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Experimental Investigation Of Mechanical Properties Of Friction Stir Spot Welding Using Circular Profile En 31 Tool On T6061 And T6082 Aluminum Alloys

*B.Srinivasulu[1], Dr.Namish Mehta[2]
1Research Scholar1 Department of Mechanical Engineering, Sri Satya Sai University of Technology & Medical Sciences Sehore, Bhopal, M.P.
[2]Department of Mechanical Engineering ,Truba College of Science and Technology, Bhopal, , Madhya Pradesh.
**Corresponding Author Mail ID:-bsrinivasulu1610@gmail.com*

Abstract: *Efforts to reduce vehicle weight and improve safety performance have resulted in increased application of light-weight aluminum alloys and a recent focus on the weldability of these alloys is need of the day. Friction stir spot welding (FSSW) is a solid state welding technique (derivative of friction stir welding) which was developed as a novel method for joining aluminum alloys. During FSSW, the frictional heat generated at the tool-workpiece interface softens the surrounding material, thus the rotating and moving pin causes material to flow. The forging pressure and mixing of the plasticized material result in the formation of a solid bond region. In the present work, Aluminum alloy plates 6061 and 6082 are joined by friction stir Spot welding (FSSW) using EN31 Tool material with Circular Profiles by varying welding parameters such as rotational speed, Feed and inclinational angle of the tool. It is evaluated that tensile strength is more for friction stir spot weldment joints of dissimilar metal than similar metals used in the study.*

I. Introduction

Weight reduction without affecting the safety performance is a great challenge in the automotive industry in order to improve fuel economy and reduce emissions. It has been reported that fuel consumption can be reduced by 5.5% for each 10% reduction in vehicle weight and a one-pound reduction in the weight of a car would reduce carbon dioxide emissions by 20 pounds over the life of the vehicle . An automobile consists of outer panels and a platform, which is typically made of steel and contains the drive system, engine system and exhaust system. The weight of the platform is around 70 % of the total weight of an automobile.

For replacing steel with aluminum in the structure of automobiles, it is necessary to explore joining methods that can be used efficiently. Current panel welding techniques used to join steels include resistance spot welding (RSW) and self-piercing rivets (SPR). However, these welding techniques cannot be applied easily to aluminum alloy, because of its physical properties, particularly surface oxide film. Friction stir spot welding (FSSW) is a derivative of friction stir welding, which was developed by TWI (Abington, United Kingdom) in 1991 as a solid-state method for aluminum alloy joining. This 2 novel joining mechanism is advantageous for producing aluminum joints without contamination, blowholes, porosity and cracks.

II. Experimental setup

In this process the aluminum plate of 4 mm thickness with grades T6061 and T6082 are selected.

EN 31 Tool was selected with a circular profile . The mechanical properties of the T6061 and T6082 are depicted in the Table1 and Table 2. The experiment was conducted on a conventional Milling machine as shown in the fig.1

2.1 Process Variables

2.1.1 Tool Design: The Design of the tool is a critical factor. It determines the quality of weld and its maximum welding speed, The tool materials should be sufficiently strong, tough, hard and wear resistance at the welding temperature. EN31 material was selected as Tool materials. It is high quality alloy steel with tensile strength, good ductility and shock resistance. It is widely used in automotive gears and parts, shafts,towing pins, load bearing tie rods, Oil and Gas Industry application.

Table 1: Chemical composition of EN 31 Alloy Steel

C	Si	MN	S	P	Cr
0.90-1.20%	0.10-0.35%	0.30-0.75%	0.050% max	0.050% max	1.00-1.60%

Table 2: Mechanical Properties of EN 31 Alloy Steel

Tensile N/mm2	Yield N/mm2	Elongation %	Hardness HRC
750	450	30	63

Source : Saaj Steel Corporation,Chennai

The rod of 40 mm dia has procured and machined as per the following dimensions.

2.1.2 Aluminum and its 6xxx series alloys

Aluminum and its alloys have been used extensively in modern life, from soda cans, household cookers to automotive and aircraft structures. Low density, high strength, high ductility, excellent formability and high corrosion resistance in the ambient environment make them promising candidates for vehicles, particularly the closure panels such as hoods, decklids and lift-gates

The weldability of aluminum alloys varies depending on the chemical composition of the alloy used. The 6XXX series aluminum alloys mainly used in this project, designating the Al-Mg-Si-(Cu) alloys, are most commonly used for extrusion purpose and are widely used as automobile body sheets.

Table3: Chemicalcomposition of aluminium 6061

component	Aluminium	Magnesium	Silicon	Iron	Copper	Zinc	Titanium	Manganesese	Chromium	Others
Amount(wt %)	Balance	0.8-1.2	0.4-0.8	Max .0.7	0.15-0.40	Max.025	Max.0.15	Max.0.15	0.04-0.35	0.05

Table 4: Chemical composition of aluminium 6082

component	Aluminium	Magnesium	Silicon	Iron	Copper	Zinc	Titanium	Manganesese	Chromium	Others
Amount(wt%)	95.2 to 98.3%	0.6 to 1.2%	0.7 to 1.3%	0.5 % max	0.1% max	0.2% max	0.1% max	0.4% to1.0%	0.25% max	0.15% max

Table 5: Process variables

Parameters	1
Tool Profile	Circular
Rotational Speed(RPM)	1120
Feed(mm/min)	25
Depth of cut(mm)	5.5
Inclination angle	0.5 deg
Tool	
Tool Dimensions	Outer Dia 18 mm Pin Dia 4.8 mm Length of Pin 5.3 mm

Fig 1. Experimental set up

2.2 Machine variables

2.2.1 Rotational Speed of the Tool: The Rotational speed of the tool is also known as machine spindle RPM affects the quality of the Joint. With increase in rotational speed, the heat generated by friction also increses which directly affects the temperature at welding position. For this experiment 1120 RPM is selected.

2.2.2 Welding Feed Speed : The welding feed speed is also know as tool advancing speed is also affects the welding joint quality. With decrees in tool rotational speed the time for which the tool in contact with work increses, so that the heat generated due to friction is also increases which directly affect the temperature at the welding position. The feed is selected 25 mm/min

2.2.3 Depth of Cut(Axial Force): The depth of cut is also termed as Axial Force required to weld the joint. Based on the thickness of the material this force is selected. There is a limitation of this force based on the machine specifications and thickness of the materials selected, In our case the depth of cut is fixed 5.5 mm.

III. Test Results and Discussions:

After friction stir spot welding of the samples, by varying welding parameters such as rotational speed, Feed and inclinational angle of the tool. It is evaluated that tensile strength is more for friction stir spot weldment joints of dissimilar metal than similar metals.

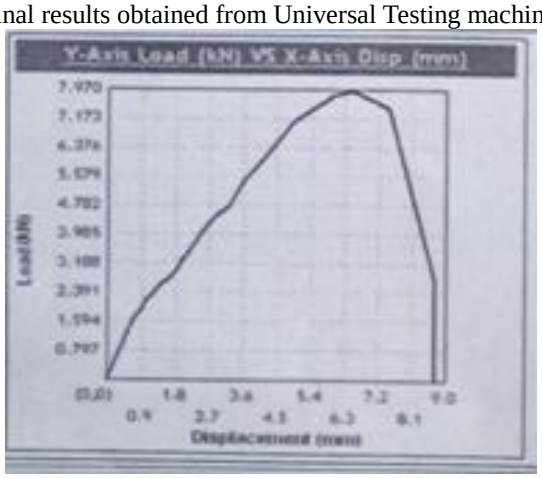
3.1Tensile and Yield Strength

This test is conducted by using Universal Testing machine This test is used to measure the strength of a welded joint. A portion of the welded plate is locate the weld midway between the jaws of the testing machine. The width thickness is of the test specimen are measured before testing and the area in square inches is calculated by multiplying these before testing and the area in square inches is calculated by multiplying these figures. A machine of the portable type, operating on the hydraulic principle and capable of pulling as well as bending test specimens. As the specimen is being tested in this machine, the load in pounds is registered on the gauge. In the stationary types, the load applied may be registered on a balancing beam. In either case, the load at the point of breaking is recorded

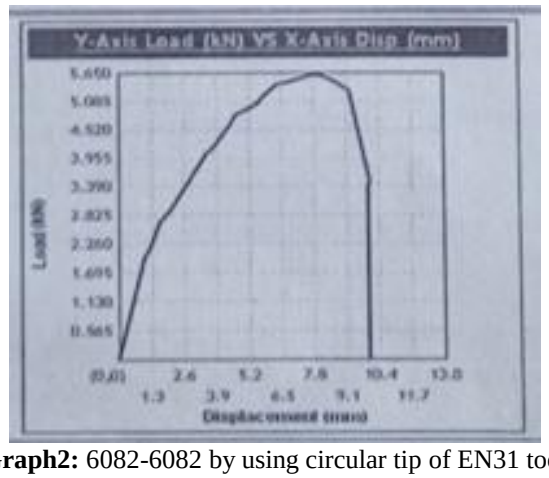
Fig:3 Test samples for Conducting Tensile Strength and Yield Strength

1. 6061-6061 by using circular tip of EN31 tool
2. 6082-6082 by using circular tip of EN31 tool
3. 6061-6082 by using circular tip of EN31 tool

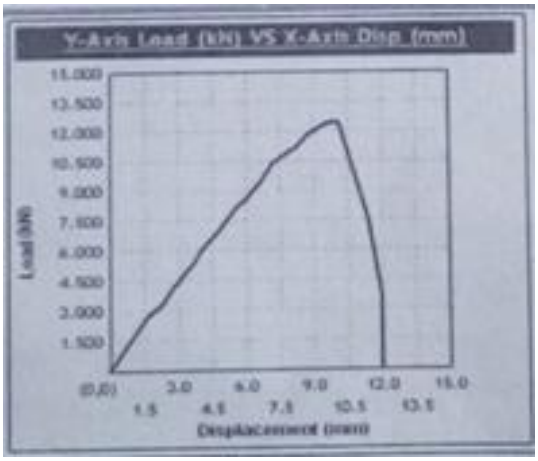
The following table gives the final results obtained from Universal Testing machine



Graph1: 6061-6061 by using circular tip of EN31 tool



Graph2: 6082-6082 by using circular tip of EN31 tool



Graph3: 6061-6082 by using circular tip of EN31 tool

Table 4. Test Results Tensile and Yield strength

Sl.NO	Material Combination	Tool Material	Ultimate Tensile Strength N/mm2	Yield Strength N/mm2
1.	6061-6061 - Circular Tip	EN31 tool	90.10	73.7
2.	6082-6082- Circular Tip	EN31 tool	61.4	42.97
3.	6061-6082- Circular tip	EN31 tool	120.01	90.4

IV. Conclusions

The experiments have been conducted On a Vertical Milling machine by using EN31 with Circular tool profiles for Friction Stir Spot Welding of T6061-6082 , 6061-6061 and 6082-6082 .

-The samples are tested on a Universal Testing machine for Ultimate Tensile Strength, Yield Strength

-T6061-6061 with circular tool(EN31) has got the values of Tensile strength 90.10 N/mm², Yield strength 73.7N/mm².

-T6082-6082 with circular tool(EN31) has got the values of Tensile strength 61.4 N/mm², Yield strength 42.97/mm².

-T6061-6082 with circular tool(EN31) has got the values of Tensile strength 120.01 N/mm², Yield strength 90.4/mm².

-The biggest tensile strength and yield strength were obtained with Circular tool(EN31) with Rotational speed(rpm) 1120 , Feed(mm/min) 25 and Inclination angle 0.5 degree is T6061-6082 with circular tool(EN31) compare with above three test.

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