DESIGN & FABRICATION OF FRICTION STIR WELDING MACHINE

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Abstract: Friction Stir Welding is a solid-state joining process that is both efficient as well as eco-friendly and versatile in its applications. Counted as one of the most significant developments in this age, Friction Stir Welding is used in the joining of high strength alloys which present difficulties with the conventional fusion techniques. As one most significant development as far as metal joining is concerned, Friction Stir Welding is a green technology that requires less energy as compared to conventional welding methods; no flux or gas is required hence making the Friction Stir Welding process environmentally safe. Being an efficient method, Friction Stir Welding process does not involve the use of any filler metal hence any alloy can be joined without consideration of compatibility of composition as opposed to conventional welding methods where compatibility is an issue. Although, Friction Stir welding process is also used to join composite materials which adds the extra benefits to the aerospace industries. Friction stir welding has less parameters to control during processing as compared to conventional welding processes. The main parameters are Rotational Speed, Transverse speed and pressure. Our project highlights the fundamentals of Friction Stir Welding and gives a literature review of studies that have been conducted to improve this technique with a major focus on aluminum alloy materials.

***Index Terms* - Rotational Speed, Transverse speed, pressure.**

I. INTRODUCTION

In Friction Stir Welding, a cylindrical shouldered tool with a profiled probe is rotated and slowly plunged into the weld line between two pieces of plate material, which are joined together. The parts are firmly clamped onto the worktable in a manner that prevents the joint faces from being forced apart. Once the pin is completely inserted, tool is moved in the welding direction. Frictional heat generates between the wear resistant welding tool and the work piece material [1]. This heat causes the material to soften without reaching the melting point and allows passing of the tool along the weld line. The deformed (plasticized) material is transferred from the leading edge of the tool to the trailing edge of the tool probe and gets forged by the intimate contact of the tool shoulder and the pin profile. It leaves a solid phase bond between the two pieces. A main benefit of Friction Stir Welding is that it has very few process elements to control. In a Fusion weld, there are many process factors to be monitored, such as gas fumes, voltage and amperage, feed, speed, shield gas and arc gap [2]. However, in Friction Stir Weld there are only three process variables to control: rotation speed, travel speed and pressure, all of which are easily controlled. The increase in weld strength joined with the reduction in process variability provides for high safety margin and degree of reliability.

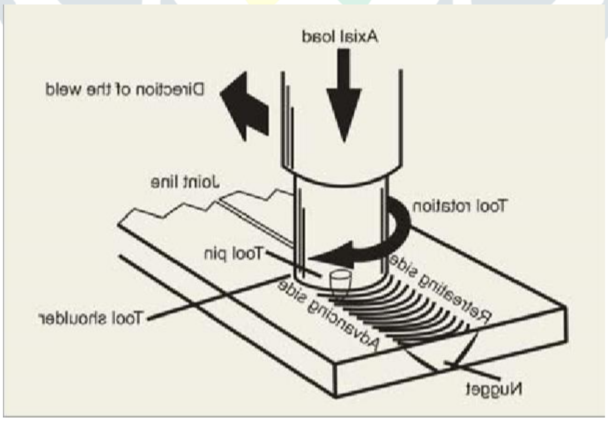

Figure 1- Friction stir welding process [2]

II. MICROSTRUCTURE DURING FSW [3]

The microstructure of weld material is mainly classified into three different zones.

1. Stirred zone
2. Thermo-mechanically affected zone
3. Heat affected zone

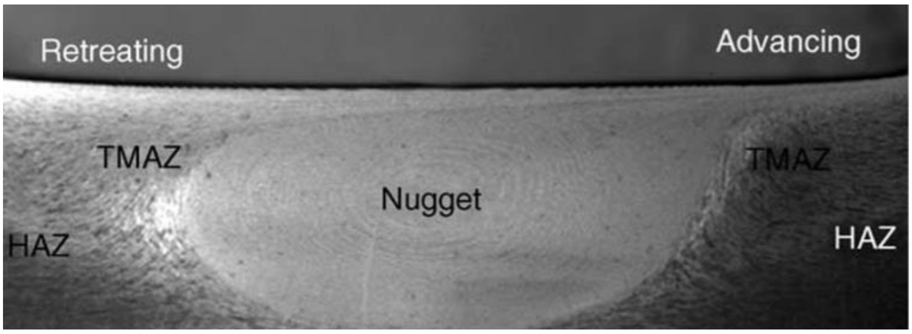

Figure 2- A typical macrograph showing various microstructural zones

1. Stirred zone:
   This zone is known as nugget zone. The grains inside this zone are recrystallized dynamically and converted into fine grains which are smaller in size as compared to the grains of parent material.
2. Thermo-mechanically affected zone:
   Very fine grains are present in this zone as compared to stirred zone due to the high deformation and temperature during the process. The hardness of the joint reduces in this zone.
3. Heat affected zone:
   The fine structured grains are present near the weld affected zone and the regular structured grains are present neat the heat affected zone.

III. Experimental Setup

The machine was design and fabricated to weld aluminum alloys by Friction stir welding process. The schematic representation of FSW machine is shown in figure 3. In this machine, step pulley and bevel gear mechanism are used to transmit power to rotate the tool. The hydraulic jack is used to lift and lower the bed. The main lead screw is used to provide transverse speed and secondary lead screw is used to adjust the center axis of tool and mating line of workpiece (Al 1100).

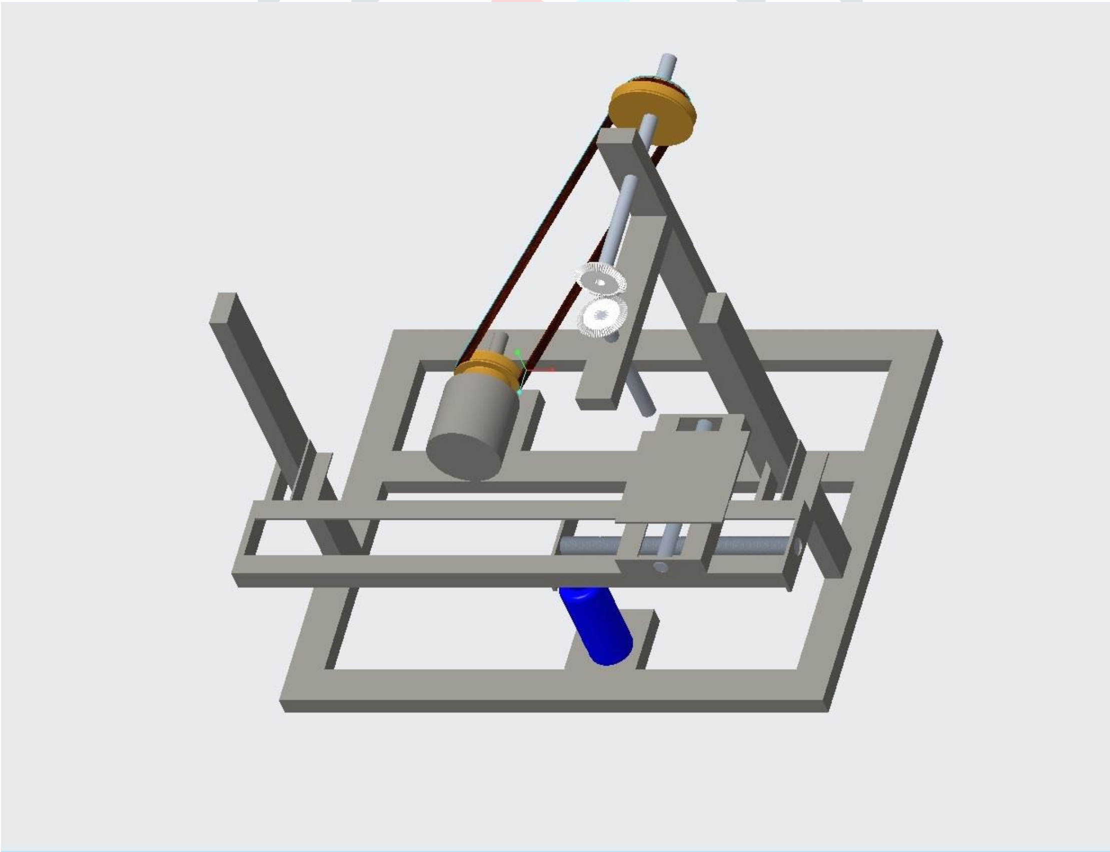

figure 3: 3D model of FSW machine.

table 1: specification of component use

Component	*Specification*
Frame	*MS material (50mm*25mm)*
Motor	*1 Hp AC motor (1440 rpm)*
Step Pulley	*Cast iron*
Shaft	*MS (diameter = 20 mm)*
Drill Chuck (tool holder)	*Steel*
Tool	*High Speed Steel*
Hydraulic jack	*3 ton capacity*
Work Piece	*Aluminum Alloy 1100 (130mm*65mm*5mm)*

Figure 4 - FSW machine

IV. DESIGN OF FRICTION STIR WELDING TOOL

4.1 TOOL PIN [4]

The tool pin is cylindrical in shape. The pin diameter is usually taken to be equal to the thickness of the plates to be welded or less than its thickness depending upon its application and strength of tool material. The tool pin diameter is kept as small as possible so that it can be easily penetrate between the two plate. The length of the tool pin kept marginally smaller than the thickness of plate (by a fraction of a 1 mm), so the pin penetrates the surface from one side only and at the same time forces the material to flow around it.

4.2 TOOL SHOULDER [4]

The tool shoulder is also cylindrical in shape. Due to the heat dissipation from the friction between the shoulder and the surface of the plates (in addition to the pin action), the material undergoes plastic deformation and the two plates are joined together. The tool shoulder length is irrelevant, but it must be long enough to allow its fixation in the rotating machine tool holder. The shoulder diameter must be not too large in order to minimize the width of the welding zone line. If the shoulder diameter is too large, then it will cause a wide area of the plate to be plasticized. The shoulder diameter is usually taken as two to three times of the pin diameter.

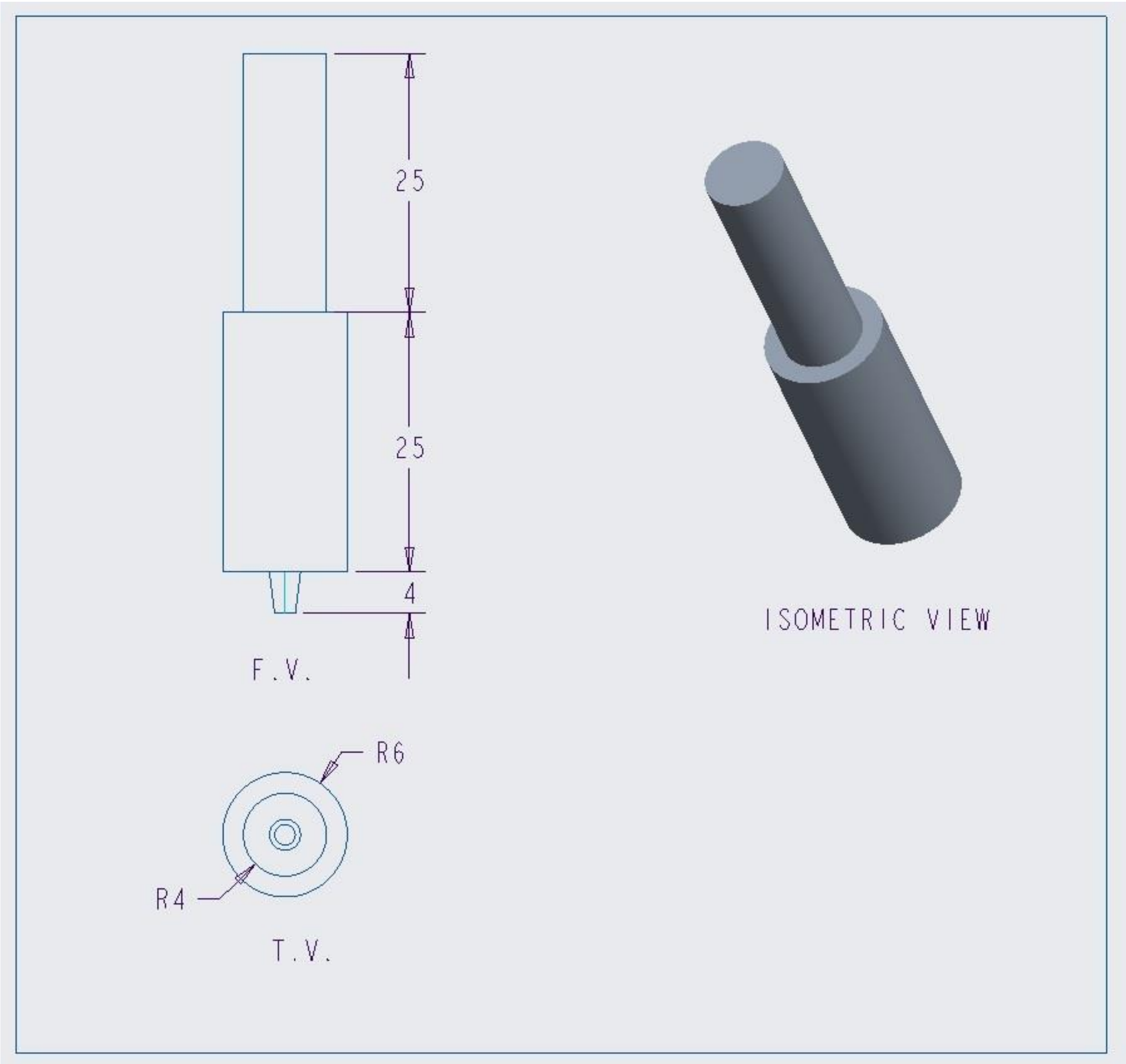

Figure 5 – Schematic design of FSW tool for 5 mm plate

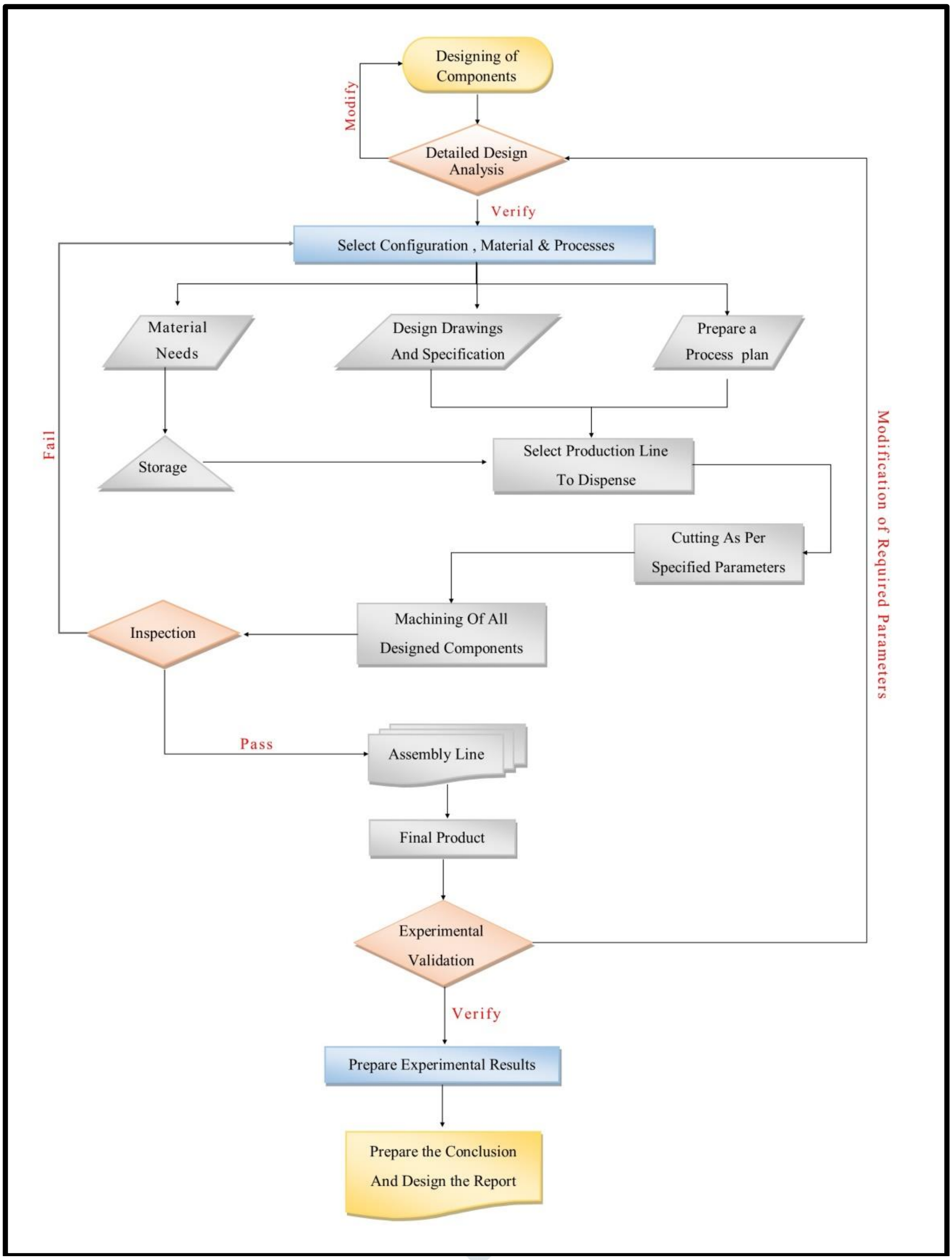

figure 2: project overview & manufacturing flow chart

V. EXPERIMENTAL ANALYSIS & VALIDATION

5.1 Friction Stir welding of AL-1100

The practice of Friction Stir welding process is done on aluminum alloy 1100 plate having thickness 3 mm and 5 mm. The key parameters that are considered are Rotational speed (approx. 1000rpm), Transverse feed (60 rpm).

5.2 Experimental Procedure.

In experimental setup, the power is transmitted from motor shaft to the main shaft with the help of V-belt and step pulley mechanism. At the other end of the main shaft, the bevel gear mechanism is mounted to transfer horizontal-rotating motion to vertical-rotating motion. The tool holder is attached with bevel gear shaft. The transverse feed of the bed is provided by the lead screw which relates to dc motor rotates with the speed of 60 rpm. The raising or lowering of bed is carried out by hydraulic jack.

VI. Results of Experiments

It is been recognized that when the welding is done on the plates of thickness of 5 mm or above the quality of weld is been noted to be good. The weld strength of 5 mm plate thickness is achieve more as compared to 3 mm plate thickness. The clamping force is more required for 3 mm plate thickness as it can be defected from the previous position when it comes in contact with the tool, rotates at very high speed. The aluminum alloy 1100 plate has the ultimate tensile strength is 88.48 MPA which is tested using Universal testing machine. The weld strength for different specimen is shown in table 2.

table 2: tensile testing of FSW specimen.

Specimen	*Material*	*Thickness (mm)*	*Strength (MPa)*
1	*Al 1100*	*3*	*39.09*
2	*Al 1100*	*3*	*38.95*
3	*Al 1100*	*5*	*51.65*
4	*Al 1100*	*5*	*53.02*

VII. Conclusions

In the era of the fusion welding process, the Friction Stir Welding process is much more suitable process among all welding types as the Friction Stir Welding is done without emitting the fumes as well as the process is carried out without fully melting the material. As the process is carried out below melting point, the properties of parent material and weld material remains same. Due to that by not melting the properties of the work piece is remained same as well as the required properties are remained unchanged. The impact of Friction stir process on environment is less as compared to arc welding and gas welding processes.

VIII Acknowledgement

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IX References

[1] Prof. Bharat Raj Singh (June 2012), A hand book on Friction Stir Welding, page no. 64-85

[2] N.T. Kumbhar, G.K.Dey, K.Bhanumurthy,“Friction stir wilding of Aluminum alloy” BARC newsletter, ISSUE NO. 321, JULY-AUGUST 2011 page no. 1-3

[3] R.S.Mishra, “ Friction Stir welding and processing” Elsevier publication, DOI: 10.1016, July 2005.

[4] Aissani Mouloud, Saliha Gachi, Boubenider Fouad “Design and optimization of Friction Stir Welding Tool”, Materials and Manufacturing Processes, ISSN No:- 1042-6914, July 2011.