (FSP) was developed based on the principles of friction stir welding (FSW) which was developed and patented by The Welding Institute Ltd, Cambridge, UK in 1991. FSP is a solid-state welding, micro structural modification technique using a frictional heat and stirring action, has recently attracted attention for making aluminum alloys with an excellent specific strength, and its studies have been actively performed. Friction Stir processing is a special technique to improve the micro structure in the solid state by using the heat from friction for the aluminum-casting alloy, which has a higher specification. It was initially applied to aluminum alloys. The basic concept of FSW is remarkably simple. A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates to be joined and traversed along the line of joint . A rotating piece is defined as the tool, which designed and manufactured to plastically deforming the processed zone and produce heat due to stirring action between work piece and the tool pin. The tool consists mainly three parts such as tool pin, shoulder and the shank. The angle of the tool as compare to the vertical direction is known as tilt angle. The trailing and leading edge will be used to differentiate between the rear and front limb of the tool as the front is described as the direction of travel. Hence to enhance the mechanical and tribological properties locally, Friction stir processing shows the great route to get desired properties. Friction stir processing can be applied variably up to the depth of in the range of 0.5 to 50 mm

II. PRINCIPLE OF FRICTION STIR PROCESSING

In friction stir welding a cylindrical, shouldered tool with a profiled probe is rotated and slowly plunged into the joint line between two pieces butted together. The parts have to be clamped onto a backing bar in a manner that prevents the abutting joint faces from being forced apart. Frictional heat is generated between the wear resistant welding tool and the material of the work pieces. This heat causes the latter to soften without reaching the melting point and allows traversing of the tool along the weld line. The maximum temperature reached is of the order of 0.8 of the melting temperature of the material. The plasticized material is transferred from the leading edge of the tool to the trailing edge of the tool probe and is forged by the intimate contact of the tool shoulder and the pin profile. It leaves a solid phase bond between the two pieces. The process can be regarded as a solid phase keyhole welding technique since a hole to accommodate the probe is generated, then filled during the welding sequence.

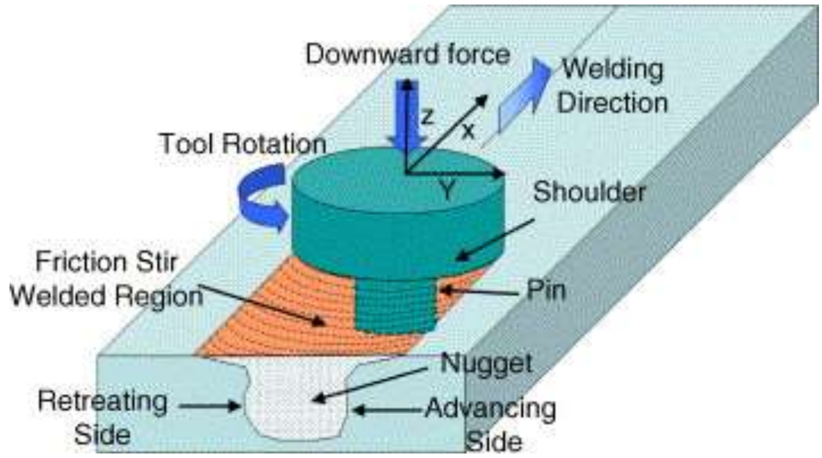

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Fig1. Schematic drawing of friction stir welding

III. LITERATURE REVIEW

Chainarong and S. Suthummanon[1] The Material used in the experiment is a SSM 356 aluminum alloy. The cylindrical pin used as the stirring tool. The tool has a shoulder diameter., pin diameter. and pin length of 20 mm, 5 mm and 3.2 mm, respectively. And these Scholars was taken as the parameters of friction stir processing for SSM 356 aluminum alloys were studied at three different traveling speeds: 80, 120 and 160 mm/min under three different rotation speeds 1320, 1480 and 1750 rpm.

These Scholars was conclude by this experiment is the surface of specimen is improved by the friction stir process. However, investigation did not find any defects with the stirred. The hardness of the area was influenced by the thermal both retreating and advancing with increased hardness for all experimental conditions compared to that of base metal. But for the stir zone, the hardness can be either increased or decreased. The condition that increased the hardness is traveling speed at 120 and 160 mm/min with any rotation speed. The condition that reduced the hardness is travel speed at 80 mm/min with any rotation speed. The highest hardness, obtained at 1750 rpm with travel speed at 160 mm/min. An increase of 59.07% compared to the base metal. The average maximum tensile strength after using friction stir processing is equal to 188.57 MPa, an increase of 11.8% compared to the base metal. It was found that the conditions providing strength to pull up the average is at the speed around the 1750 rpm and at the travel speed at 160 mm/min.

IV.METHODOLOGY

Material Properties

The base material employed in this study is a aluminium alloy 6061.

Table 1. Chemical compositions (% weight) of the Al-6061 alloy

Element	Mg	Si	Cu	Zn	Ti	Mn	Cr	Al
Amount (%)	0.85	0.68	0.22	0.07	0.05	0.32	0.06	97.7

Modulus of Elasticity: 70-80 G Pa.

Melting Point: Approx 580°C.

Thermal Conductivity: 173 W/m K.

The material has elongation (stretch before ultimate failure) of 25 to 30%. High Strength light weight Better corrosion Properties

V. RESULTS AND DISCUSSIONS

Table 2: Experimental Results

TOOL PROFILE	SPEED (rpm)	FEED (mm/min)	Ra (µm)	Rz (µm)
ø10 mm Tapered	900	40	0.805	5.628
		125	2.457	13.343

	1800	40	2.297	14.717
		125	0.582	3.857
Parent Material			0.360	1.874
ø10 mm Stepped Tapered	900	40	1.776	9.483
		125	3.81	19.67
	1800	40	2.049	10.951
		125	2.53	4.61

From Table:2 it is evident that for a plain tapered pin profile with rotational speed 900 rpm, as the traverse speed is increasing the surface roughness also increased for ϕ10 shoulder diameter but its vice versa in case of ϕ20 mm. Stirred roughness boundaries surface as a result of heat generated during stirring caused by rotation speed and travel speed. In the condition of rotation speed at 900 rpm and travel speed 125 mm/min on Shoulder diameter 10 mm stepped tapered plate, the high roughness was about 19.67µm, and found that The Minimum Surface Roughness was measured on the condition of rotating speed at 1800 rpm and travel speed 40 mm/min on Shoulder diameter 20 mm Plain tapered plate, the minimum roughness was about 2.597 µm. The variation in the surface roughness is minimal for plain tapered profile when compared with the stepped tapered profile. The pin surface area is more in case of stepped tapered profile when compared with plain tapered and this might be the cause for such high surface roughness values for stepped tapered profile.

VI.CONCLUSION

In this investigation an attempt has been made to study the effect of tool pin profiles and different rotational and welding speeds on mechanical properties and heat generation. From this investigations following conclusion are derived

- Increasing the welding speed will effect on tensile properties.
- Threaded shape is effectiveness on mechanical properties.
- Differences between peak temperatures of samples welded by different pin profiles are very little and not significant.

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