A REVIEW ON FRICTION STIR WELDING OF ALUMINIUM ALLOYS

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Abstract:

Friction stir welding is a solid -state welding process in which metals are heated up to a suitable temperature with high pressure without melting the parent parts to be Joint. So that a homogeneous mixture of welding can be achieved. , FSW welding has superior properties compared to arc welding. In this welding uses a cylindrical rotating tool,tapered ,square ,sections (non-consumable) with a profiled pin that penetrates into the parts to be joined. FSW mostly used for soft materials and alloys ex-AL alloys, Due to high tool wear out the cost. FSW tool design, which plays an important role included the geometry of tools, material selection, that affect heat generation, joint strength, plastic flow, thus resulting in microstructure and mechanical properties for various applications for the industry applications .

Keywords: Friction stir welding process, variable speeds , Al alloy, Effect of tool geometry.

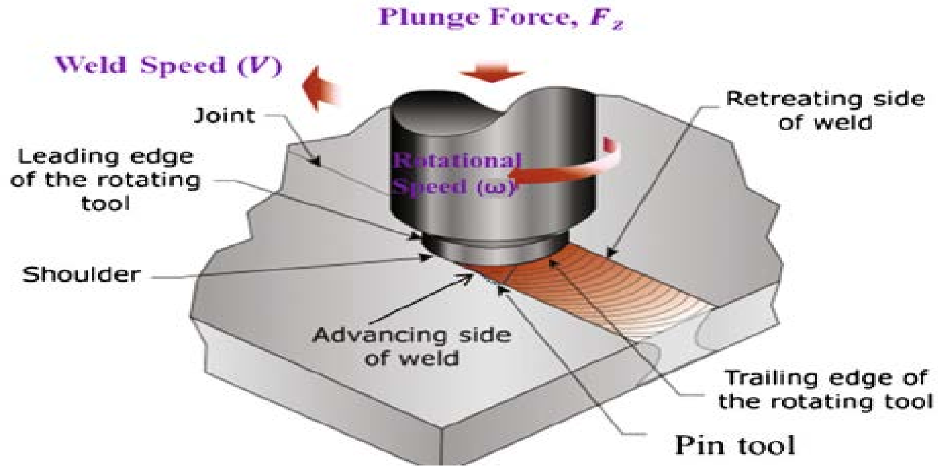
Introduction

Friction-stir welding (FSW) is a solid-state joining process in which arotating tool rotates at a certain speed with a shoulder and , moves along the surfaces of two rigidly clamped plates that placed on a surface plate.

Other types of metal join process as lap joint can be produced. In all cases, FSW process causes a large reduction of hardness within the stir zone below the tool. A slow tool rotation speed has lesser reduction and a narrower weld. After that, the final grain- size in the stir weld zone is always coarser than that in the starting microstructure.

Basic concept:

A rotating cylindrical tool with a profiled probe is fed into a butt joint between two clamped work pieces, until the shoulder, which has a larger diameter than the pin, touches the surface of the work pieces The probe is slightly shorter than the weld depth required, with the tool shoulder riding atop the work surface. After a short dwell time, the tool is moved forward along the joint line at the pre-set welding speed.



Basic principle of FSW

FSW Parameters

Independent process variables play significant effect on the welding process and the process control. The process variables entail the axial force for plunging, rotating tool rotational speed, , welding speed and tool geometry. The aforementioned variables strongly affect the heat generation rate, temperature profile within the work material, mechanical power required by the process, material evolution of the weldment and also loads distributed within the work material

Important Welding Parameters& Tool Design:

Advanced friction stir welding and processing tools by MegaStir shown upside down.The design of the tool is a critical factor, as a good tool can improve both the quality of the weld and the maximal possible welding speed.

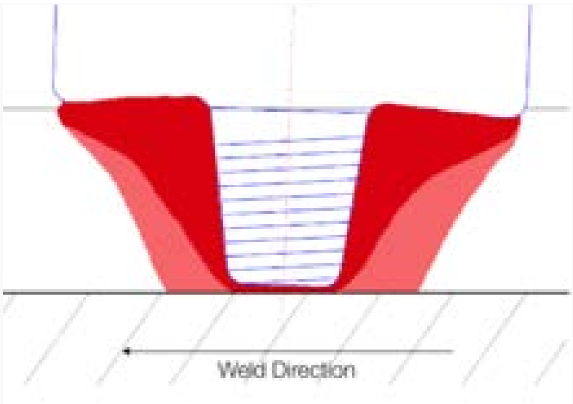
It is desirable that the tool material be sufficiently strong, tough, and hard wearing at the welding temperature. Further, it should have a good oxidation resistance and a low thermal conductivity to minimise heat loss and thermal damage to the machinery further up the drive train. Hot-worked tool steel such as AISI H13 has proven perfectly acceptable for welding aluminium alloys within thickness ranges of 0.5–50 mm but more advanced tool materials are necessary for more demanding applications such as highly abrasive metal matrix composites or higher-melting-point materials such as steel or titanium

Tool Rotation and Traverse Speeds:

There are two tool speeds to be considered in friction-stir welding; how fast the tool rotates and how quickly it traverses along the interface. These two parameters have considerable importance and must be chosen with care to ensure a successful and efficient welding cycle. The relationship between the rotation speed, the welding speed and the heat input during welding is complex, but in general, it can be said that increasing the rotation speed or decreasing the traverse speed will result in a hotter weld.

In order to produce a successful weld, it is necessary that the material surrounding the tool is hot enough to enable the extensive plastic flow required and minimize the forces acting on the tool. If the material is too cold, then voids or other flaws may be present in the stir zone and in extreme cases the tool may break.

Tool tilt and plunge depth:



A drawing showing the plunge depth and tilt of the tool. The tool is moving to the left.The plunge depth is defined as the depth of the lowest point of the shoulder below the surface of the welded plate and has been found to be a critical parameter for ensuring weld quality. Plunging the shoulder below the plate surface increases the pressure below the tool and helps ensure adequate forging of the material at the rear of the tool. Tilting the tool by 2–4 degrees, such that the rear of the tool is lower than the front, has been found to assist this forging process. The plunge depth needs to be corrected, both to ensure the necessary downward pressure is achieved and to ensure that the tool fully penetrates the weld. Given the high loads required,

Welding forces:

During welding, a number of forces will act on the tool

A downwards force is necessary to maintain the position of the tool at or below the material surface. Some friction-stir welding machines operate under load control, but in many cases the vertical position of the tool is preset, and so the load will vary during welding.

The traverse force acts parallel to the tool motion and is positive in the traverse direction. Since this force arises as a result of the resistance of the material to the motion of the tool, it might be expected that this force will decrease as the temperature of the material around the tool is increased.

The lateral force may act perpendicular to the tool traverse direction and is defined here as positive towards the advancing side of the weld.Torque is required to rotate the tool, the amount of which will depend on the down force and friction coefficient (sliding friction) and/or the flow strength of the material in the surrounding region.

Flow of material:

Early work on the mode of material flow around the tool used inserts of a different alloy, which had a different contrast to the normal material when viewed through a microscope, in an effort to determine where material was moved as the tool passed.

The data was interpreted as representing a form of in-situ extrusion, where the tool, backing plate and cold base material form the "extrusion chamber", through which the hot, plasticised material is forced. In this model the rotation of the tool draws little or no material around the front of the probe; instead, the material parts in front of the pin and passes down either side.

Generation and flow of heat:

For any welding process, it is, in general, desirable to increase the travel speed and minimise the heat input, as this will increase productivity and possibly reduce the impact of welding on the mechanical properties of the weld. At the same time, it is necessary to ensure that the temperature around the tool is sufficiently high to permit adequate material flow and prevent flaws or tool damage.

The welding cycle can be split into several stages, during which the heat flow and thermal profile will be different:

Dwell. The material is preheated by a stationary, rotating tool to achieve a sufficient temperature ahead of the tool to allow the traverse. This period may also include the plunge of the tool into the workpiece.

Transient heating. When the tool begins to move, there will be a transient period where the heat production and temperature around the tool will alter in a complex manner until an essentially steady state is reached.

Pseudo steady state. Although fluctuations in heat generation will occur, the thermal field around the tool remains effectively constant, at least on the macroscopic scale.

Post steady state. Near the end of the weld, heat may "reflect" from the end of the plate, leading to additional heating around the tool.

Micro-structural features:

The solid-state nature of the FSW process, combined with its unusual tool shape and asymmetric speed profile, results in a highly characteristic microstructure. The micro-structure can be broken up into the following zones:

The **stir zone** (also known as the dynamically recrystallised zone) is a region of heavily deformed material that roughly corresponds to the location of the pin during welding. The grain within the stir zone are roughly equiaxed and often an order of magnitude smaller than the grains in the parent material

The **flow arm zone** is on the upper surface of the weld and consists of material that is dragged by the shoulder from the retreating side of the weld, around the rear of the tool, and deposited on the advancing side.]

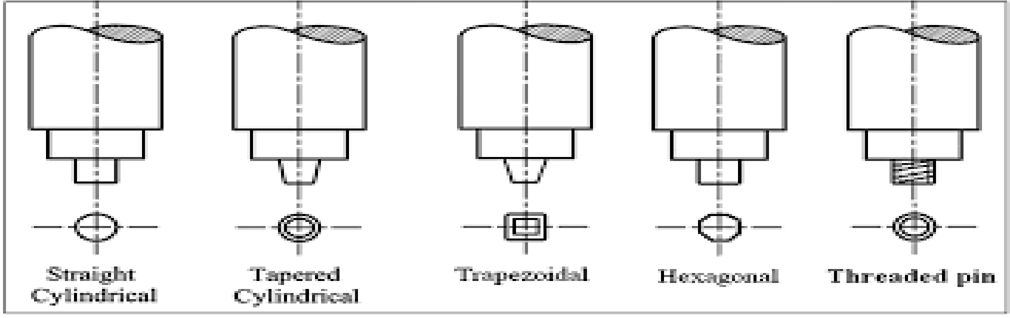
The **thermo-mechanically affected zone (TMAZ**) occurs on either side of the stir zone. In this region the strain and temperature are lower and the effect of welding on the micro-structure is correspondingly smaller. Unlike the stir zone, the micro-structure is recognizably that of the parent material, albeit significantly deformed and rotated

The (HAZ) is common to all welding processes. As indicated by the name, this region is subject cited to a thermal cycle but is not deformed during welding. The temperatures are lower than those in the TMAZ but may still have a significant effect if the micro-structure is thermally unstable

Advantages and limitations:

The solid-state nature of FSW leads to several advantages over fusion welding methods, as problems associated with cooling from the liquid phase are avoided. Issues such as porosity ,solute redistribution, solidification cracking and liquation cracking do not arise during FSW. In general, FSW has been found to produce a low concentration of defects and is very tolerant to variations in parameters and materials

Proposed Types of Tools Design for Future Experiments



Conclusion

1) FSW is the most useful joining method used for soft aluminium alloys . Tool speed, welding speed, tool shoulder diameter and probe diameter are parameters that affecting FSW process forces andheat input.
2) FSW is difficult by rapid and severe wear of the tool which is due to the contact in between the tool and hard particles..Heat input in FSW is affected by tool speed, tool diameter, and welding speed.
3) Friction stir welding process improves the surface of the specimen.

Future scope

This process FSW has its capability and been approved as a one of the best method for joining aluminium and other metals. If proper care is taken weld properties become equal tothose of base material.

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