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FRICTION STIR WELDING & EFFECT OF ITS PROCESS PARAMETERS ON MECHANICAL PROPERTIES OF WELDED MATERIAL : A REVIEW

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Abstract: **In present world the requirement of material arises which have high strength to weight ratio. The material like Al , Mg have such properties but the joining of this material is nearly impossible with traditional fusion welding processes. TWI in 1991 patented a technique called friction Stir Welding (FSW), which can weld materials by melting the material by 70-80% of its melting temperature. By using this technique material which are hard welded can be welded. Butt, Lap T, Cylindrical, Hollow joints can be welded.**

In this review a study is done on mechanical properties affected by process parameters of friction stir welding & to which extend. The material welded by FSW gives better mechanical properties than material welded by tradition fusion welding processes. Application & Future Scope are discussed in this study.

Keywords: FSW, Process Parameters, Mechanical Properties

INTRODUCTION

FSW originated & patented at TWI (The Welding institute) UK in 1991, is a process of joining soft & light, similar & dissimilar materials which was nearly impossible to weld with other traditional fusion welding process because they have low melting temp. FSW is said to be a solid state welding because which are to be joined is melted around 70-80% of the melting temperature of the base material. The ferrous & non-ferrous material can be welded as lap or butt joints. The material welded by FSW gives better mechanical & microstructural properties then tradition fusion welding process.

Process:

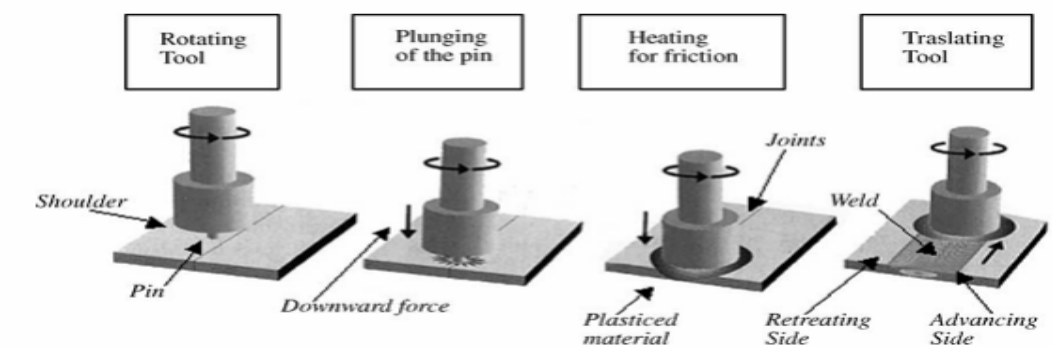

Figure :- Friction stir welding process

FSW is called as solid state welding because during process no melting of joining material takes place. A Non-consumable tool fixed in FSW machine (generally CNC Milling) is rotating at some desired rpm. The materials which are to be joined are placed in fixture of machine to avoid the movement of material due to forces on work piece during welding. The non-consumable, rotating

tool is fed towards the work piece & the tip of tool is plunged into the material on centerline & kept in same position for some time for proper heat generation. Afterwards, the tool is made to move along the centerline, & forces the material from front behind due to which joining of the material takes place.

Process Parameters: The variable parameters which can affect the mechanical properties of the joint are:-

1) Tool shapes
2) Rotation & welding speed
3) Downward force
4) Position of two materials to be welded
5) Tool offset from centerline
6) Tilt angle
7) Tool shoulder diameter

Advantage of FSW

- For joining nonferrous materials, no filler material or shielding gases are required in this process.
- This method also requires minimum surface preparation (normally only degreasing is needed), and uses only 20 percent heat input compared to traditional gas metal arc welding (GMAW or MIG) processes.
- In both high and low melting temperature alloys, no fumes or toxic gases are produced.
- The resulting surface is ready to use, as no spatter has been produced. The root side is a perfect copy of the backing, and the top side has a smooth, scalloped appearance caused by the shoulder of the tool.
- Another advantage to FSW is that dissimilar materials and alloys can be joined together.

Disadvantage of FSW

- Exit hole is produced when the process is completed.
- Large down forces are required causes high clamping action to hold the plates.
- Less Flexible than manual and arc process.
- Often slower Transverse rate than fusion welding process.
- For clamping purpose, suitable jigs and fixtures are widely used.

Applications

1) Railway industry
2) Marine industries and Shipbuilding
3) Aerospace industry
4) Automotive Companies
5) Robotics
6) Construction
7) Fabrication Industry

LITERATURE SURVEY

Won-Bae lee et al.(2003) investigated the mechanical properties of FS welded 4mm plates of copper by non-consumable tool. Tool rotation speed, welding speed & tool tilt angle were taken as process parameter with values 1250mm, 61mm/min. & 3° respectively. Defect free joint was prepared & tensile strength of 87% of base material was recorded.

Esther T. Akhinlabi et al. (2006) investigated the microstructure & micro hardness effected by the FSW on 3.175 mm thick plates of copper 11000 & Aluminium 5754. Three parameter were used by them are shoulder diameter, traverse speed & tool rotation speed. The values taken were 15mm, 18mm & 20mm, 50mm/min, 150mm/min & 300mm/min & 600rpm, 950rpm & 1200rpm respectively. With varying shoulder diameter of the tool, the tool pin diameter kept constant at 5mm. the paper concluded that the welding of copper & aluminium was successful with good mixing of material showed by microstructural test done on optical microscope & micro hardness test conducted on FM-ARS 9000automatic indenter with a load of 200gf & 10sec. dwell time shows acceptable results of the joint.

Peng liu et al. (2008) presented a test result after conducting an experimental investigation on microstructure & tensile properties of 3mm friction stir welded copper (T2) and Al (5A06). The Rotation Speed & welding speed ranges from 950-1180 rpm & 150-235mm/min. respectively were taken as varying parameters. The tensile test of joint which was conducted on CSS-1100 tensile test machine, show that maximum tensile strength of 296 MPa which is around 100% of copper & 94% of Al can be obtained when tool rotation speed & traverse speed was taken 950 rpm & 150 mm/min respectively.

Z. Barlas et al.(2008) studied the tensile & hardness properties of Friction Stir Welded pure copper to brass with tool rotation speed, welding speed & tool tilt angle were taken as process parameter as 800rpm, 22mm/min. & 3° respectively. Form this trail it was found that tensile strength of joint was nearly equal to copper & about 46% lower then brass, also yield strength of joint was 17% higher & 54% lower than copper & brass respectively.

Dinaharan et al. (2012) determined the effect of tool rotation speed & position of material om mechanical properties of 6mm cast & wrought Aluminum alloy 6061 joint made by FSW by pursuing an experiment. Eight sample were prepared with 800, 1000, 1200 & 1400rpm rotation Speed & placing wrought & cast AA6061 on advancing & retreating side respectively with every tool rotation speed. Experiment concluded the major portion of weld was occupied by the material on advancing side, Hardness joint is higher than cast alloy & tensile strength is maximum at 1200 rpm & cast Aluminum placed on advancing side.

R.S. Coelho et al. (2012) performed an experiment to compare the mechanical properties of two different grades of steel (HC260LA & DP600) friction stir welded with Aluminum alloy (618-T4) Traverse speed, rotation speed & downward force with values 8mm/s, 1600rpm & 5KN respectively, were taken as parameters. The experiment concluded that , tensile strength of the joint is almost equal to 80% of the base metal (AA6181-T4) & acceptable micro hardness was achieved.

Manoj Kumar et al. (2013) done an experiment to determine the effect of process parameters on the mechanical properties of 6.5mm friction stir welded Aluminum 2014 & 6061 plates. Input parameters taken were welding speed & rotation speed with values 45 & 60mm/min & 1050 & 1950 rpm respectively. This experiment concluded that, tool rotation speed have much effect on mechanical properties of material then welding speed. Also with increase in welding speed, tensile strength increases.

Alireza. Masoudian et al. (2013) investigated the effect of process parameters on mechanical properties of joint of 3mm plates of AZ31-OMg & 6061-T6 Al made by FSW. Tool rotation speed & traverse speed were taken as varying parameters ranging from 600-1400rpm & 20-60mm/min. respectively. Experiment concluded that sound weld is achieved at 1000rpm rotation speed & 40mm/min traverse speed.

Moneer H. Tolephih et al. (2013), investigated the microstructure, micro hardness & tensile properties of 5mm AA2024 & commercial pure copper joint made by FSW. HSS with 6mm pin dia. 20mm shoulder dia. & 4.8mm tool tip is used as tool for FSW. Rotation speed & feed were kept constant at 900 rpm & 25mm/min respectively. The experiment concluded that

(1) Tensile Strength (which was checked on Zwick/Rockwell Z100 testing m/c with a load of 100KN) with 1mm tool offset is much higher than 0.5 & 1.5mm
(2) Micro hardness (which was conducted on Vickers indenter with 500g & load for 10sec) is higher at 1mm tool offset & 2° tilt angle than other combinations
(3) Also the elongation of weld is lower than the base metals.

Mr. Satyaveer Singh et al. (2015) investigated the effect of tool pin offset on the tensile & hardness properties of friction Stir Welded 3mm AA8011 & pure copper plates. Tungsten Carbide having 20mm shoulder dia., 6mm pin dia. & 2.65mm length was used at welding tool. The traverse, rotation speed & tilt angle taken as 100mm/min., 750rpm & 2° & tool pin offset was set at 0.5, 1 & 1.5mm to aluminum & copper side respectively. The paper conclude that pin offset to aluminum side gives better results of tensile strength as compared to offset to Cu side, Max. tensile strength was achieved at tool offset at 1mm towards Al side (145Mpa), % elongation is max. at tool offset of 0.5mm towards Aluminum (6.63%). It was also determined that sound weld can be achieved when hard material i.e. copper is placed at advancing side.

M.Azizieh et al.(2015) – studied the effect of different process parameters on material properties of 3mm AA1100 & AZ31 FS Welded plates in their experiment. H13 tool steel with 18mm shoulder diameter , 2.7 mm tool tip diameter & 5mm threaded diameter of pin with 1mm pitch was used as tool material for performing experiment . varying process parameters taken were rotation speed (420, 480, 570, 660, 750, 800 & 1000rpm) Traverse/welding Speed (15,20 & 30mm/min) & tool offset (0, 1.5, 2.5 towards AA1100, 1.5 & 2.5 towards AZ31), also both material are kept on AS respectively. The experiment concluded the satisfactory result were achieved with taking both material on advancing side, maximum tensile strength & % elongation achieved was 120MPa & 9% respectively with 480 rpm tool rotation speed & 15 mm/min. welding speed, Also sound weld were achieved when tool offset was towards AZ31 side as compared to offset towards AA1100 side.

Arshad Noor Siddiquee et al. (2015) explored the effect of different process parameters on the tensile & microstructural properties of 2.95mm similar AISI-304 Stainless Steel plate joined together by friction Stir Welding. The Tool applied in the experiment was of WC & have 2.75mm pin length 7mm, 7mm taper pin diameter (taper angle as 45°) & two different shoulder dia as 14 & 16mm. Taguchi L4 orthogonal array was used for experiment design with three different process parameters, tool shoulder diameter, Tool rotation speed & welding speed with two values as 14 & 16, 355 & 450rpm, 66 & 84mm/min. respectively. The experiment concluded the UTS, (which was conducted on Computer Interfaced Tachometer with 20KN capacity) have maximum value of 677 MPa with 14mm shoulder diameter, 355rpm tool rotation speed & 66mm/min. welding speed. It is also noted that all the specimens of tensile test are fractured from either side of the weld but not from center.

A. Nagamalleswara rao et al.(2016) given a test report after conducting on experiment on friction stir welded copper 2200 of 5mm thickness, effect of different values of process parameters on mechanical properties of the joint. H13 with 20mm shoulder dia. 6mm pin diameter & 4.7mm pin length was used as tool material for welding . Experiment concluded that with increase in tool rotation speed & traverse speed increases tensile strength but increase in axial force decrease the tensile strength.

Shojaei Zoeram et al. (2017), in their research, discussed the friction Stir Weldability of 2mm sheet of Al 5052 & C22000 bronze alloy. H13 steel with 20mm shoulder diameter, 2mm pin dia. and 1.7mm pin length was used as tool material. Input process parameter were taken as, welding speed (20, 31.5 & 50 mm/min) & Rotation Speed (800, 1000, 1250, 1400) with 3° tilt angle (constant). This experiment concluded that hardness of the joint can be higher from base metal in some cases. Also the tensile Strength increases with increase in rotation speed.

CONCLUSION

1) FSW can be used to weld material have a large difference in melting temperature.
2) Defect free welding can be done.

FUTURE SCOPE

Flaw occurrence can be investigated due to the effect of different process parameters. Non destructive testing can be carried out to investigate flaws and internal defects.
Second pass of FSW tool on the weld after some time. Time interval effect can also be investigated.
From literature survey we noticed that much research has been done on different materials, but a very few research is done on AL 2014 with different material. This material can be investigated using different process parameters and with different optimization methods.

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