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A Review on Welding of Metal Matrix Composite

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Abstract- Metal Matrix Composites (MMCs) stand over other conventional alloys in the field of aerospace, automotive and marine applications owing to their excellent improved properties. In this paper we consolidated some of the aspects of mechanical and wear behavior after the welding is done for MMCs by using different techniques. The MMC joints were subjected to microstructural and mechanical characterization, including hardness, tensile and fatigue tests .The aim of this study is to observe the possibility of using the friction stir welding technique to produce sound joints, micro hardness distributions and tensile property of the joints .Here we also observed the other type of welding techniques and their mechanical properties on MMCs.

Index Terms- MMC, Wear, Welding Technique, Mechanical Properties

1. INTRODUCTION

Metal matrix composites are being increasingly used in aerospace and automobile industries owing to their enhanced properties such as elastic modulus, hardness, tensile strength at room and elevated temperatures, wear resistance combined with significant weight savings over unreinforced alloys. The commonly used metallic matrices include al, mg, ti, cu and their alloys. These alloys are preferred matrix materials for the production of MMC'S. The reinforcements being used are fibers, whiskers and particulates. Joining high quality metal matrix composites (MMC'S) to conventional monolithic alloys is of great interest since it would allow the use of the more expensive composite material only where its properties are needed. In this way the costs could be reduced and the applications of MMC'S would become wider.

In spite of all these advantages, the applications of MMC'S are not as much as expected. The reason for this is, not only their higher cost but, also the difficulty they present during different secondary processes- an important one among them is welding. Using fusion welding techniques brings problems such as porosity and chemical reaction of the molten matrix with the reinforcing particles, which deteriorate the mechanical properties of the material.

To evaluate the effect of the lateral off-set in the microstructural characteristics of the alloy composite boundary and to correlate the differences with the mechanical properties of the joints. In a more general way, we attempted to improve the mechanical properties of the joints by using a lateral off-set different from the traditional centered one.

Opportunities for obtaining high quality mmc welds have recently been widened using solid state welding processes, in which joining is obtained at temperatures substantially below the melting point of the base material, without the addition of brazing filler metal, allowing one to weld dissimilar alloys. In friction welding (FW), joining is obtained through frictional heating, produced from a sliding motion between rubbing surfaces, held together under pressure.

So far no literatures on the USW of composites were Reported, and thus, it is unclear how the particles behave under the high frequency vibration and whether a sound spot joint of these composites could be obtained via USW or not. This study was, therefore, aimed to identify the feasibility of joining these composites. Tungsten inert gas (TIG) welding is an inexpensive welding process that produces good quality welds. It has been adopted for welding since earlier 1940's. However, the welding of alloys is difficult .here this study reports that using of TIG welding is efficient or not.

2. LITERATURE REVIEW

2.1 *Review on different Welding Techniques*

Florencia Cioffi [1] in the year 2014 studied the effect of lateral off-set on the tensile strength and fracture of dissimilar friction stir welds, 2024Al alloy and 17%SiC/2124Al Composite. The study showed that plates were fixed so that the contact surface of the plates formed a 9 degree angle with respect to the tool path. The plunging was done in the alloy with the edge of the tool shoulder aligned with the contact surface of the plates.

The fracture surface of the samples was observed under the Scanning Electron Microscope (SEM). The diagonal welding parameters are summarized and shown in fig.1.

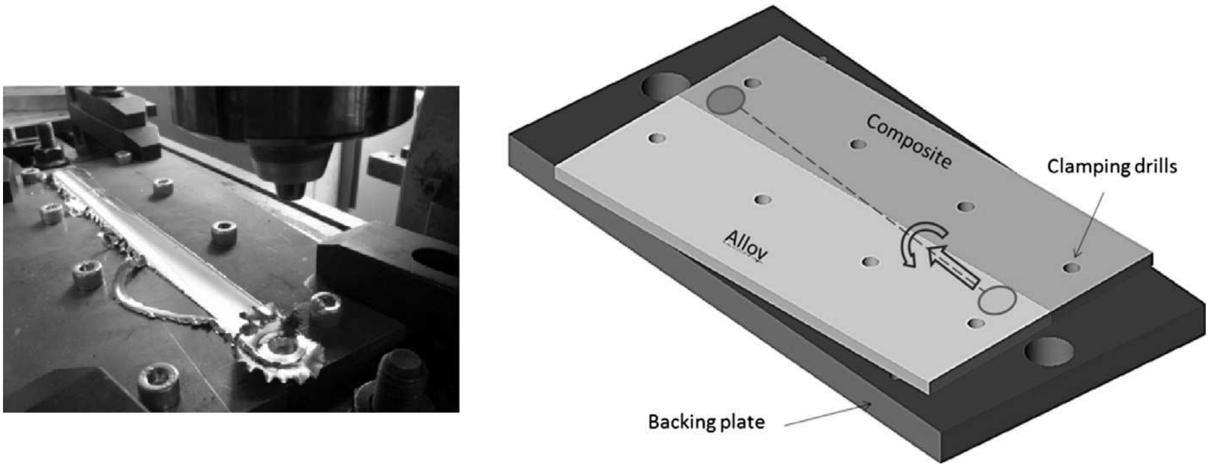

Fig. 1. Experimental setup used for the diagonal friction stir weld, (a) photograph of weld D2 and (b) scheme

V.K. Patel [2] in the year 2014 had studied the solid state ultrasonic spot welding of SiCp/2009Al composite sheets. Ultra sonic welded Samples, Welding Zone Regions Contained Higher Volume Fractions of Sic Particles Compare to the BM (Or Top and Bottom of the Welding Zone). Welding Zone Left with Higher Volume Fraction of Hard Sic Particles with Less Amount of Al Matrix. Due To Differences in The Thermal expansion Between Sic and Al Matrix, Rapid Heating and Cooling during Ultra sonic welding Increases. The Residual Plastic Strain And Will Lead To Generation Of Dislocation At The Matrix-SIC Interface. The Lap Shear Tensile Load Increased With Increasing Energy Inputs and Peaked 2000 J Energy Input. This Micro Level Crack Experienced Higher Stress Concentration Effect, Which Allowed The Cracks To Grow Toward The Outward Al Sheet. Thus, The Samples Failed At The Edge Of The NZ.

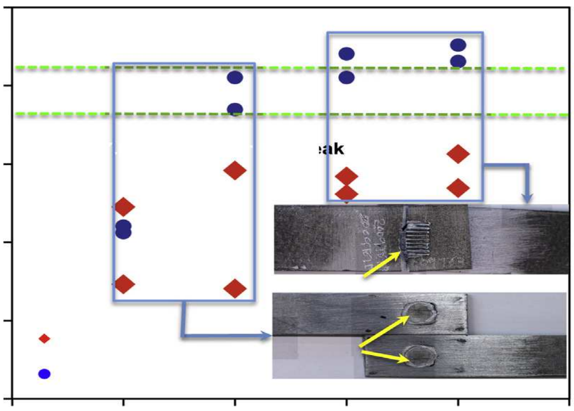

Fig. 2. (a) Micro hardness profiles across the USWed 2009Al–O/SiC and 2009Al–T6/ SiC at a welding energy of 1000 and 2000 J, (b) comparison of a lap shear fracture load of USWed SiCp/2009Al–O composite and SiCp/2009Al–T6 composite as a function of energy input.

Manikandan M [3] in the year 2014 had done the investigation of microstructure and mechanical properties of super alloy C-276 by Continuous ND: YAG laser welding. The Welding was carried out in an Argon (80%) + Carbon Dioxide (20%) gas atmosphere with a flow rate of 30 L/min. They observed the average hardness at the weld zone is 261 HV, peak hardness 270HV and the interface was 234HV.A hardness minimum of 196 HV next to the weld interface. The average tensile strength was 761Mpa with 40% average elongation.

A.K. Lakshminarayanan [4] in the year 2014 had done test for Feasibility of surface-coated friction stir welding tools to join AISI 304 grade austenitic stainless steel. The atmospheric plasma spraying (APS) and plasma transferred arc (PTA) hard facing processes, in order to bring down the cost and increase the durability (increasing the wear resistance of tool and reducing the tool debris in the weld nugget) of the Friction Stir Weld tools. In this study the developed tools failed mainly due to the abrasive and adhesive wear compared to the failure due to plastic deformation. The majority of wear occurred in the pin region and the amount of wear that occurred at the shoulder of the tool was very less. The tensile strength decreases with the increase in rotational speed and the decrease in the welding speed due to the coarsening of banded structure.

Belete Sirahbizu Yigezu [5] in the year 2013 had completed study on friction stir butt welding of Al + 12Si/10 wt%TiC in situ composite. In their current study, Al + 12%Si/10 wt%TiC in situ composites were prepared in-house through direct reaction synthesis (DRS). At 700 °C pure titanium was added and temperature was increased 100 °C and charcoal was is added During the preparation of the composites a mixture of 50%NaF and 50%KF was utilized as the flux and Hexa Chloro Ethane (C2Cl6) as the degasser The observed fairly uniformly distributed refined in situ reinforcements in the grain refined metal matrix in the weld. The micro-hardness uniformly increased with the increase in tool shoulder diameter as well as tool rotational speed. On the contrary, the micro-hardness decreased uniformly within the increase in welding speed.

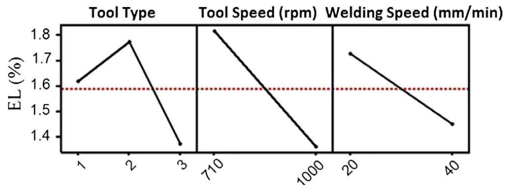

Fig. 3. Main effect plot – data means for percentage elongation.

Jau-Wen Lina [6] in the year 2013 compared the mechanical properties of pure copper welded using friction stir welding and tungsten inert gas welding. The hardness values of micro-hardness test are shown in Figure. The hardness of pure copper after FSW was higher than that after TIG welding. The hardness difference between TIG and FSW was found to be 20 HV. The yield strength and tensile strength of TIG and FSW are 53 and 168 MPa and 70 and 194 MPa resp. There is a reduction in TIG i.e. 20% which is 24.3% and 13.4% higher than those of TIG for FSW. In this experiment, the weld efficiency for TIG is 79%, while it is 92% for FSW.

M. Velamati [7] in the year 2012 completed the Laser and resistance joining of aluminum–graphite composite. Here they had observed Laser welding of Al–Gr did not provide a quality weld due to formation of Al4C3, shrinkage cavities, porosities, and unfavorable redistribution of the graphite fibers. Zinc or tin plating of the Al–Gr composite prior to brazing enhanced the brazing adhesion and shear strength of the joint. Shear stress of a plated then brazed lap joint matches the shear strength of the parent composite.

Zhiwu Xu [8] in the year 2011 successfully executed the Wetting and oxidation during ultrasonic soldering of an alumina reinforced aluminum–copper–magnesium (2024 Al) matrix composite. The joint strength increased significantly with soldering time, the increase rate decreasing when the soldering time was greater than 3 sec.

A.Pirondi [9] in the year 2008 compared the Fracture and fatigue crack growth behavior of PMMC friction stir welded butt joints of 6061 aluminum alloy reinforced with 20% vol. of Al_2O_3 particles (W6A20A) and a 7005 aluminum alloy reinforced with 10% vol. It was evident that the FSW process refined both grain and particle size, while the shape factor of the particles was a little increased. At the same time, the statistical analysis of particle size distribution shows a lower standard deviation of the values. Joining PMMCs by fusion welding techniques such as Laser Beam Welding (LBW) or MIG/TIG gave in general non-optimal microstructures, especially in the case of Al-alloys reinforced with SiC particles [13–16, 42]. Values of SE not higher than 70% were attained in [15, 42] only with a careful choice of the filler materials.

Paola Bassani [10] in the year 2006 studied about the Effect of process parameters on bead properties of A359/SiC MMCs welded by laser. The main effects plots of figure were helpful to individuate which factors, between P and V, seemed to affect the bead dimensional attributes. Conduction welded beads present a homogeneous dispersion of SiC particles and an overall good metallurgical quality.

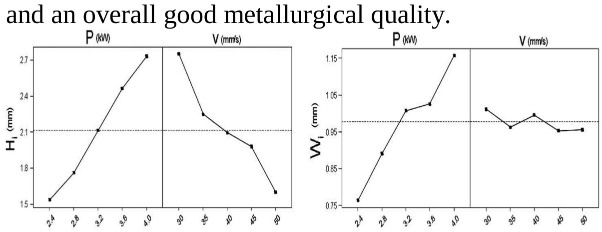

Fig. 4. Main effects plots for W_o and H_o.

Ahmet Hascalik [11] in the year 2006 studied about the Effect of particle size on the friction welding of Al2O3 reinforced 6160 Al alloy composite and SAE 1020 steel. Microstructural evaluation of the friction welding joints revealed four distinct zones across the specimens were identified as base composite material, oxide fragmented region in composite side, plastically deformed region in SAE 1020 steel side and base steel. Reinforcing particles closed to bonding line change their size and distribution compared to the base material region.

L.M. Marzoli [12] in the year 2005 did experiment on Friction stir welding of an AA6061/Al2O3/20p reinforced alloy. They observed that a slower speed at the beginning guaranteed a higher heat input, and the right plasticity to start the weld. All the specimens failed in the heat affected zone (HAZ), because of the loss of strength (under matching) is observed and slower welding speed corresponds to a higher heat input, which results in wider nugget and TMAZ areas.

H.J. Liua [13] in the year 2004 compared the Wear characteristics of a WC–Co tool in friction stir welding of AC4AC30 vol%SiCp composite. In order to quantitatively assess the tool wear, the percent variation in tool size was given by the formula variation = (original size-measured size)/ (original size)* 100%. Wear rate=varying quantity/travel distance. Lower the welding speed, higher the wear rate.

A. UrenÄ [14] in the year 1999 studied the Influence of interface reactions on fracture mechanisms in TIG Arc-welded aluminum matrix composites. They observed that there was a large number of cracked particles inside large dimples produced by plastic deformation of the surrounded matrix. There interfacial reactions between SiC particles and molten aluminium during welding also produced degradation of fracture behavior of the aluminium matrix which was associated with the Si enrichment increased. In specimens welded with input power greater than 2500 W, the tensile fracture tended to be brittle and the level of interdendritic porosity high.

3. CONCLUSION

Here in this paper we observed that MMC has wide range of use in automobile industry, aerospace and many more. After welding the mechanical properties like tensile strength, hardness of metal joints are increasing. The welding of MMCS' can be done by different techniques like friction stir, TIG, SPOT, Ultra Sonic Welding etc. Most work is done by Friction stir welding technique only.

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