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Using Friction stir welding Investigation of failure on welded plates of aluminum alloy

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ABSTRACT:
FSW (Friction Stir Welding) is an emerging solid state joining process with great potential as good joint is exceptionally high and the process is very repeatable. These processes are widely used in aerospace vehicles etc. FSW is applied to the joining of two pipes, thin-walled, thickness different hollow hemispheres. In this work Aluminium alloy AA 2014, 5 mm thickness plates were welded in butt joint geometry by FSW process. Process parameters such as welding speed, tool rotational speed and Tilt angle play an important role to obtain a better weld joint for similar metals. The FSW tool is one of the critical components to the success of this process. It consists of a cylindrical shoulder and a pin with different geometry. In this experimental work, the said tool has been adopted with cylindrical tapered tool for friction stir welding of the similar metal plates. FSW has been carried out at welding feed varying from 10 to 40 mm/min and tool rotational speed from 800 to 2000 rpm. Effects of process parameters on butt welded joint are investigated for weld strength and Failure. In this work, we made a weld joint between aluminium alloys AA2014 similar metals using FSW by cylindrical tapered tool and welding parameters. And we compared strength of weld joint influenced by FSW by conducting tensile test. We determined welding failures using Scanning Electron Microscope (SEM).
Keywords: FSW, Aluminium alloy, Tool Profile, Welding speed, SEM**.**

I. INTRODUCTION

Friction stir welding (FSW) is a significant manufacturing process for producing welded structures in solid state. This process offers several advantages compared to the conventional welding methods including higher mechanical properties and lower residual stresses as well as reduced occurrence of defects. In FSW process, a rotating tool having a shoulder moves along the welding line. Rotational motion of the shoulder generates frictional heat leading to a softened region around the pin while the shoulder prevents deforming material from being expelled. In fact, a weld joint is produced by the extrusion of material from the leading side to the trailing side of the tool.

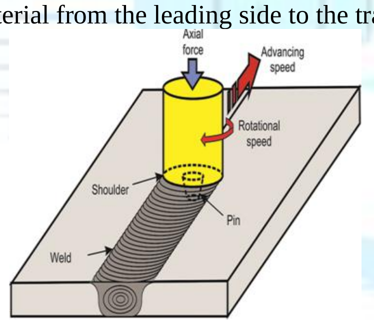

Fig: 1 Schematic diagram shows friction stir welding process and terminology.

Fig: 2 Friction stir welding process

II. OBJECTIVES

The main objective of this work was to develop the knowledge base regarding performance of FS welded joints. Findings in this area would cater to the viability of using the FSW process in this alloy in the industry. This project has another objective failure investigation, tensile test.

III. APPROACH TO THE PROBLEM

Friction stir welded joints have highly variable microstructures that affect the performance of the material. If all loads and environmental conditions were combined in a single test, isolation of factors that find the failure would be complex. In order to bring the behaviour of FSW in actual uses, static loading are used for conducting the tests.

IV. ACHIEVEMENTS

This project investigated welding failures of FSW in aluminium alloy AA2014 similar joints at various speeds and feeds. Finding the failure investigation is imperative in understanding methods for improving the process. Information gathered from static load testing of sample joints, processing parameters that affect the static performance of the joints are determined.

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V. WELD CREATION

Welds were created in 100mm weld lengths in Aluminium alloy stock of 5mm thick. In each weld, the base material was formed so that the rolling direction was perpendicular to the welding direction. Welds were created for six sets of parameters. The baseline parameters were chosen per recommendation of the tool manufacturer form their suggested feed and speed for the welding tool used. These parameters were selected because welds created using this set of feeds and speeds had minimal observable welding defects. In all cases, loads on the milling machine never exceeded 100%, indicating that the FSW operations were well within the capabilities of the machine, providing consistent and repeatable welds. The result of the FSW procedures was six sets of welds on each alloy with individual time-temperature histories and differing resultant microstructures. All welding samples were named according to the order in which they were produced. The welding parameters that are paired with each sample are presented in below Table

Table: 1. Operating Parameters

TYPE OF ALLOY	SPEED (RPM)	FEED (MM/MIN)
ALUMINIUM ALLOY AA2014	900	20
	1100	30
	1400	40

VI. TESTS PERFORMED

1. Microstructures
2. Tensile Tests
3. SEM Analyses (Failure Investigation)

VII. RESULTS AND DISCUSSIONS

Micro structure

The microstructures of welds produced for this project demonstrated all the characteristics of friction stir welds found in reviewed literature.

All welds had a distinct dxz, tmaz, and haz that were clearly defined by the standard FSW geometries. AA 2014 and copper were used as the base material in this study. The material is readily available and was acquired from a local provider.

An image micro structure of AA 2014 with different weld parameters can be seen in the following figures.

(a) AA2014, Speed-900rpm, Feed-20mm/min,

(b) AA 2014, Speed-1100rpm, Feed-30mm/min

(c) AA 2014, Speed-1400rpm, Feed-40mm/min

Fig.3 Micro structures of welded Al-Al 2014 specimens at different spindle RPMs and Feed rates

Tensile Test Samples

Tensile samples were cut from sections of the 100mm X 1000mm weld. Cohesive sections of weld were selected of dimension 70mm X 100mm in the tool traverse direction. All samples were produced with minimal defects and conformed to specified dimensions with a tolerance of 0.01". Figure 5.8 shows a dimensioned image of the tensile samples used in testing.

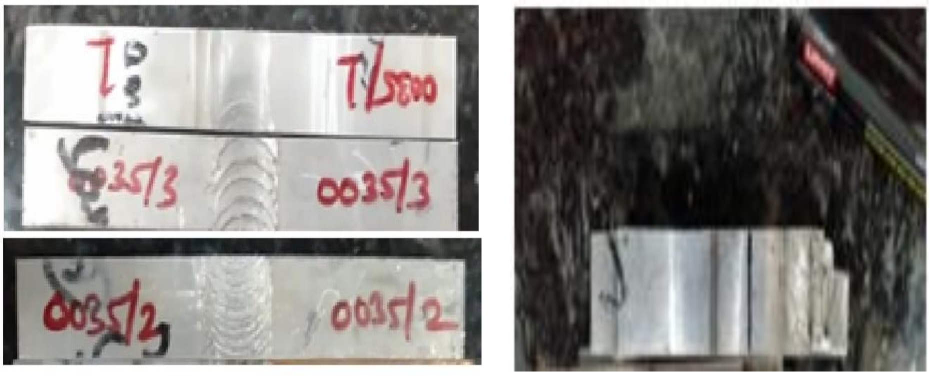


Fig: 4. Specimen before and after testing

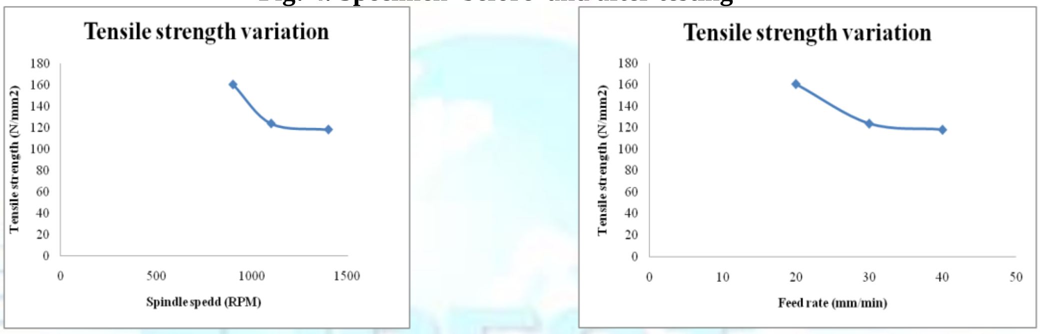


Fig.5 Variation of Tensile strength of Al-Al joint with respect to spindle speed and feed rate

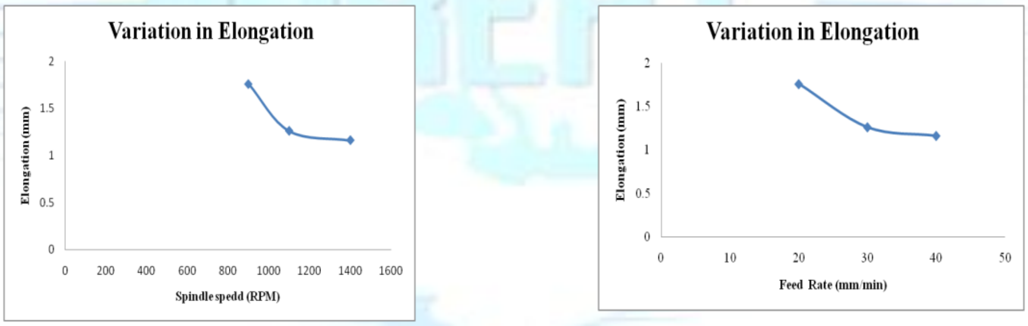
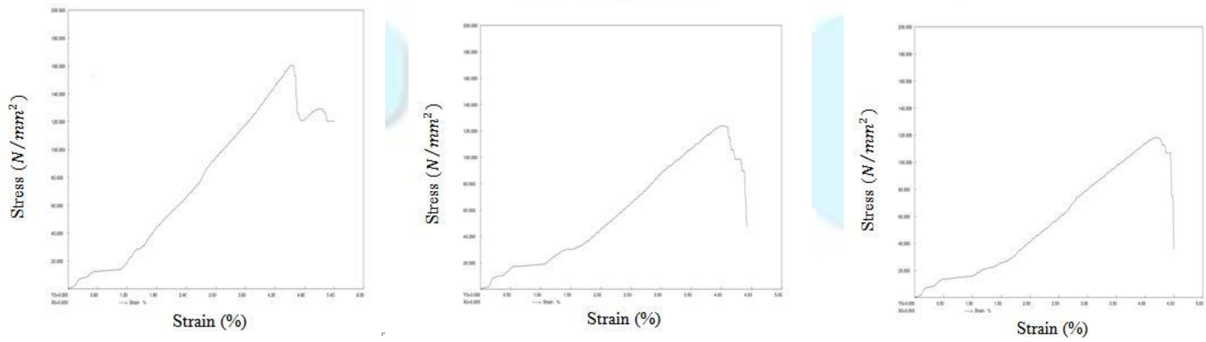


Fig.6 Variation of Elongation of Al-Al 2014 joint with respect to spindle speed and feed rate

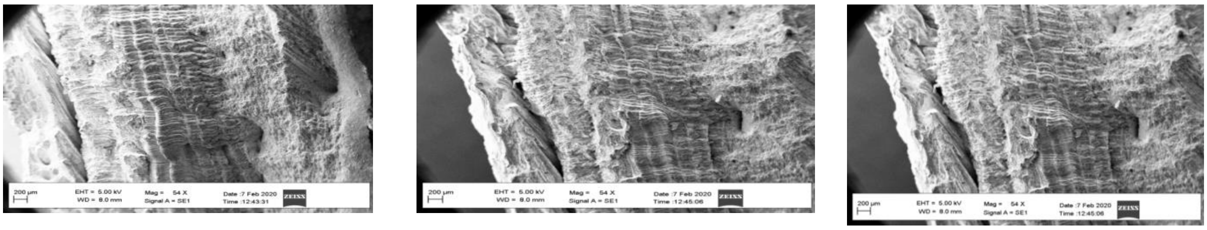


(a) 900RPM & 20mm/min (b) 1100RPM & 30mm/min (c) 1400RPM & 40mm/min

Fig.7 Stress and Strain diagrams of Al-Al Weld Joint at different RPM and feeds

SEM Analysis

A Scanning Electron Microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. Specimens are observed in high vacuum in conventional SEM, or in high vacuum or wet conditions in variable pressure or environmental SEM, and at a wide range of cryogenic or elevated temperatures with specialized instruments.



(a) Speed-900rpm, feed-20mm/min (b) Speed-1100rpm,feed-30mm/min (c) Speed-1400rpm,feed-40mm/min

Fig.8 SEM image of Al-Al 2014 at different and speeds

a) This SEM image showing the micro structural area of clear distinction of smooth fatigue zone and final overload. In this the fatigue zone is limited to one end only. At this low rpm & weld speed the failure is low.

b) This SEM image gives that it is a ductile material fatigue. And SEM evaluation revealed that cleavage pattern in dominant failure mode of overload zone. A limited zone of ductile dimpled area is also noticed.

c) This SEM image gives that it is a ductile material fatigue. SEM evaluation revealed that there is a slow crack growth zone and ductile trans granular as the dominant fracture mode and mixed mode area close to final shear lip zone containing ductile tearing dimples. There is a detail of restricted shear zone consisting of fine ductile dimples.

VIII.CONCLUSION

The samples were characterised by means of tensile strength. From the investigations it is found that an increase in weld speed increases tensile strength and increase in tool rotation speed increases the tensile strength. Among all the samples welded, the samples with tool rotation speed of 900 rpm and weld speed (feed) of 20mm/min has given the highest value of tensile strength for aluminium alloy (AA2014) joint.

From the results, we concluded that ductile failures were observed in Aluminium alloy AA2014 using SEM analysis.

IX.FUTURE SCOPE

The conclusions presented in this section may be used to develop methods to enhance specific properties for industrial applications. The selection of the welding parameters used fully determines the tensile behaviour of the material. Accordingly, specific parameter combinations may be chosen for industrial purpose.

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