Microstructure and Mechanical Properties of Friction Stir Welded AL/MG Joint with Addition of Nano Filler

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***Abstract*—In engineering applications, such as automobile, marine, aerospace, and railway, lightweight alloys of aluminum (Al) and magnesium (Mg) ensure design fitness for fuel economy, better efficiency, and overall cost reduction. Friction stir welding (FSW) for joining dissimilar materials has been considered better than the conventional fusion welding process because of metallurgical concerns. In this study, dissimilar joints were made between the Aluminium (Al) AA6061-T6, Magnesium (Mg) AZ31-B, with addition of SiC –Nano partical combinations based on the varying process parameters. The dissimilar joints prepared by the FSW process were further characterized by tensile testing, hardness testing, fracture testing. The results of the properties were supported by fracture analysis by scanning electron microscopy (SEM) observations. In this study, tensile testing, micro-hardness, and fracture behavior of the joints of Al and Mg alloys manufactured by the FSW process is considered for evaluation.**

***Index Terms*—Friction stir welding lap joint (Lap-FSW)- Aluminium alloy (AA606-T6)- Magnesium (AZ310B)- Nano filler - Silicon carbide.**

I. INTRODUCTION

In engineering applications, such as automobile, marine, aerospace, and railway, lightweight alloys of aluminum (Al) and magnesium (Mg) ensure design fitness for fuel economy, better efficiency, and overall cost reduction. Friction stir welding (FSW) for joining dissimilar materials has been considered better than the conventional fusion welding process because of metallurgical concern. In this study, dissimilar joints were made between the AA6061 (A), AZ31B (B), and AZ91D (C) combinations based on the varying with SiC nano process parameters. The dissimilar joints prepared by the FSW process were further characterized by tensile testing, hardness testing. Friction stir welding (FSW) is a solid-state welding process that has been widely used to join aluminum alloys due to its advantages of low heat input, high weld strength, and good ductility. However, the welding of aluminum alloys to magnesium alloys has been challenging due to the formation of brittle inter-metallic compounds (IMCs) at the weld interface. One way to improve the weld quality of Al/Mg joints is to add nano fillers to the weld zone. Nano fillers are small particles with dimensions on the nanometer scale (1-100 nm). They can be made from a variety of materials, such as ceramic particles, metal particles, and carbon nano tubes. Nano fillers can improve the microstructure and mechanical properties of friction stir welded Al/Mg joints in a number of ways. First, they can act as grain refiners, which means that they can reduce the size of the grains in the weld zone. This leads to a more uniform microstructure and improved mechanical properties. Second, nano fillers can improve the distribution of IMCs in the weld zone. This reduces the formation of brittle IMC clusters, which can lead to the formation of cracks in the weld joint. Third, nano fillers can strengthen the weld joint by acting as barriers to dislocation motion. The addition of nano fillers to friction stir welded Al/Mg joints has been shown to improve the tensile strength, yield strength, and elongation of the weld joint. In addition, nano fillers can improve the fatigue resistance and corrosion resistance of the weld joint. The following are some of the benefits of adding nano fillers to friction stir welded Al/Mg joints: Improved microstructure: Nano fillers act as grain refiners, which leads to a more uniform microstructure and improved mechanical properties. Improved distribution of IMCs: Nano fillers improve the distribution of IMCs in the weld zone, which reduces the formation of brittle IMC clusters and improves the weld quality. Nano fillers can improve the fatigue resistance and corrosion resistance of the weld joint. Overall, the addition of nano fillers to friction stir welded Al/Mg joints is a promising way to improve the microstructure, mechanical properties, and durability of the weld joint.

II. AIM

In this study, hardness testing of the joints of Al and Mg alloys manufactured by the FSW process were conducted. This review does not cover a combined effect of all properties of FSW. The Al/Mg lap-joint technique prioritizes dissimilar friction stir welded joints.

III. OBJECTIVES

The main objectives of the current trending in Friction stir welding lap joint. To study the friction phenomena at the tool and work piece interface. To define the welding parameters provide acceptable quality welds. To evaluate the applicability and reliability of the design of experiments by taguchi when used for parameter optimization in FSW lap joint. To evaluates the microstructure of low quality with high quality welds. To characterized the different welding regions and their extent using micro hardness probes and mapping.

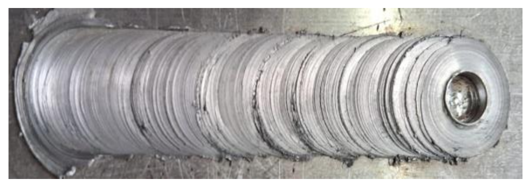
IV. EXPERIMENTAL WORK

BASE MATERIAL SELECTION: The base materials used in this investigation are the rolled sheets of 2 mm thick AA6061 aluminum alloy and AZ31-B Magnesium alloy. Aluminium alloy 6061-T6 is a medium to high strength heat-treatable alloy. It has very good corrosion resistance and very good weld ability although reduced strength in the weld zone. It has medium fatigue strength. It has good cold formability in the temper T4, but limited formability in T6 temper. Not suitable for very complex cross sections.

REINFORCEMENTS (SILICON CARBIDE): Silicon carbide particles prepare on the size of 3 µm by reinforced on AZ31B Magnesium alloy welding joints. Ceramics consist of a host of different materials with special properties. Silicon Carbide (SiC) is one such material which is also known as carborundum or mossanite (the commercial name for silicon carbide when used as gems). SiC was accidentally discovered by Edward G. Acheson, an assistant to Thomas Edison, about 1890, when he was running an experiment on the synthesis of diamonds..

V. EXPERIMENTAL TESTS

VISUAL INSPECTION: The most common welding discontinuities found during the visual inspection are conditions such as undersized welds, undercut, overlap, surface cracking, surface porosity, underfill, incomplete root penetration, excessive root penetration, burn through, and excessive reinforcement. The output is shown in below.



VII. CONCLUSION

The dissimilar joints have been FSW between the Al AA6061, Mg AZ31B combinations based upon the varying metals. The dissimilar FSW joints are characterized by tensile testing, hardness testing. The performance of dissimilar joints has been statistically analyzed. The main contribution of prioritizing AA6061 and AZ31B FSW properties based on the combined effect of the FSW lap joint method is beneficial for engineering applications, and the presented methodology is welded this both Al and Mg. Therefore, the present study has made conclusions based on the significant results.

REFERENCES

[1]. C. G. Rhodes, M. W. Mahoney, W. H. Bingel, R. A. Spurling and C. C. Bampton, “Effects of friction stir welding on microstructure of 7075 aluminum” Scripta Materialia, 36 (1997), 69-75

[2]. W. M. Thomas and E. D. Nicholas, “Friction stir welding for the Transportation Industries” Material Design, 18 (1997), 269-273

[3]. Michael Booth, “Effects of Processing Parameters on Friction Stir Welded Lap Joints of AA7075-T6 and AA6022-T4”Waterloo, Ontario, Canada, 2016

[4]. WoongSeong Chang, S.R. Rajesh, Chang-Keun Chun and Heung Ju Kim “Microstructure and Mechanical Properties of Hybrid Laser-Friction Stir Welding between AA6061-T6 Al Alloy and AZ31 Mg Alloy”2011,27(3),199204

[5]. Arun M &Ramachandran k “Effect Of Welding Process On Mechanical And Metallurgical Properties Of Aa6061 Aluminium Alloy Lap Joint”ISSN 0973-4562 Vol. 5 No.1 (2015)

[6]. ShudeJi, Zhengwei Li, Zhenlu Zhou, and Baosheng Wu “Effect of Thread and Rotating Speed on Material Flow Behavior and Mechanical Properties of Friction Stir Lap Welding Joints”JMEPEG (2017) 26:5085–5096

[7]. S. Lomolino, R. Tovo and J. Dos Santos, “On the fatigue behaviour and design curves of friction stir butt welded Al alloys”, International Journal of Fatigue, 27 (2005), 305-316

[8]. RathinasuriyanChandran, SankarRamaiyan, AvinGanapathiShanbhag, “Optimization of Welding Parameters for Friction Stir Lap Welding of AA6061-T6 Alloy” Modern Mechanical Engineering, 2018, 8, 31-41

[9]. S. A. David2, W. M. Thomas3, E. Lara-Curzio2 and S. S. Babu2 “Friction Skew-stir welding of lap joints in 5083–0 aluminium”

[10]. Juan Chen, Jingyu Han, Yujuan Wu, Liming Peng, “Effects of process parameters on microstructure and mechanical properties of friction stir lap linear welded 6061 aluminum alloy to NZ30K magnesium alloy” Journal of Magnesium and Alloys 5 (2017) 56–63

[11]. H. Bisadi1, M. Tour1,*, A. Tavakoli2 “The Influence of Process Parameters on Microstructure and Mechanical Properties of Friction Stir Welded Al 5083 Alloy Lap Joint” American Journal of Materials Science 2011; 1(2): 93-97

[12]. H. Das, R. N. Ghosh & T. K. Pal “Study on the Formation and Characterization of the Intermetallics in Friction Stir Welding of Aluminum Alloy to Coated Steel Sheet Lap Joint” Metallurgical and Materials Transactions A • October 2014