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A Review on Analysis of Friction Stir Welding Process of Steel

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ABSTRACT

Friction Stir Welding (FSW) is a solid state welding method and is common for aluminium alloys Friction Stir Welding is a novel green solid state joining process particularly used to join high strength aerospace aluminium alloys. This review paper addresses the overview of Friction stir welding which includes the basic concept of the process, microstructure formation, influencing process parameters, typical defects in FSW process and some recent applications. These welded joints have higher tensile strength to weight ratio and finer micro structure. FSW of aluminium alloys have the potential to hold good mechanical and metallurgical properties. This paper gives the review of basic concepts of Friction Stir Welding on tool design, mode of metal transfer and process parameters. It is demonstrated that FSW of aluminium is becoming an increasingly mature technology with numerous commercial applications.

Keywords: Tool, FSW, Friction Stir, Processing, Steel.

I. INTRODUCTION

Friction-stir welding (FSW) was patented by Thomas.et.al in 1991. The Welding Institute (TWI) of UK did experiments initially on aluminium and its alloys [1]. The process uses the non-consumable specially designed rotating tool which is inserted in to the material by giving the axial force and then translated along the joint line to make the weld [2]. TMAZ zone is formed due to thermo mechanical cycles and HAZ is the zone which is affected by the frictional heat produced by the shoulder. WN is the region formed due to the stirring action of the pin. Frictional heat produced by the tool makes the plastic deformation of material and grain boundary sliding. Excessive heat formation leads to tool wear which results in loss of material in the tool. Loss of tool material will be formed as an inclusion in the weld region. Feed rate, material flow and heat transfer favours the tool wear to emerge along the weld direction. Tool wear can be reduced by preheating the work piece [3] Friction Stir Welding is considered to be the most significant development in metal joining in a decade. In Friction Stir Welding no cover gas or flux is used, thereby making the process environmentally friendly, energy efficiency and versatility or it is a „green technology‟. The joining does not involve any use of filler metal and therefore any aluminium alloy can be joined without concern for the compatibility of composition, which is an issue in fusion welding. In FSW no cover gas or flux is used, and does not involve any use of filler metal so that the properties of the joints are improve compare to the parent metal [4].

II. METHODS AND MATERIAL

A. Benefits of Friction Stir Welding

- Good mechanical properties in the as-welded condition.
- Improved safety due to the absence of toxic fumes or the spatter of molten material.
- Easily automated on simple milling machines lower setup costs and less training.
- Can operate in all positions (horizontal, vertical, etc.), as there is no weld pool

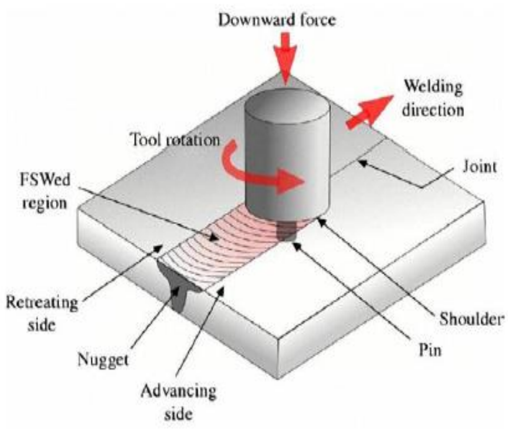

Figure 1 : Schematic diagram of friction stir welding process [6]

B. Friction Stir Welding Tool

FSW tool is considered as a heart of the welding process which has two primary parts namely shoulder and pin, which heats the work piece material by friction. Shoulder part of the tool frictionally heats the portion of the work piece and induces the axial downward force for welding consolidation. The FSW is emerged from a concept of drilling and hence the tool was initially used with threaded pin. The compaction of plasticized material is given by the bottom of the tool shoulder and prevents the material from escaping. The shoulder have different profile such as flat, concave, smooth or grooved, with concentric or spiral grooves[5]. FSW is considered to be the potentially useful solid state welding technique in which welding is done below the melting point of the work piece material.

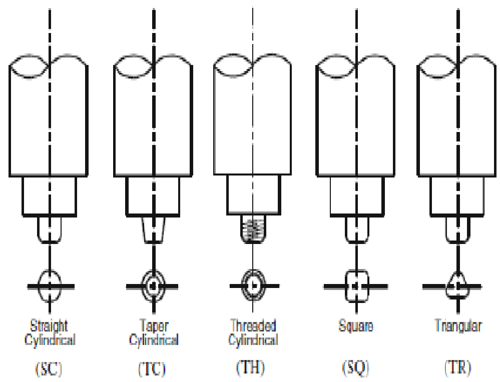

Figure 2 : Schematic diagram of the FSW tool. [7]

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 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 welding speeds 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 Design

The design of the tool is a critical factor as a good tool can improve both the quality of the weld and the maximum possible welding speed. It is desirable that the tool material is sufficiently strong, tough, and hard wearing at the welding temperature. Further it should have a good oxidation resistance and a low thermal conductivity to minimize heat loss and thermal damage to the machinery further up the drive train.

C. Friction Stir Welding Process

Friction stir processing is a new and unique thermo mechanical processing technique that changes the mechanical properties and microstructure of the material [8]. Friction Stir processing has been applied to Aluminium, copper, and nickel based alloys. By Friction Stir Processing the strength of the cast nickel aluminium bronze was doubled, the ductility of the Al alloys A356 was increased by five times. FSP is also used to increase the fatigue life of the fusion weld surfaces [9]. The working principle of Friction Stir Welding process is shown in Fig. 1. A welding tool comprised of a shank, shoulder, and pin is fixed in a milling machine chuck and is rotated about its longitudinal axis. The work piece, with square mating edges, is fixed to a rigid backing plate, and a clamp or anvil prevents the work piece from spreading or lifting during welding. The half-plate where the direction of rotation is the same as that of welding is called the advancing side, with the other side designated as being the retreating side. The rotating welding tool is slowly plunged into the work piece until the shoulder of the welding tool forcibly contacts the upper surface of the material.

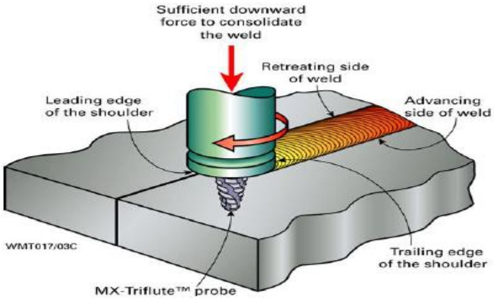

Figure 2: A Schematic Diagram Of Friction Stir Welding Process [7]

III. RESULT AND DISCUSSION

A. Applications of FSW

- Shipping and marine industries: - Such as manufacturing of hulls, offshore accommodations, aluminium extrusions, etc.
- Aerospace industries: - for welding in Al alloy fuel tanks for space vehicles, manufacturing of wings, etc.
- Railway industries: - building of container bodies, railway tankers, etc.
- Land transport: - automotive engine chassis, body frames, wheel rims, truck bodies, etc.

B. Friction Stir Welding Defects

Friction Stir welding is susceptible to the defects which are different from the fusion welding defects. Selection of improper welding process parameters leads to insufficient heat input, excessive heat input, abnormal stirring, and insufficient pressure underneath the shoulder which leads to the any one or more of the following defects in the friction stir welding. Worm hole [a] is the tunnel of inadequately consolidated and forged material running in the longitudinal direction which is formed due to excessive heat input due to high rotational speed, low transverse feed. Defect in which the Series of small voids located in the advancing side interleaving the stir zone along the weld is known as Scalloping [b].

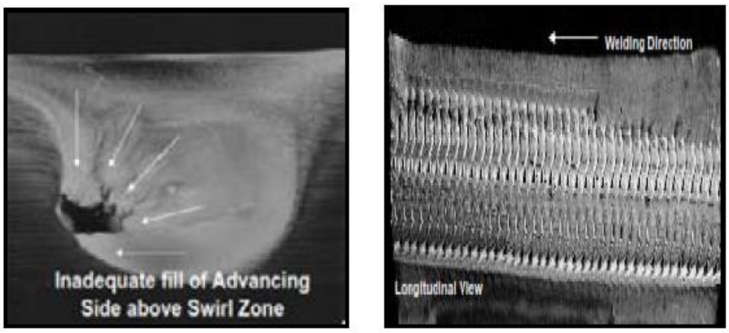

Figure 4: (a): Worm hole (b). Scalloping

IV. CONCLUSION

The present review paper based on the basic concepts to understand formation of welding and its process parameter which functions to give such a permanent joint. Friction stir welding being a widespread interest for most of the upcoming researchers in the area of welding, it finds its importance in welding steels. Without the application of steel in industries is unimaginable. It identifies a number of areas that are worthwhile for further study. it has been suggested that higher tensile strength of these alloys, a manufacturer allow to use in the area of aerospace and automobile industries, where the high strength to weight ratio is important.

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