PARAMETRIC OPTIMIZATION OF FRICTION STIR WELDING

[1] Vinay D R, [2] Pavan Kumar Reddy, [3] Vijay A, [4] Vishal, [5] Ashish Satpathy
[1] Assistant Professor, Department of Mechanical Engineering, New Horizon College of Engineering, Bengaluru, India
[2, 3, 4, 5] U G Student, Department of Mechanical Engineering, New Horizon College of Engineering, Bengaluru, India

Abstract: Amongst the emerging new welding technologies, Friction Stir Welding (FSW), invented and established by The Welding Institute (TWI) in 1991, is used frequently for welding of high strength aluminium alloys such as AA6061, AA6082, etc. which are difficult to weld by conventional fusion welding techniques. Friction welding (FW) is a collection of a series of friction-based solid-state joining processes which can produce high quality welds of different components with either similar or dissimilar materials and has been attracting increasing attention. The aim of this work is to weld two plates of AA6061 using circular tool profiles and to optimize the parameters like tool rotational speed, tool profile, depth of cut, feed etc. affecting the properties of welded joints. In this work, the hardness test is conducted at different welded locations for all specimens. The result showed that hardness of the weld is increased with the addition of silicon carbide.

***Keywords* – Friction Stir Welding, Aluminium Alloy, Hardness, Silicon Carbide, Vertical Milling Machine, etc., …**

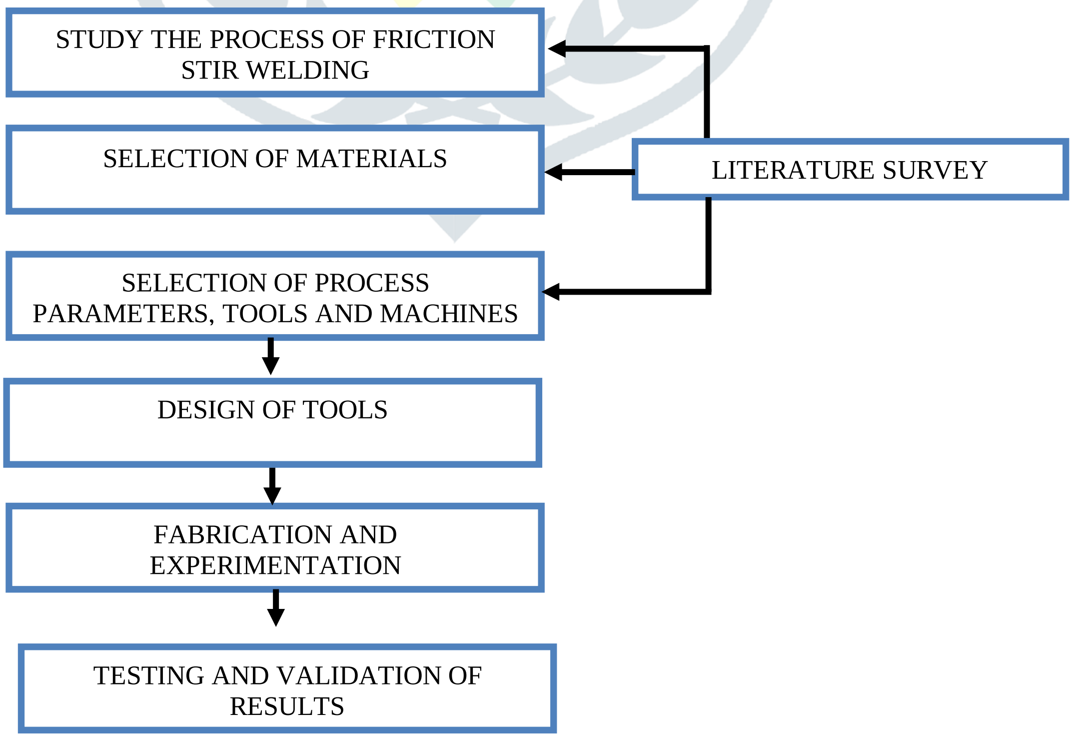
I. INTRODUCTION

Welding is the process of metal joining with help of heat, with or without pressure. Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is often added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that can be as strong as the base material. Pressure may also be used in conjunction with heat, or by itself, to produce a weld.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including in open air, under water, and in outer space. Welding is a hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

In this report we will come across classification of different welding procedure and their uses and we will mainly focus on Friction Stir Welding which is one of the types of friction welding.

II. METHODOLOGY



III. Experimental Parameters

3.1 Joint Strength

The resistance of a material to breaking under tension. We increase tensile strength of weld joint using appropriate tool profiles and choosing proper input parameters.

3.2 Optimum Parameters

The optimum input parameters like speed, feed and depth of cut are taken for better result.

3.3 Tool Profiles

The appropriate tool profiles like as circular, hexagonal and triangle are taken for better result.

3.4 Material Selection

Aluminium and its alloys belong to the light metals, given their approximate density of 2.70 kg/dm³. For comparison: steel has a density of typically 7.85 kg/dm³. Aluminium has the largest field of application of the light metals. In 2005, the worldwide annual production of aluminium was 31 Mt. Aluminium is ductile; it can be hot rolled or cold rolled down to thicknesses of 6-7 μm (foil). It can be extruded down to wall thicknesses of 0.5 mm. It can also be pressed, drawn, forged, stamped or cast by traditional methods. Aluminium is corrosion resistant, and its surface can be further protected from corrosion by anodising, painting or lacquering. Aluminium can be joined by most well-known joining methods, including welding, brazing, soldering, gluing and riveting.

The tensile strength of aluminium can be varied from 70 to 700 MPa, depending on the alloying elements added and the processing. Its ductility and strength can be altered during the working process to give the material the desired degree of strength. If aluminium is used in structural components that are subject to stress or bending however, it must be borne in mind that the metal's rigidity (modulus of elasticity) is not altered significantly by alloying or hardening. It will always remain about one-third that of steel (EAl = 70 GPa, EFe = 210 GPa).

Aluminium is light-weight. Used in vehicles, it reduces deadweight and energy consumption while increasing load capacity. Aluminium has only one-third the density of steel. Aluminium is a good conductor of heat. This property is exploited in products such as cooking utensils and heat-exchange systems. Aluminium is an excellent conductor of electricity: its thermal coefficient per weight unit is twice that of copper. This has made aluminium the most commonly used material in major power transmission lines. Aluminium does not have a ductile-to-brittle transition temperature (contrary to steels), which explains their use for cryogenic applications.

3.5 Tool Parameters

There are different tool geometries like circular, to analyse their effect on joint properties. These tool profiles are made up of material mild steel. These profiles give different properties of welded joints. Circular pin profile can be considered as multi edge cutting tool, the hexagonal pin profile can be considered as six edge cutting tool, the hexagonal pin profile can be considered as tool with three cutting edges. The tool profile should be such that which creates less amount of flashes. It should also prevent formation of chips and the material should be well penetrated by tool to form the sound weld joint. The main input parameters in friction stir welding are as follow:

3.5.1 Rotational Speed of Tool

The rotational speed of tool also known as machine spindle rpm affects the quality of joint. With increase in tool rotational speed the tool, the heat generated by friction also increases which directly affects temperature at welding position. Proper temperature is required for desired welding there for the rotational speed of tool must be selected properly.

3.5.2 Depth of Cut

The depth of cut in Friction Stir Welding also termed as axial force applied affects the quality of the welding output. If the thickness of the material plates to be welded is increased, the required depth of cut to properly join the material increases, so the required axial force will also increase. There is certain limit of axial force that can be applied based on machine specification. So, the range of thickness that can be welded by machine based on its capability to apply axial force is limited. The input parameters used in this work is shown in Table 1.

Table 1: Input Parameters

Parameters	Without Silicon Carbide	With Silicon Carbide
Rotational Speed (rpm)	1200	1200
Feed (mm/min)	10	10
Depth of Cut (mm)	5	5
Tool Profile	Circular	Circular

3.5.3 Welding Feed Speed

The welding feed speed which can also be termed as tool advancing speed also affects the quality of welded joints. With decrease in tool rotational speed the tool, the time for which tool is in contact with material increases, so the heat generated by friction also increases which directly affects temperature at welding position. Proper temperature is required for desired welding there for the welding feed speed must be selected properly.

IV. Experimental Design

On vertical milling center machine Friction Stir Welding is done. The input parameters as mentioned before were taken for machine process parameters. Tools of different profiles were mounted on turret of machine. The material taken is AA 6061 plates in the size of 10 square centimeters and 10 mm thickness by automatic showing cutter. After cutting of plates the edges of plates have gone through rough and smooth files. Then two plates were clamped on machine bed tightly such that it can withstand the force of tool motion without dislocating from its size.

The taken circular tool profile and speed of 1200 rpm and feed of 10 mm per minute. The work was started and the tool penetrated between two plates. At the time of penetration some chips came out after that the shoulder of tool made the material to stay inside and to form the good weld as the tool pass from that area.

In following figures, the Figure 1 shows welding of two plates on machine, Figure 2 shows the plates after welding and Figure 3 shows tool after welding.

Figure 1: Tool Setup in Vertical Milling Machine

Figure 2: Aluminium Welded Joint without Silicon Carbide

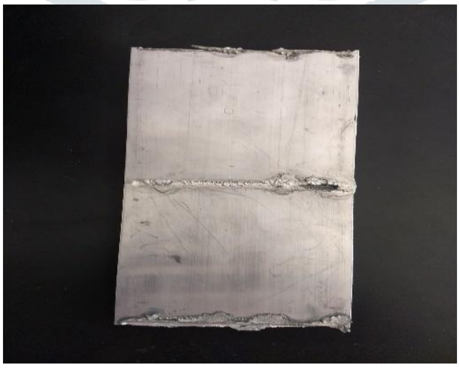


Figure 3: Aluminium Welded with Silicon Carbide

V. EXPERIMENTAL RESULTS

The experiments were conducted on Aluminium 6061 with & without Silicon Carbide using Friction Stir Welding. The hardness test has been done for the welded portion using Brinell Hardness Testing Machine. The results obtained are shown in Table 2 and the Figure 4 shows the comparison between the Aluminium without Silicon Carbide and Aluminium with Silicon Carbide. The experimental results show that Aluminium with Silicon Carbide has a higher hardness number than the Aluminium without Silicon Carbide. Thus, this work influences that incorporation of Silicon Carbide in the Aluminium has significant improvement in the material properties.

Table 2: Hardness Number

Sl. No	Material Composition	Hardness
1	Aluminium without Silicon Carbide	73 BHN
2	Aluminium with Silicon Carbide	114 BHN

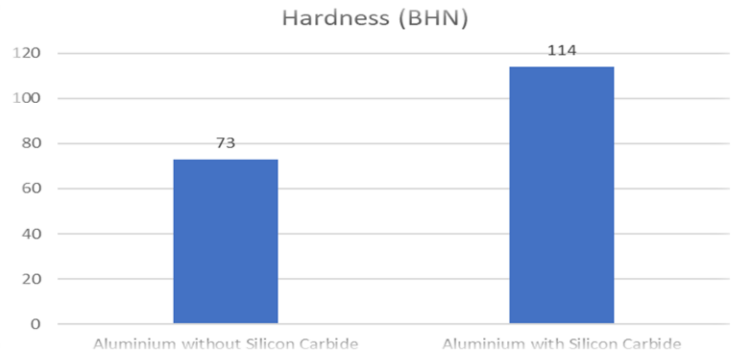


Figure 4: Hardness Number

VI. CONCLUSION

The hardness of pure aluminium and aluminium with addition of silicon carbide for friction stir welding is obtained. The tool geometry has been designed to get optimum welded joint property for obtaining maximum hardness. The Friction Stir Welding was performed in the laboratory using a Vertical Milling Machine. The tool was designed using High Carbon Steel material, having a circular cross section of dimension 5 mm depth and 6 mm diameter at the tip of the tool. The operation was performed on the Vertical Milling Machine to complete the two specimens, one without adding Silicon Carbide to Aluminium and one with addition of Silicon Carbide to Aluminium at the tool speed of 1200 rpm and tool feed of 10mm/min. The two welded specimens were tested using Brinell Hardness Testing Machine. The results show that the joint strength at different profiles maximum weld hardness with circular tool profile with silicon carbide was found to be 114BHN & without silicon carbide the maximum weld hardness was 73BHN.

REFERENCES

[1] Karan singla, Dr.Deepak Bhardwaj, VikasBurman "Friction stir welding", INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING-(2014).

[2] A. Suresh Babu, C. Devanathan "An Overview of friction stir welding", International Journal of Research in Mechanical Engineering & technology-(2013).

[3] Sivakumar, Vignesh Bose, D. Raguraman, D. Muruganandam "Review Paper on Friction Stir Welding of Various Aluminium Alloy", IOSR Journal of Mechanical and Civil Engineering-(2014).

[4] Aleem Pasha M. D., Ravinder Reddy P., Laxminarayana p. And Ishtiaq Ahmad Khan "INFLUENCE OF PROCESS AND TOOL PARAMETERS ON FRICTION STIR WELDING – OVERVIEW", International Journal of Applied Engineering and Technology-(2014).

[5] M. EL-SHENNAWY, ADEL A. OMAR & M. AYAD "SIMILAR AND DISSIMILAR FRICTION STIR WELDING OF AA 7075" International Journal of Mechanical Engineering (IJME)-(2014).

[6] Mandeep Singh Sidhu, Sukhpal Singh Chatha "Friction Stir Welding – Process and its Variable: A Review", International Journal of Emerging Technology and Advanced Engineering-(2012).

[7] C. DEVANATHAN, A. MURUGAN, A. SURESH BABU "OPTIMIZATION OF PROCESS PARAMETERS IN FRICTION STIR WELDING OF AL 6063", International Journal of Design and Manufacturing Technology (IJDMT)-(2013).

[8] Prashant Prakash, Sanjay Kumar Jha, Sree Prakash lal "A STUDY OF PROCESS PARAMETERS OF FRICTION STIR WELDED AA 6061 ALUMINUM ALLOY", International Journal of Innovative Research in Science, Engineering and Technology-(2013).

[9] Hasan I. Dawood, Kahtan S. Mohammed and Zurida A. Wahab "The Effect of Rotational Speed on Flow Behaviour and Weld Properties in Friction Stir Welding Of Pure Aluminium", Advanced Materials Research-(2013).

[10] Renjumohan, N.R. Rajesh, Satheesh Kumar S. "FINITE ELEMENT MODELING FOR MAXIMUM TEMPERATURE IN FRICTION STIR WELDING OF AA 1100 AND OPTIMIZATION OF PROCESS PARAMETER BY TAGUCHI METHOD", International Journal of Research in Engineering and Technology-(2014).

[11] G. Gopala Krishna, P. Ram Reddy & M. Manzoor Hussain "Effect of Tool Tilt Angle on Aluminium 2014 Friction Stir Welds", Global Journals Inc. (USA)-(2014)