

# Analysis of Contact Conditions and its Influence on Operations and Process Parameter and Tool Pin Design in Friction Stir Welding

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**Abstract:** This paper provides a review of research that was done during the previous two years. The friction stir welding technique is an environmentally friendly welding method that does not require the use of welding rods. The welding speed, for example, is one of the FSW machining parameters. The strength of a weld connection is influenced by rotational speed, traverse speed, and tool characteristics such as tool pin diameter, pin length, shoulder diameter, and tool tilt angle. Many studies were performed on a variety of materials and tools. The newest literature publications and welding flaws, as well as related processes such as friction stir process and friction stir spot welding, are reviewed in this study.

**Keywords:** Welding Speed, Rotational Speed, Traverse Speed, Friction Stir Process, Friction Stir Welding

## I. INTRODUCTION

TWI of the United Kingdom presents friction stir welding to the globe in 1991. In recent years, numerous researchers have worked on friction stir welding process parameters in the aerospace vehicle body, shipbuilding maritime sector, and railway wagons. The main advantages are that it is fume-free and requires less filler material. Less skilled workers produce less waste, and green technology helps to keep the environment clean. (2) The Friction Welding Process in Its Basic Form (FSW). plate's receding side (1) Obtaining good weld joints in the FSW process is dependent on process factors such as tool rotating speed, tool geometry, axial force, and pin tool traverse speed. A rotating tool passes along the joining line of welding plates, rotating tool against plate with axial load of tool, producing frictional heat between tool shoulder and welding plate surface, the probe (or) the pin of the tool used to stir the metal joint surface to be weld, half of the side of the plate, as tool rotates clockwise, is called advancing side of plate, and the other half part of plate called retreating side of plate (1) In the FSW process getting sound weld joints is depends upon the process variables such that tool rotational speed, tool geometry, axial force and traverse speed of pin tool.

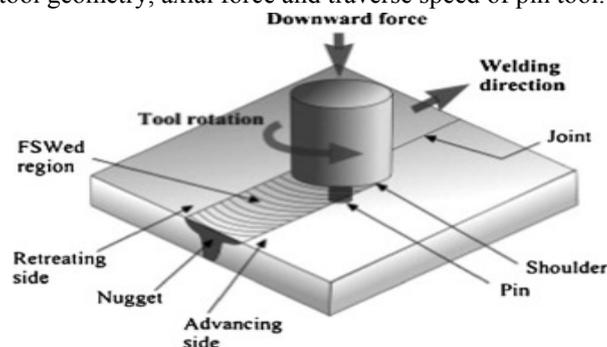
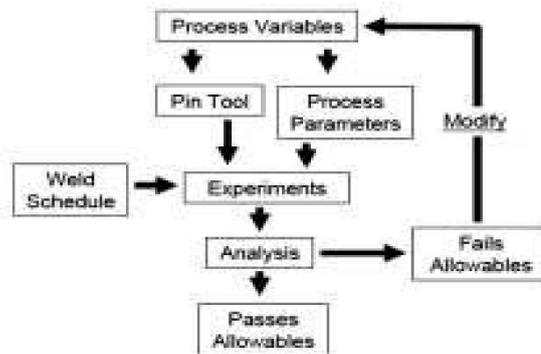


Figure 1: Principle of Friction Stir Welding

It is essential a proper methodology to complete the experiments to identify the exact values of variables, to arrives a perfect result in a correct duration and in economical manner Figure illustrates a flowchart showing the methodology [3] for carrying out experimental investigations in FSW process.

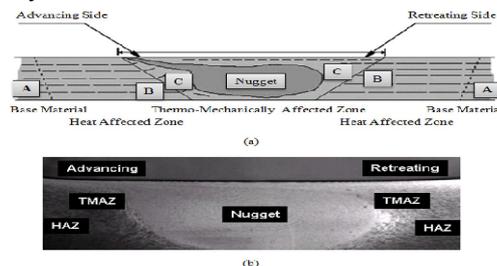
**II. FRICTION STIR WELDING PROCESS**

The TWI recommended an inverted trapezoid with four zones as a generic profile for butt joints. (A) There is no change in the micro structure in the unaffected base metal zone, which is distant from the nugget zone and where micro deformation occurs. (B)A thermo cycle is used to heat the weld metal and cause micro structural changes. The heat in this area does not cause plastic deformation. (C) The TMAZ is an essential transformation zone in FSW During the welding process, this region is affected by both temperature and deformation, which is insufficient to form re crystallisation in the joining metal. (D) The dynamically re-crystallized Zone (DXZ) or nugget Zone is the area where actual stirring takes place, causing micro structural changes and heavy strain. The greater temperature and extreme plastic deformation experienced during welding in the agitated zone leads in the creation of a new very fine grain structure. PL Thread gill was the first to attempt to categorise the weld's microstructure. (4).



**Figure 2:** Flowchart showing the experimentation methodology for FSW

The common type of nugget Zone are basin shaped nugget (a) which is larger in upper surface and elliptical nugget (b) The shape of the nugget will be obtained by various factors such as process parameters, tool size, heat observed by the work piece and thermal conductivity.



**Figure 4:** Microstructure of the weld

The nugget zone of a typical nugget is somewhat bigger than the probe diameter. In low rotational speed and higher rotational speed, R.S. Mishra et al discovered basin-based nugget zone and elliptical shaped nugget zone, respectively (5) FSW requires the following tools. The tool plays a crucial role in the friction welding process. The shoulder and pin are the two components of the tool.

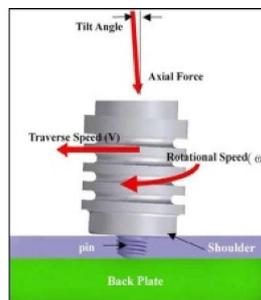


**Figure 5:** Nugget Zones

The tool is produced heat by friction. Shoulder part of tool heat the work piece by friction between weld plate and shoulder diameter by axial force solidification ((or) weld joint is formed) The tool shoulder bottom surfaces are flat, concave, and convex with spiral knurled, scrolls, grooves& concentric circles features are used to better mixing and sound weld mint (6) probe (or) pin is a part of t tool which shears weld plate by axial force, The tool probe is flat (or) curved , flat pin transfer increased forge force and curved (or) domed transfer reduced forge force . Different types of pin shapes are cylindrical outer surface, fluted cylinder and taper with or without thread (6)

**III. FRICTION STIR WELDING TOOL**

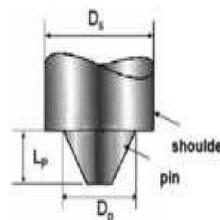
Along with tool rotation, tool travel speed, tool tilt angle, and penetration, another significant element is tool rotation. The tool is tilted to an appropriate angle to traverse direction to penetrate and stir material more effectively, and the shoulder also makes good contact with the metal surface, transferring extra force to the welding joint surface Fig. 8 Tool Tilt Angle [7].



Tool design is the important factor in the FSW. The tool shoulder is increasing the frictional heat produce between weld plate and tool so that the enough plastic state of weld metal and to transfer sufficient axial load to compress the metal joint. The (pin) play a major role in the process, it pierces and collapse the solid metal at the trailing edge and press the moulding state metal. Tool pin profile play a major role in deciding the joint strength of the material Al 6061 [1].



**Figure 9:** Triflute series design FSW tool



**Figure 10:** Pin Tool Geometry

**Table 1:** Pin Tool Geometry

(Dp = Diameter of Upper Pin, Ds = Diameter of the tool, Length of pin=Pin height )

Weld Tool Geometry	AL (Aluminum)	TI (Titanium)	Tool Steel
D <sub>s</sub> /D <sub>p</sub>	2.4	1.2 – 3.8	2.3 – 2.4
D <sub>p</sub> /L <sub>p</sub>	1.5	1.4 – 1.9	1.7 – 2.0
Pin Surface	Threads	Smooth	Smooth
Taper (Degrees)	0	30 – 60	30 – 60

Wear on a pin tool happens when two solid surfaces glide over one other, whether lubricated or not. Mild wear at low loads and a transition to severe wear at greater loads appear to exist, according to the findings. The Archard wear equation [3] may be used to represent the data in each regime.

$$Q = KW / H$$

This equation is helpful for finding wear resistance of tool during Friction stir welding process





2	M. Jafarzadegan et al	304stainless steel and ST37	Travel speed and grain structure	Refined grain structure identified at stir zone and this increased the hardness and tensile strength in the stir zone.
3	Abdul Arief et al	AA5086 and AA6061	Longitudinal residualstresses, values of temperature distribution	Found that longitudinal residual stresses are about 30- 45 % traverse residual stresses in weld contribution

**VI. CONCLUSION**

A typical technique for carrying out experimental work on the friction stir welding process is demonstrated. Microstructures, different zones, different sorts of tools, and weld joint designs are all explored. The general faults in FSW are outlined, along with their causes; a cause-and-effect graphic is given to show the strength of the weld joint. For initiators, FSW provides a tool wear equation and a taper tool geometry table.

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