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Evaluation of Mechanical Properties of Friction Stir spot Welded AA5083-H321 Joint with CNC Milling Machine

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ABSTRACT

Aluminum alloys are used in many applications in which the advantages of high strength and low weight have a significant impact, on industries such as; Shipbuilding, Aviation, and Transportation industry. Friction stir Spot welding (FSSW) is a new non-flammable welding technique, particularly well suited to aluminum alloys. Friction stir spot welding provides joints with low defects, fine microstructures, minimum phase transformation, and low oxidation compared to conventional welding techniques such as resistance spot welding. In this paper, the swept type FSSW was carried out in AA5083-H321 for mechanical properties (lap shear test and Hardness test) were carried out and reported in this research paper. The hardness result shows that the harness was increased as the rotational speed of the tool increased, but decreased after attaining a marginal speed. The maximum lap shear load was obtained with the rotational speed of 1400 rpm.

Keywords : AA5083-H321, Friction Stir Spot Welding, Aluminium alloy, Lap Shear Test, Hardness

I. INTRODUCTION

The Friction Stir Spot Welding (FSSW) has more benefits in the aspect of metallurgical, environmental, and energy economy over other joining methods [1]. There are many types of FSSW that have been developed by the researchers and many investigations were also made by using all the types of FSSW. The various kinds of FSSW are Normal (or) conventional FSSW [2], Refill FSSW, Stitch FSSW, Swing FSSW, and the newly developed Swept FSSW [3-4]. Each of these FSSW types has a different level of complexity, and diversity in such a way that in the spot shear area and shear strength, Degree of control in motion, and time to complete the weld. In recent years the increasing the use of alminium alloys, especially 6xxx such as the extruded aluminium tubes in space frame structures, and inner and outer panels to improve the sustainability of the automobile industries [5-6].

There is some research on spot joining on aluminium alloys using the FSSW process [7–9]. Based on previous studies, tool rotation speed plays a significant role in the strength of the weld joint followed by the plunge feed rate, Dwell time and shoulder plunge depth.

In this study, 5083-H321 aluminium alloy sheets were friction stir spot welded by varying tool rotational speed. The hardness and lap shear strength of the FSS welded joint on aluminium alloy sheet due to changes in tool rotation speed were presented and discussed.

II. METHODS AND MATERIAL

An AA5083-H321 sheet of 2mm thickness was used in this experiment. 100 mm length and 35 mm width are the dimensions of the specimen prepared with the overlapping area of 35 x 35 mm using a wire-cut EDM process. Their nominal chemical compositions of the base material are listed in Table 1 and the configuration of the Specimen coupon is shown in Fig. 1. The welds were made using a Friction Stir welding setup in the CNC Vertical Machining Centre. FSSW tool was made of H13 tool steel and hardened to 56-59 HRC. The tool with a pin diameter of 5 mm with thread, shoulder diameter of 12 mm, and a pin length of 2.8 mm was used in this study.

TABLE I. Chemical Composition of AA5083-H321

Fe	Si	Mn	Mg	Zn	Ti	Cu	Al
0.7	0.5	0.5	0.3	0.1	0.02	0.13	Balance

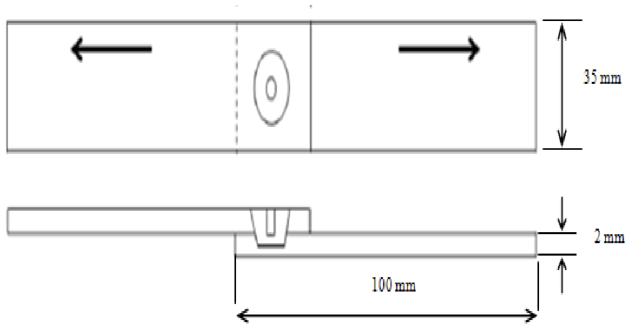

Figure 1: Lap Shear Test Coupon

The tool rotational speed of 900, 1200, 1350, and 1600 rpm was chosen for producing the FSS weld joints. The other parameters of dwell time, tool plunge depth, and tool travel speed are 20 sec, 0.3 mm, and 15 mm/min respectively were kept constant for all the experiments. The constant parameters were selected based on the trial work and available literature [10-11]. After welding, the lap shear test was conducted using a universal tensile machine at a crosshead speed of 1mm/min at room temperature. The Vickers hardness test was conducted in the weld cross section at the load of 150 kg for evaluating the strength of the weld joint. The hardness survey was taken at a 1 mm constant distance at every indentation.

III.RESULTS AND DISCUSSION

A. Hardness survey

The hardness measurement was taken at the stir zone (SZ), Heat affected zone (HAZ), and thermo mechanically affected zone (TMAZ) section and base material (MB) of the cross-sectioned specimen. This is to determine the differences between the hardness of the base material, stir zone, and other sections. The different section of the cross-sectioned FSS welded sample is shown in Fig. 2.

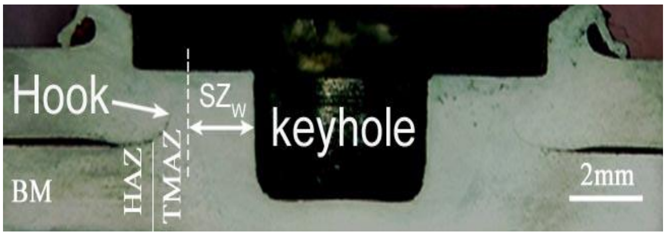

Fig. 2 Cross-section of FSSW joint showing different weld zones

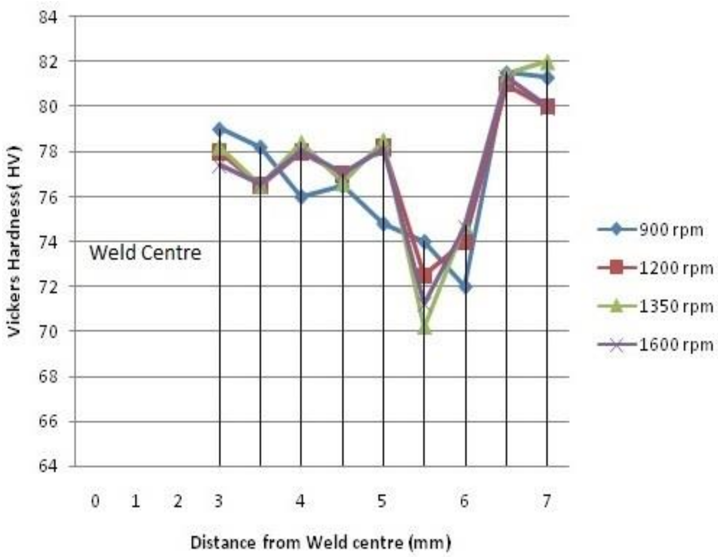

Fig. 3. Lap shear strength of FSSW joints

The results were obtained from the five different welding speeds from each specimen as shown in Fig. 3. In the all welded conditions the higher hardness value was obtained in the stir zone area followed by the TMAZ and HAZ because of fine grain structure due to the association of very high temperature during the welding process, In addition, the parent material has the same value because of an inadequate supply of heat generation to change the strength. The hardness values are the minimum in the HAZ section compared with the other sections because of averaging.

B. Lap Shear Test

The lap shear load of the FSSW specimens was measured in the longitudinal rolling direction at room temperature. The welded sample in the universal testing machine is shown in Fig. 4. The results obtained from the test was shown in Fig. 5. As seen, the lap shear fracture load increases gradually with the increase of the tool rotation speed up to a certain level and then decreases in scales rate. The maximum lap shear load of 3.9 KN is obtained at a rotation speed of 1350 rpm. The increase in the strength of FSSW joints is most likely due to the higher stirring area and dislocation density of the welded joint [13]. The lower strength of FSSW can be also due to the flow of material during the plunging and circular action of the tool, thus creating an increase in the sheet interface [14-15].

Fig. 4. A Photograph of lap shear test

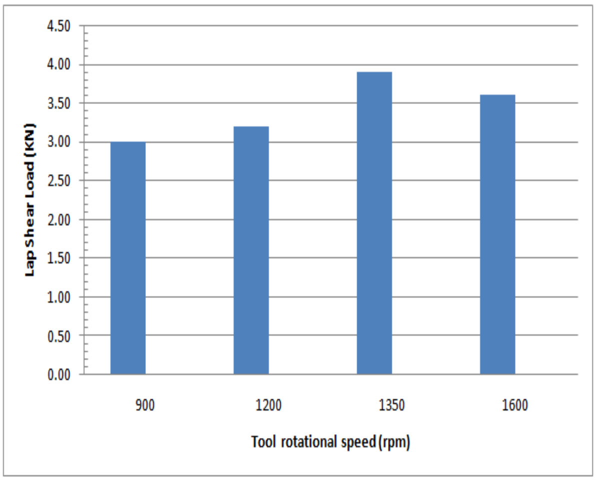

Fig. 5. Lap shear strength of FSSW joints

IV.CONCLUSION

This work investigates the mechanical property of the swept FSS welded AA5083-H321 aluminium alloy based on the experimental observations. The following conclusions have been made from the present investigation.

The maximum lap shear load obtained in the FSSW at the tool rotating speed of 1300 rpm is 3.9 KN. The increase in the lap shear load is due to the high stir area and fine grains.

The maximum hardness was measured at the stir zone of all the samples.

Further study on optical and scanning electron microscopes analysis would give a better understanding of the strength variation of the joints.

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