FRICTION STIR WELDING ON ALUMINIUM PLATE

[1]Prof. Bhawthankar Amol, [2]Mr. Dhadake Shridhar P, [3]Mr. Anagale Santosh A, [4]Mr. Dhanashetti Sharanbasaveshwar H, [5]Ghodake Vitthal N

Lect in Mechanical Engineering Department, SVSMD's KKI Polytechnic, Akkalkot, Solapur, Maharashtra, India[1], Student, Department of Mechanical Engineering SVSMD's KKI Polytechnic, Akkalkot, Solapur, Maharashtra, India[2,3,4,5]

ABSTRACT: -

Friction Stir Welding (FSW) is a solid state joining process that involves joining of metals without fusion or filler materials. The frictional heat is produced from a rapidly rotating non-consumable high strength tool pin. Which is rotated and plunged into the interface of two work pieces The tool is then moved through the interface and the frictional heat causes the material to heat and soften. The process is particularly applicable for Aluminum Plate welded by this method. The process is also suitable for automation. The weld produced is of finer microstructure and superior in characteristics to that parent metal.

Keywords: Friction-stir welding Tool Material Tool Design Defects

INTRODUCTION: -

Friction Stir Welding (FSW), as a solid-state welding process, can achieve the joining of metals below the melting point or in the plastic stage of the metals with the aid of a non-consumable tool [1]. Compared with the welds made by fusion welding processes, the friction stir welds have a more homogeneous grain structure and better mechanical properties like tensile strength, hardness, and toughness [2]. Friction stir welded specimen's exhibit better corrosion resistance properties due to the homogeneous microstructure and narrow heat-affected zone. The feature of joining metals in the semisolids state helps this FSW method to join metals with different melting points like aluminum and copper. Nowadays, FSW has become one of the prevailing joining processes of aluminum alloys in the industry [3–5]. While considering hard metals like steel, FSW still does not accomplish the same feasibility in aluminum alloys.

TOOL MATERIAL

There are several tool materials that have been used in the FSW process .For welding Two Aluminum Plate Tool steel is one of the most commonly tool materials for aluminum copper and magnesium alloys and can weld up to 50 mm in these materials. These materials are easily available and have good machinability and thermal fatigue resistance. Tool steels can be used to weld both similar and dissimilar welds as lapped joints or as butt joints.

TOOL DESIGN

The non-consumable tool has a circular section except at the end where there is a threaded probe or more complicated flute; the junction between the cylindrical portion and the probe is known as the shoulder. The probe penetrates the work piece whereas the shoulder rubs with the top surface. The tool has an end tap of 5 in 6 mm diameter and a height of 5 to 6 mm (may vary with the metal thickness). The tool is set in a positive angle of some degree in the welding direction. The design of the pin and shoulder assembly plays a major role on how the material moves during the process.


Different types of tools used

TRAVERSE FEED:-

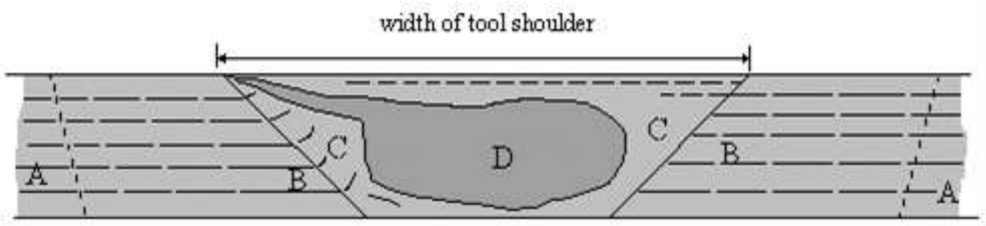
In order to produce a successful weld it is necessary that the material surrounding the tool is hot enough to enable the extensive plastic flow required and minimize the forces acting on the tool. So the traverse speed will be having range of 5 mm/min to 10mm/min .Defect free weld depends not only on the rotational speed, but also on the combined effect of welding speed and rotational speed. Higher hardness profile is observed with higher welding and rotational speeds; defect-free joints are also observed in this combination.

Tapered pin tools were applied to fabricate FSW joints on Al plate, using different rotation and travel speeds. Various microstructures were observed in the stir zone which can be attributed to using different travel and rotation speeds. Mechanical evaluation including lap shear fracture load test and micro hardness measurements indicated that by simultaneously increasing the tool rotation and travel speeds, the joint tensile strength and ductility reached a maximum value

DESIGN OF EXPIRMENT:-

We Conducted test on vertical CNC milling machine with toll probe connected to milling machine spindle & Al plate clamp of Machine table with Fixture design. The input parameters of the model consist of weld speed and tool rotation speed (TRS). The outputs of the model include property Parameters namely: tensile strength, yield strength, elongation, hardness of weld metal and hardness of heat effected zone (HAZ). Little bit good performance of the model was achieved.

HEAT AFFECTED ZONE :-



A. Unaffected material B. Heat affected zone (HAZ) C. Thermo-mechanically affected zone (TMAZ) D. Weld nugget (Part of thermo-mechanically affected zone)

A.Unaffected material or parent metal: This is material remote from the weld, which has not been deformed, and which although it may have experienced a thermal cycle from the weld is not affected by the heat in terms of microstructure or mechanical properties.

B.Heat affected zone (HAZ): In this region, which clearly will lie closer to the weld centre, the material has experienced a thermal cycle, which has modified the microstructure and/or the mechanical properties. However, there is no plastic deformation occurring in this area. In the previous system, this was referred to as the "thermally affected zone". The term heat affected zone is now preferred, as this is a direct parallel with the heat affected zone in other thermal processes, and there is little justification for a separate name.

C.Thermo-mechanically affected zone (TMAZ): In this region, the material has been plastically deformed by the friction stir welding tool, and the heat from the process will also have exerted some influence on the material. In the case of aluminium, it is possible to get significant plastic strain without recrystallisation in this region, and there is generally a distinct boundary between the recrystallised zone and the deformed zones of the TMAZ. In the earlier classification, these two sub-zones were treated as distinct microstructural regions. However, subsequent work on other materials has shown that aluminium behaves in a different manner to most other materials, in that it can be extensively deformed at high temperature without recrystallisation. In other materials, the distinct recrystallised region (the nugget) is absent, and the whole of the TMAZ appears to be recrystallised.

D.Weld Nugget: The recrystallised area in the TMAZ in aluminium alloys has traditionally been called the nugget. Although this term is descriptive, it is not very scientific. However, its use has become widespread, and as there is no word which is equally simple with greater scientific merit, this term has been adopted. A schematic diagram is shown in the above Figure which clearly identifies the various regions. It has been suggested that the area immediately below the tool shoulder (which is clearly part of the TMAZ) should be given a separate category, as the grain structure is often different here. The microstructure here is determined by rubbing by the rear face of the shoulder, and the material may have cooled below its maximum. It is suggested that this area is treated as a separate sub-zone of the TMAZ.

6.DEFECTS :-

FSW defects include excessive flash, excessive concavity, tool particulate inclusions, foreign substances, voids, wormholes, lack of penetration (LOP) root defects etc.

ADVANTAGES OF FSW

- The process is environment friendly since no fumes or spatter is generated and no shielding gas is required.
- A non-consumable tool is used
- Since the weld is obtained in solid phase, gravity does not play any part and hence the process can be done in all positions(vertical, horizontal, overhead or orbital)
- No grinding, brushing or pickling is required.
- Since the temperature involved in the process is quite low, shrinkage during solidification is less
- One tool can be typically used for up to 1000 metres of weld length (6000 series aluminium alloy)
- No fusion or filler materials is required
- No oxide removal necessary as in fusion welding.

LIMITATION

- Welding speeds are moderately slower
- Work pieces must be rigidly clamped
- Backing bar required

- Keyhole at the end of each weld
- Requirement of different length pin tools when
- welding materials of varying thickness

- he weld obtained is of superior quality with excellent mechanical properties and fine micro structure.
- The process is cost effective since mechanical forming after welding can be avoided
- Dissimilar metals can be welded.
- Automation is possible

APLICATION OF FSW

Shipbuilding and marine industries

1) The shipbuilding and marine industries are two of the first industry sectors which have adopted the process for commercial applications. The process is suitable for the following applications:

- Panels for decks, sides, bulkheads and floors
- Aluminum extrusions
- Hulls and superstructures
- Helicopter landing platforms
- Offshore accommodation
- Marine and transport structures
- Masts and booms, e.g. for sailing boats
- Refrigeration plant

Aerospace industry

At present the aerospace industry is welding prototype parts by friction stir welding. Opportunities exist to weld skins to spars, ribs, and stringers for use in military and civilian aircraft. This offers significant advantages compared to riveting and machining from solid, such as reduced manufacturing costs and weight savings. Longitudinal butt welds and circumferential lap welds of Al alloy fuel tanks for space vehicles have been friction stir welded and successfully tested. The process could also be used to increase the size of commercially available sheets by welding them before forming. The friction stir welding process can therefore be considered for:

- Wings, fuselages, empennages
- Cryogenic fuel tanks for space vehicles
- Aviation fuel tanks
- External throw away tanks for military aircraft
- Military and scientific rockets
- Repair of faulty MIG welds

Railway industry

The commercial production of high speed trains made from aluminium extrusions which may be joined by friction stir welding has been published. Applications include:

- High speed trains
- Rolling stock of railways, underground carriages, trams

- Railway tankers and goods wagons
- Container bodies

Electrical industry

The electrical industry shows increasing interest in the application of friction stir welding for:

- Electric motor housings
- Busbars
- Electrical connectors
- Encapsulation of electronics

REFERANCES: -

[1] S Sato, H Kokawa, H T Fujii, et al. Mechanical properties and microstructure of dissimilar friction stir welds of 11Cr-Ferritic/Martensitic steel to 316 stainless steel. *Metallurgical and Materials Transactions A: Physical Metallurgy and Materials Science*, 2015, 46(12): 5789–5800.

[2] M Hajian, A Abdollah-zadeh, S S Rezaei-Nejad, et al. Microstructure and mechanical properties of friction stir processed AISI 316L stainless steel. Materials and Design, 2015, 67: 82–94.

[3] V Msomi, S Mabuwa. Analysis of material positioning towards microstructure of the friction stir processed AA1050/AA6082 dissimilar joint. Advances in Industrial and Manufacturing Engineering, 2020, 1: 100002.

[4] X Xu, X Ren, H Hou, et al. Effects of cryogenic and annealing treatment on microstructure and properties of friction stir welded TA15 joints. Materials Science and Engineering A, 2021, 804: 140750.

[5] Y Hu, H Liu, D Li. Contribution of ultrasonic to microstructure and mechanical properties of tilt probe penetrating friction stir welded joint. Journal of Materials Science and Technology, 2021, 85: 205–217.

[6] V Karami, B M Dariani, R Hashemi. Investigation of forming limit curves and mechanical properties of 316 stainless steel/St37 steel tailor-welded blanks produced by tungsten inert gas and friction stir welding method. CIRP Journal of Manufacturing Science and Technology, 2021, 32: 437–446.

[7] R Padmanaban, V Balusamy, V R aira Vignesh. Effect of friction stir welding process parameters on the tensile strength of dissimilar aluminum alloy AA2024-T3 and AA7075-T6 joints. Materialwissenschaft Und Werkstofftechnik, 2020, 51(1): 17–27.

[8] D G Mohan, S Gopi. Influence of In-situ induction heated friction stir welding on tensile, microhardness, corrosion resistance and microstructural properties of martensitic steel. Engineering Research Express, 2021, 3(2): 025023.

[9] O Abedini, E Ranjbarnodeh, P Marashi. Effect of tool geometry and welding parameters on the microstructure and static strength of the friction-stir spot-welded DP780 dual-phase steel sheets. Materiali in Tehnologije, 2017, 51(4): 687–694.