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Friction Stir Welding (SS, DSW) Process Effort On Mechanical Properties of Aluminium Alloys 6061

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ABSTRACT :

Friction stir welding (FSW) was used in this work to combine the 6061 Al alloys. FSW is essentially a solid-state joining technique that generates heat between the tool and the work piece while rotating the plate with the tool. Another name for it is an eco-friendly method. The Impact of Mechanical Properties on Aluminium 6061 Alloys' Single Sided and Double Sided FSW Single-sided friction stir welding (SS-FSW), a viable substitute for a few traditional welding techniques, is one of the environmentally friendly production methods. welding materials that are difficult to weld. Using plastic deformation, solid state welding produces a metallurgical link between two substrates without the need for a filler material. There can be very little distortion and a good dimensional stability of the linked product because the procedure is less interconnected than the melting temperature of the material combined. This technique, known as double side friction stir welding [DS-FSW], involves the tool's multiple working sides acting on opposing sides of a plate that needs to be fused. The DS-FSW welding procedure produces welds of superior quality, however the tool and pin sizes and shapes differ greatly. Mechanical characteristics of stir welding aluminium 6061 with double side friction, varying the top and bottom tool axes and rotation speed. Two sources of heat input—pressing force and friction-stirring—are introduced by these two instruments.

Keywords: SS-FSW, DS-FSW, Aluminium 6061 Alloys, Mechanical Properties.

1.INTRODUCTION :

Aluminium alloy 6061 is currently in greater industrial demand as of Because of its higher strength to weight ratios, excellent ductility, and resilience to corrosion and cracking in hostile environments, its use in aerospace, aircraft, and automobiles has risen. These alloys are difficult to weld because of additional softening in the heat-affected and weld fusion zones, as well as the possibility of thermal cracking in the weld. To overcome these obstacles, the solid-state bonding method is highly advised. FSW is a novel solid-state welding technique that involves pressing both types of weld joint together and forging a very strong interface under the force created by heavy plastic. The metal that has to be joined is not heated in that process. Lastly, structural The stir pin's insert rotation causes deformations. In Single Sided FSW, a cylindrical tool probe with shoulders spins and pierces the material. The tool then makes contact with the plate's upper face. However, when joining plates of varying thicknesses of aluminium alloy, there is a real uneven thermal-mechanical interaction along thickness for a single-sided FSW (SS-FSW) using large-scale welding tools. It was suggested that SS-FSW connections with varying sheet sizes use a typical sequenced double-sided FSW (CDS-FSW) to improve microstructure uniformity.

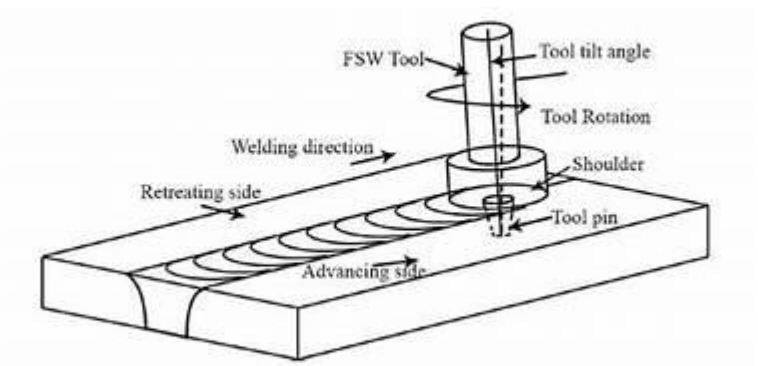
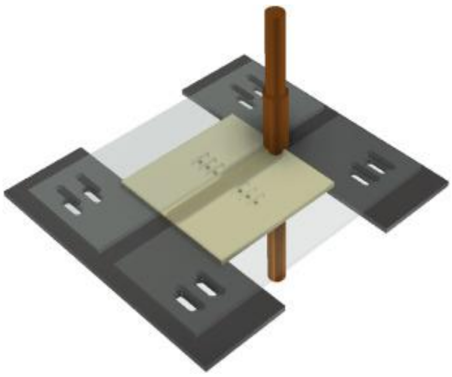


Fig:1.1 Single Sided-FSW Process

The welding process known as double-sided FSW (DS FSW) for aluminium alloys stirs material at the top and lower sides of the joint at the same time using two different tools. It provides an effective joining technique that tackles issues like porosity and hot cracks, which frequently occur during fusion welding. For alloy plates that were 12 mm thick, the DS-FSW setup joints showed a more uniform microstructure and microhardness distribution than the single-sided type, increasing the complexity of the fixture. The welding process known as double-sided FSW (DS FSW) for aluminium alloys stirs material at the top and lower sides of the joint at the same time using two different tools. Double-side FSW (DFSW) is introduced by first performing

FSW on one side, then flipping the plates, and finally doing FSW on the opposite side. Aluminium alloy hollow panels are essential components of civil and mechanical structures, such as large vehicle platforms and building floors. They increase rigidity while retaining their tiny weight and material volume. To improve the joint performance and weld efficiency of contact stir-welded aluminium alloy plates of different thicknesses, this panel must be connected utilizing welding procedures. DS-FSW The maximum thickness of aluminium alloys is 25 mm. Aluminium has been the focus of extensive industrial research due to its beneficial properties. These advantageous characteristics include strength ratio, good ductility, corrosion resistance, low prices, light weight, and good weldability. Because it can lower vehicle loads without sacrificing safety, it is used in the transportation sector.



1.2 Double Sided-FSW Process

Fundamentals of FSW:

A friction stir tool is rotated by a machine to begin the FSW process. On a backing plate support, a non-consumable pin and shoulder are inserted into the joint line for two materials that are firmly fastened. With the exception of the area around the tool-workpiece interface, both the tool and the work piece are at room temperature during the plunge phase. The rate of insertion determines the extent of flexibility and the rate of temperature rise. When the tool shoulder makes contact with the substrate, the plunge phase is complete. The material to be welded becomes softer due to the creation of local heat through friction and plastic deformation. Compared to the pin surface, the tool shoulder generates more heat. Nevertheless, the tool pin's motion causes the deformation, which in turn produces more heat. At this point, the metallic workpiece achieves the crucial temperature for plastic flow, and force begins to decrease. In order to attain the required temperature for plastic flow when welding metals with higher melting temperatures, it may be possible to purposefully keep the rotating tool in this position for a set amount of time, known as time to hold (also called dwell time). The FSW machine begins moving the friction stir tool over the weld path as soon as the plunge reaches the chosen plunge depth. Geometric features on the shoulder and probe move and mix (stir) material along the weld joint while maintaining the tool's rotation. The tool shoulder limits metal flow to a level that corresponds to its location, which is near the top surface of the workpiece initially. The friction stir tool retracts from the joint as it reaches the end of its course. According to the type of FSW machine, displacement, force, power, torque, and temperature can all be used to manage this actual welding phase.

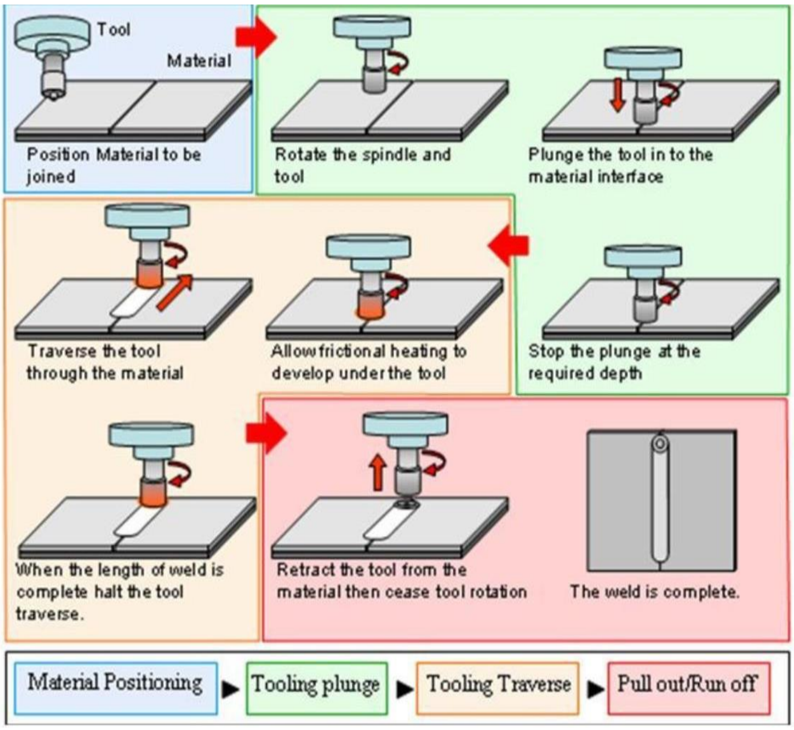


Fig 1.3 FSW Process Flow chat

Frictions stir processi:

Friction stir processing, also referred to as the surface modification technology, operates on a similar concept to FSW. It can be applied to enhance tribological and mechanical properties. The distinction between FSW and FSP is that, in real-world applications, they serve distinct functions. The FSP seeks to alter the microstructure of a single component, whereas the FSW method strives to fuse two plates together. A material's mechanical characteristics are improved as a result of the resulting plastic deformation, which improves the material's microstructure. The basic material's size and shape are unaffected by this operation. Without changing the qualities of the remaining material, it can be applied selectively to a portion for a particular attribute enhancement. The FSP tool's pin is frequently shorter than the sheet's thickness when compared to FSW. In order to treat composites and create surface composite layers, friction- stir manufacturing can also introduce second phase materials into a material. The powder (for instance, ceramic powder) can be inserted into the processing zone by making a groove, filling it with powder, and then FSP.

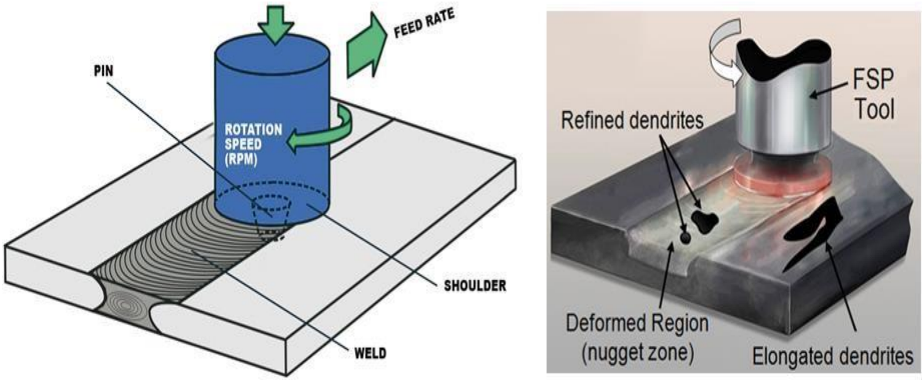


Fig 1.4 Friction Stir Welding (left) and Friction Stir Processing

Welding Tool:

The tooling needs to be able to react to the axial and radial forces produced by the process and retain the part in a specified place. For the specified weld head articulations, the tooling fixture must include gripping mechanisms that let the FSW tool access the workpiece and prevent the component from bending, splitting, or moving lengthwise as a result of the torque forces. Weld quality and welding parameters can be affected by the clamping system's and the weld surface's thermal conductivity. The tooling must have a backing surface that physically supports and presses against the rear side of the item during fixed-pin and adjustable-pin welding. The FSW tool will plunge into the material if the fit is incorrect because the welding load will drop and the system will move into the part as a result of the force change. Whether the system is in position control or load control, this scenario may arise, but it will be more noticeable during load control since the controller will try to move into the part until the desired axial load is reached or a position limit is reached.

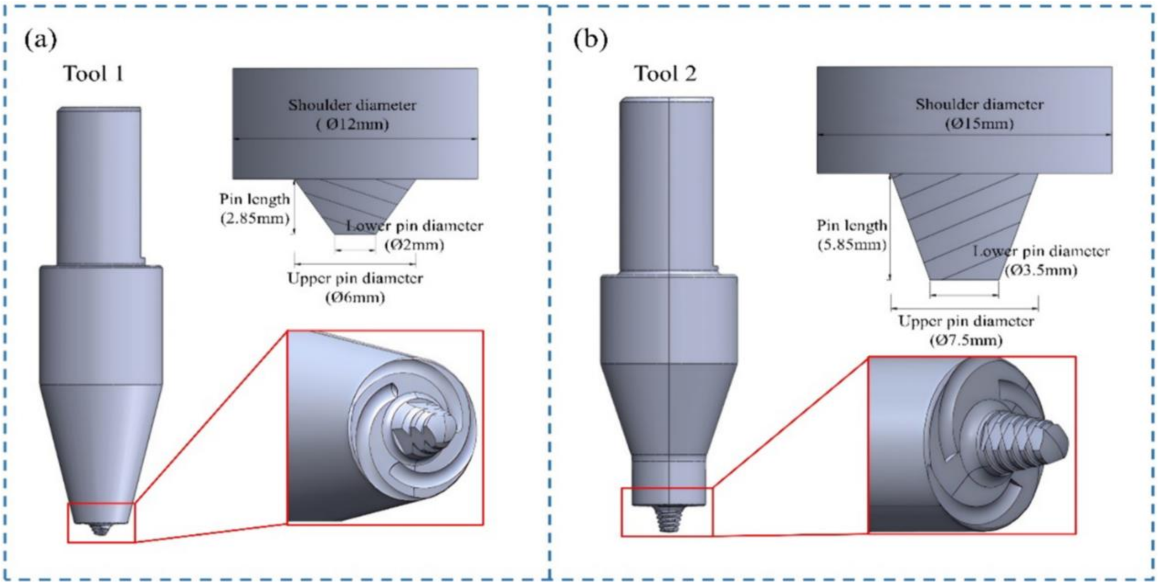


Fig 1.5 tool shape

METHODOLOGY :

Friction Stir Welding FSW process parameter:

1] Shoulder Velocity:

Definition: The rate at which the shoulder of a tool rotates, measured in revolutions per minute (RPM).

Importance: Affects heat generation through friction between the tool and the work piece. Increased temperature accumulation may result from faster rotations, however material handling may be hampered. Slower rates can result in flaws such voids and insufficient heat delivery. It is produced when heat is produced by the frictional force between the work piece and the tool's outer surface. Increased heat input may result from faster speeds, although material flow control may be compromised. Reduced speeds could lead to potential flaws like cavities and inadequate heat.

Optimization: To prevent overheating or inadequate material plasticization, a delicate balance must be struck.

2] Dwell Speed (DS):

Definition: The amount of time that a stationary tool remains at the location following material penetration; this tool is frequently used to warm the workpiece.

Importance: Heats the material sufficiently and softens it so that the tool can form it. It is essential for preventing major flaws like incomplete fusion or coldwelds. guarantees that the material's substance will boil and that the tool will transition smoothly before the point of beginning. Controlling the initial flaws, like cold welds for incomplete fusions, is crucial.

A too-short dwell time causes the material to become un plastified; a too-long dwell time wastes time and produces too much heat, changing the material's characteristics.

3] Tool Geometry:

Definition: The design of the welding tool, which includes the shoulders and pin profiles as well as the remaining components such the flats and threads.

Importance: A hip profile is a component that directly contributes to the material's consolidation and supplies the necessary quantity of heat.

The piece of machinery that produces the stirring action, flow of material, and mixing efficiency is referred to as the pin profile.

Typical

Types:

Shoulder shapes include convex, concave, and flat. Pin profiles might be trapezoidal, threaded, tapered, or cylindrical.

Process Parameters:

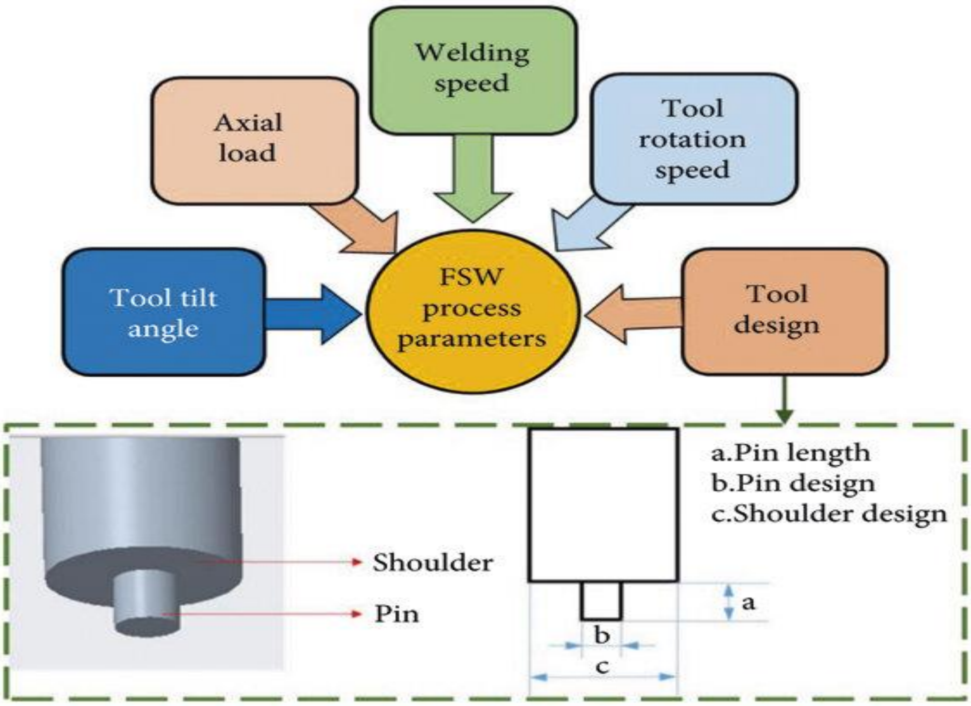


Fig1.6 process parameters

4.CONCLUSION:

This 6061-aluminum alloy was successfully joined using both single-sided (SS-FSW) and double-sided friction stir welding methods (DS-FSW). FSW has been verified as a solid-state, sustainable joining method with minimal environmental effect that joins hard-to-weld materials—like aluminum alloys—without the use of filler materials. It produces metallurgical bonding at minimum distortion and with great geometrical stability across the joints by using frictional heat and metallic deformation. DS-FSW is more efficient than SS-FSW. It enhances the quality of the weld. Both procedures, however, deal with issues such root defects and under penetration, particularly when bigger plates are used. Variations in tool form, pin geometry, and rotating speed have a significant impact on the mechanical behaviour of the joints. Due to improved heat balance and material consolidation, DS-FSW showed improved joint hardness and tensile strength. Compared to SS-FSW, DS-FSW has superior mechanical performance, including greater ultimate tensile strength and more uniform hardness profiles. Specimen fatigue resistances were improved over AS-FSW by removing residual stresses by using symmetrical heating and stirring in DS-FSW—a definite benefit when applications get more demanding. This study confirms that DS-FSW can, in fact, be used exclusively for the joints that are required with better quality, stability in size, and less distortion, replacing traditional and single-sided welding techniques. This study confirms that DS-FSW can, in fact, be used exclusively for the joints that are required with better quality, a stable dimension, and less distortion, replacing traditional and single-sided welding techniques.

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