

# The Effects of Friction Stir Welding on the Mechanical Properties and Microstructure of 5A06 Aluminium

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**ABSTRACT:** Welding makes use of a number of techniques or processes, including melting base One of the most recent welding techniques is friction stir welding (FSW). Friction stir welding is a joining process in which a non-consumable rotating tool plunges between work pieces which are rigidly fixed with clamps and moves along the joint to be welded. Workpieces composed of aluminium 5A06 with a size of 100 mm × 75 mm and a thickness of 6 mm were selected. Aluminium work pieces were joined by friction stir welding with the tool spindle speed being varied from 1000 rpm to 1800 rpm, and the tool feed rate being varied from 25 mm/min to 100 mm/min. The experiments were conducted using FSW Tool having dimensions of 16 mm shoulder diameter, 6 mm pin diameter and 5.9 mm pin length

**KEYWORDS:** Friction stir welding, Microstructure, UTM, Mechanical properties

## I. INTRODUCTION

Friction stir welding (FSW) is a solid-state welding technique invented at the Welding Institute (TWI) in 1991. The friction stir welding process operates without melting the work pieces. It operates slightly below the solidus temperatures of the metals being joined. Since its invention in 1991, continuous research has been done by industries and researchers to improve the technique.

Friction stir welding is a joining process in which a non-consumable rotating tool plunges into workpieces which are rigidly fixed with clamps and fixtures, and moves along the joint to be welded. The cylindrical rotating tool used in FSW has a profiled threaded unthreaded probe of a length less than the weld depth, protruding from the tool shoulder. The FSW process is started by plunging a rotating tool into the joint of the work piece metals until the shoulder contacts the upper surface of the metal work piece. As the tool moves along the joint, heat is generated by the friction action of the tool shoulder against the metal work piece.

FSW is a continuous process that involves plunging a portion of a specially shaped rotating tool between the butting faces of the joint. The relative motion between the tool and the substrate generates frictional heat that creates a plasticized region around the immersed portion of the tool. The shoulder prevents the plasticized material from being expelled from the weld. The tool is moved relatively along the joint line, forcing the plasticized material to coalesce behind the tool to form a solid phase joint.

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The benefits of this technology include: low distortion, greater weld strength compared to the fusion welding process, little or no porosity, no filler metals.

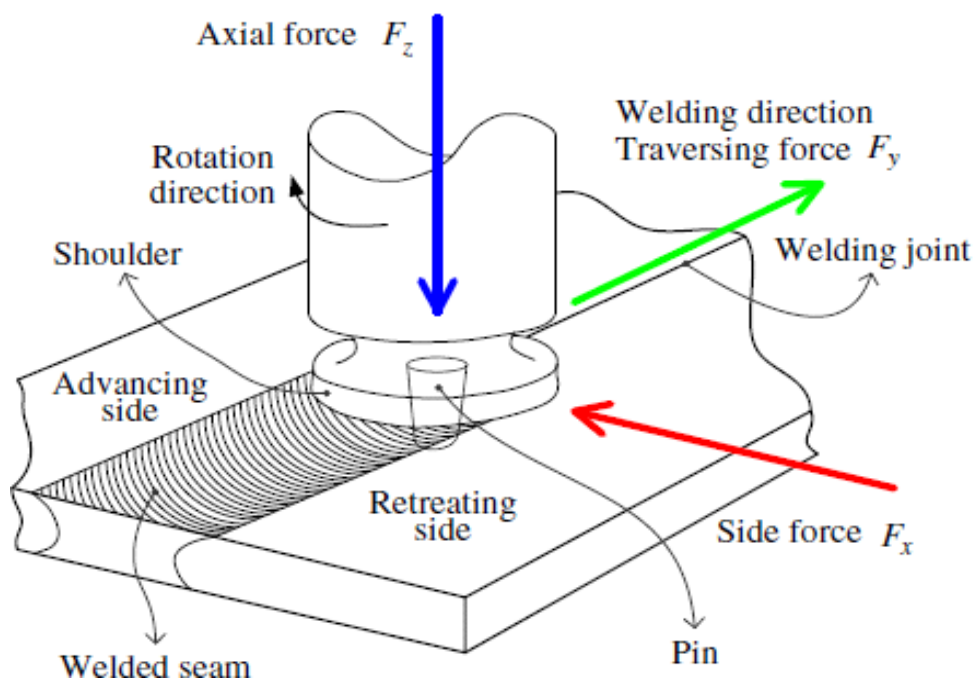


Fig Friction stir welding

### 1.1 Micro structural zones in FSW

The weld gotten in FSW handle is for the most part fine grained, hot worked with no captured oxides or gas porosity. The primary endeavor on classifying the microstructures of contact mix weld was made by String gill [10-11] for aluminum combinations. The total weld and its encompassing range as gotten by FSW can be classified in four unmistakable locales as:

- A. Unaffected or parent material
- B. Heat affected zone (HAZ)
- C. Thermo-mechanically affected zone (TMAZ)
- D. Weld nugget or Stir zone (WN or SZ)

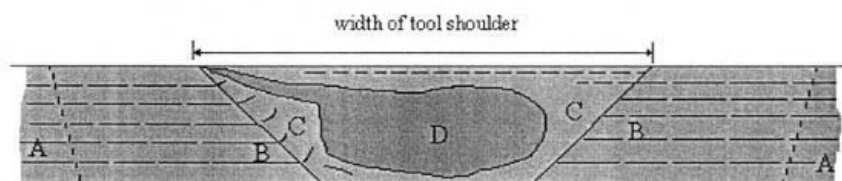


Fig 2 Schematic drawing showing micro structural zones  
In a friction stir weld

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## II. LITERATURE REVIEW

**Zhang et al. (2019)** :- studied the similar and dissimilar FSW joints of Aluminum alloys AA7075-T651 and AA2024T351 to measure the effect of rotational speeds (600, 950, 1300 and 1650 rpm) on the mechanical properties, microstructure inspection and materials flow rate and specifications of the welding joints. Its concluded that the rotational speed has considerable effect on the mixing amounts of dissimilar materials in AA7075-2024 joints. When using low rotational speed, the mixing of materials decreases, while the usual onion ring form can be attained at the high tool rotational speed. Increasing rotational speed decrease hardnessmeasurements in the nugget zone.

**Singh et al.(2018)** :- studied the microstructure and mechanical behaviour experimentally of FS-welded AZ61 magnesium alloy. The free defect joint produced at parameters conditions: rotational speed at 1400 rpm and welding speed at 25 mm/s. This samples shows tensile strength220 MPa, yield strength175 MPa, efficiency of weld about 82% and elongation about 7.2%. The development in hardness of the weld generate finer grains in the stir region. The micro-hardness values of base material are higher than thermo-mechanically affected region values but lower than stir region values.

## III. EXPERIMENTAL SETUP

### 3.1 Milling machining

The specimen size 100 mm (length) × 75 mm (width) × 6 mm (thick)In present study, die steel tool (pin length: 5.9 mm, pin diameter: 6 mm at bottom, shoulder diameter: 16 mm) was used to fabricate the FSW joints. . To carry out the FSW experiment vertical milling machine was used to produce friction stir butt. The development of the FSW machine will be made possible by converting conventional milling machine into an adequate, functional, workstation where experimental friction stir welded joints may be performed on various base materials. Milling is the machining process of using rotary cutters to remove material Workpiece. This experimental analysis of friction stir welding is critical to enabling the integration of the welding of aluminium material in a wide range of applications in the industrial sector, and to improve the usage of eco-friendly manufacturing processes. For the following experiments, two plates ofAA 5A06 aluminium with a thickness of 6mm were butt welded by FSW . Aluminium plates were ordered from India Mart. The samples were cut to 100 mm in length and 75 mm in width and 6 mm in thickness. The machine used in this process is vertical milling machine and is shown in figure given below

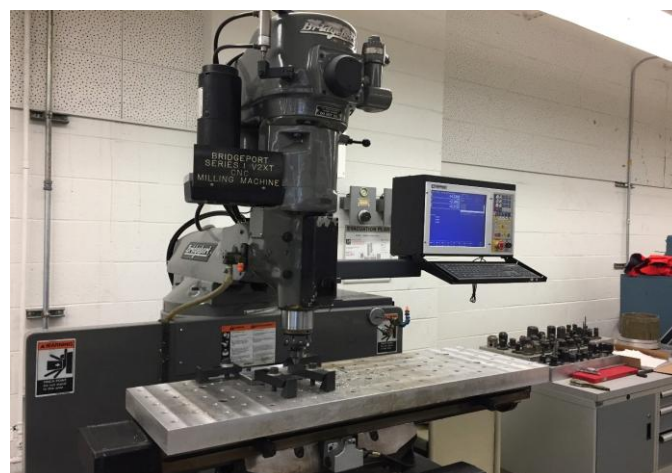


Fig3: Vertical Milling Machine

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The dimensions of the friction stir welding tool are shown in Table 5

. Table 5. Dimensions of friction stir welding tool

Material	High speed steel
Shoulder diameter	16 mm
Pin diameter	6 mm
Pin length	5.9 mm

## IV. RESULT AND DISCUSSION

### 4.1 Universal Testing Machine

UTM comprises two main units, one is the loading unit and other is the control panel.

**Loading unit:** The loading of the specimen is conducted in the loading unit. The equipment in the left is called as the loading unit. The loading unit consists of three crossheads, they are the upper head, middle head, and lower head. These crossheads are used depending on the type of load (tensile, compressive or shear) applied on the specimen. When undergoing the tensile test, the upper and lower crossheads are used.

**Control Panel:** This unit facilitates the load application on the specimen. The load application is performed by the action of hydraulic pressure. A pendulum dynamometer is fitted to measure and indicate the force coming on the specimen. A big size load indicating dial fitted with a glass cover is mounted at the side of the control panel. The range indicating dial is to be adjusted for the particular range selected.

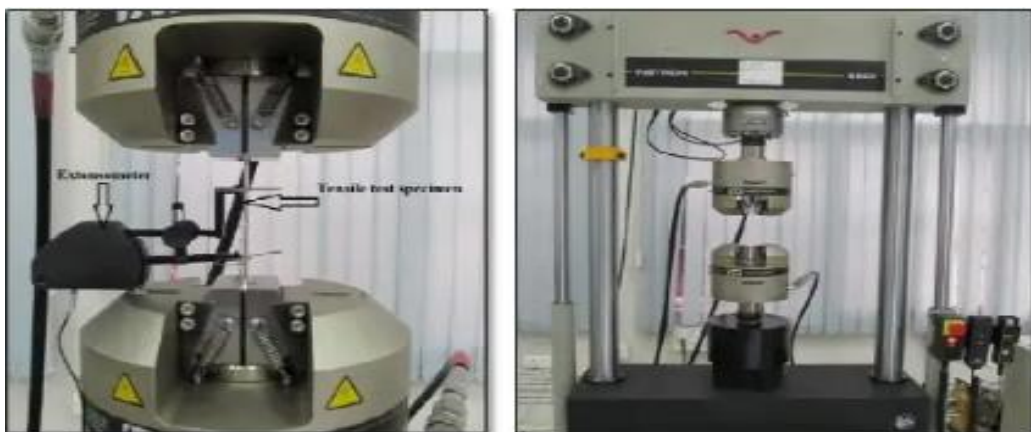


Fig4: UTM (universal testing machine)

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S NO	RPM	Feed rate mm/min	Breaking load	Ultimate tensile strength (MPa)	HV
S 1	1000	25	6940	69	43
S 2	1200	40	7040	71	44
S 3	1400	60	6220	63	44
S 4	1600	80	5600	57	43
S 5	1800	100	5200	51	41

Table showing tensile test and hardness test

## V. CONCLUSION

It is observed that the greatest tensile strength and micro hardness is achieved using spindle speeds of 1000 to 1200 rpm and feed rates of 25 to 40 mm/min, particularly at 1200 rpm and 40 mm/min.

Aluminium plates with a high tensile strength are produced.

Stable and consistent tensile strengths and micro hardness are achieved using spindle speeds of 1000 to 1200 rpm and feed rates of 25 to 40 mm/min,

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