STUDY ON WELDED PLATES OF ALUMINIUM ALLOY 2618 REINFORCED WITH AlN, Si_3N_4, ZrB_2 USING FRICTION STIR WELDING (FSW)

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Abstract -This research article is about to investigate, the Al 2618 alloy is mixed with the reinforcements of AlN (Aluminum Nitride), Si_3N_4 (Silicon Nitride), and ZrB_2 (Zirconium Boride) in various ratios. The mechanical and tribological characteristics of these composites are assessed in the dry sliding settings. The main focus is given to assess the hardness, pressure, and pliable values of the composite. These are valuable to examine the weight percentage of support and the grid metal. This is trailed by the miniature underlying investigation to inspect the bond arrangement and impact of grain size decrease because of the friction stir welding

Keywords: FSW, Al 2618, Microstructures, MMC

1. Introduction

Aluminium metal grid composites (AMC) possess various advantageous characteristics such as high resistant to erosion, suitable mechanical properties and its lightweight [1]. Even distribution of the reinforcements is one of the significant characteristics in the AMC manufacturing strategy. In the powder metallurgy technique, many methods to attain the even distribution of reinforcements in the AMC are available [2-4]. In common, the use of reinforcements in the AMC is beneficial to the mechanical properties and other properties of the composites [5, 6]. The composites are employed in-situ measure technique to achieve the reinforcements. In this strategy, reinforcements of composite are combinedly provided the excellent outcome. Besides, better attachment is attained between the reinforcements and lattice [7-14]. In situ measure offered the fine grain size, fine combination, even distribution, clear interface and thermodynamically stable reinforcements that is contrasted to ex situ measure [15, 16]. In this experiment, Al 2618 is chosen as grid material and Aluminum Nitride (AlN), Silicon Nitride (Si3N4), and Zirconium Boride (Zrb2) are used as the reinforcements. To produce the Al 2618 composites, the grid material and reinforcements are mixed well through the method of mix projecting. The reinforcements are utilized in the 4-weight percentage to the Al 2618 composite. Characterization of this composite is performed through various tests (hardness, pressure and tractable tests). This study investigates welding effects on Al 2618 composites. Al 2618 matrix with 4 wt.% reinforcement analyzed by using EDS, X-ray diffraction and microstructural analysis, although Al 2618 composites are scanned using scanning electron microscope (SEM) for analysing the defects.

2. Experimental procedure

2.1 Material selection

Al 2618 composite is reinforced with reinforcements of AlN, Si_3N_4 and ZrB_2 with weight percentages. AlN is employed as reinforcement due to the excellent properties such as thermal expansion co-efficient, thermal stability and high strength [5]. Si_3N_4 and ZrB_2 are also offered the higher thermal stability and high strength to the composites [6]. The reinforcements with 4 wt.% are added in the Al 2618 aluminium alloy using casting process and prepared as a parent metal (PM). The composite plates are prepared in the size of 100 x 50 x 6 mm. Al 2618 alloy composition is given in the Table 1 and the mechanical properties of the alloy is listed in Table 2.

Table 1 Elemental composition of the Aluminium alloy 2618

Elemental composition of Al 2618 alloy (wt.%)							
Element	Cu	Mg	Fe	Ni	Si	Ti	Al
wt.%	2.30	1.60	1.1	1.0	0.18	0.07	Bal

Table 2 Mechanical properties of the Aluminium alloy

Vickers Microhardness (HV)	**Tensile Strength (MPa)**	**Compressive Strength (MPa)**
120	440	370

2.2 Friction Stir Welding

In solid state welding there are various processes; of those friction stir welding process is the most suitable process for aluminium [7]. FSW is selected for the welding of plates in our study. After cutting the plates for the required size from the cast material, the plates were welded using friction stir welding (FSW) method to make the weld joint. The tool nib was in the size of 6 mm diameter and 5.7 mm long, and the shoulder was 18 mm in diameter. The tool is made of H-13 steel. The welding setup for friction stir welding process is shown in Fig.1.

During friction stir welding, casting defects are removed through the stirring mechanism in the alloy. It is expected that reinforced composite will be offered with enhanced mechanical properties as stated in the literature [8]. The FSW process is carried out for the plates of reinforced Al 2618. For finding optimum weld process parameters, method of trial and error is used [9]. After few trials of process, the appropriate parameters are found. The process parameters employed in this investigation for the welding process of the workpiece are presented in Table 3.

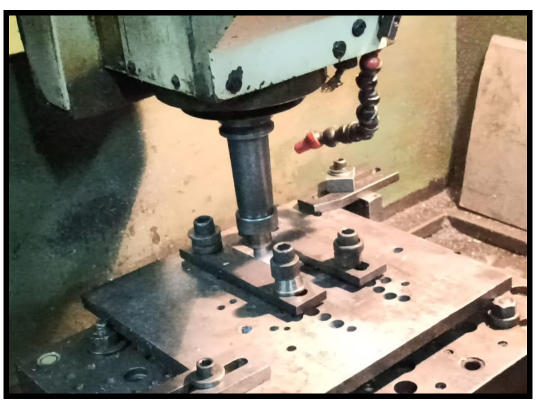

Fig.1. Welding setup used in this study

Table 3 FSW process parameters

Speed (rpm)	**Feed (mm/min)**	**Load (kN)**	**Tool tilt (Deg)**
2000	5	5	0^{o}

3. Results and discussion

The welded specimen of reinforced Al 2618 is then subjected to scanning electron microscopy (SEM) with EDX, optical microscopy, XRD, micro hardness and impact testing. SEM observations of the base metal (Al 2618) are found to have an improved microstructure.

3.1 SEM evaluation of welded specimens

SEM micrograph shows that the reinforcements were evenly distributed in both the parent material and reinforced welded plates. SEM results are taken at 500 x to obtain the required view of grains and focus. The SEM image of the specimen of 4% reinforced Al 2618 at weld zone and base metal are shown in Fig.2 and Fig.3. It has been clearly showed that grains in weld zone are refined and better than that of base metal.

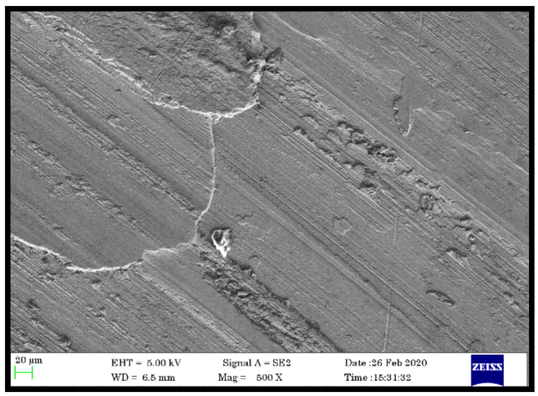

Fig.2 SEM micrograph of weld zone

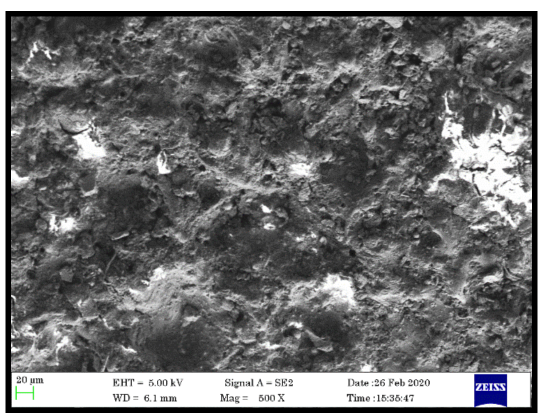

Fig.3 SEM micrograph of base metal

SEM image shows the bright and dark spots that prove the existence of aluminium and Zrb_2 and Si_3N_4 particles in the casted composite as well as welded composite. In the casted composite, the cluster of reinforced particles is noticed. It is due to the higher density of the reinforcement particles than the aluminium. Reinforced particles are evenly dispersed in the welded composite as compared to casted material. From the SEM images, it is found that the good interface between the Al matrix and reinforced particles.

3.2 Optical microscopy test

Microstructures of casted and welded Al 2618 composite are captured using optical microscope as shown in Fig. 4 and 5. Dynamically recrystallized grain structure is noticed in the stir zone (weld zone). Welded alloy is noticed with even distribution of Al matrix and reinforced particles in the stir zone. Additionally, refinement of the grain structure is also noticed in the stir zone of welded Al 2618 composite. The good interface between the Al matrix and the ceramic reinforcement particles is achieved at the stir zone of the welded Al 2618 composite. Accumulation of the reinforcement particles in the composite lead to reduction of mechanical properties. In this welded Al 2618 composite, uniform distribution of ceramic particles is expected to offer excellent mechanical properties.

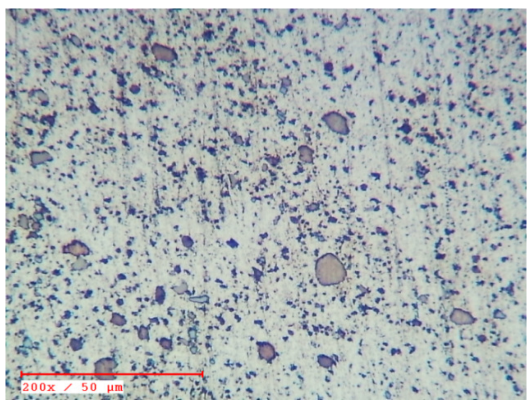

Fig.4 Optical micrograph of Weld zone

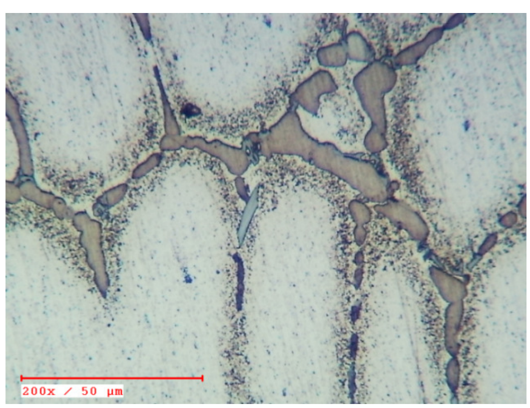

Fig.5 Optical micrograph of base metal

Microstructure of casted composite is shown with evenly distributed dendritic structure that is successfully produced through the stir casting process. In common, augmented size and shape of reinforcement particles in the Al composite enhance the wear properties. The shape of Al 2618 metal matrix is round and cylindrical as seen in the microstructure. Selection of size for the reinforcement particles is based on the specific applications. Composite is noticed with phases which is observed with good interfacial bonding between the Al matrix and Zrb_2 reinforcements. The Al 2618 composite during welding the heat is evenly distributed and the particles were internally migrating within the weldment area. The higher bonding of the composite is seen while the heat is reduced gradually.

3.3 Vickers Hardness test

The microhardness test is conducted in the Al 2618 composite with the load of 1 kg using Vickers hardness tester. The hardness is tested at three regions since it is a reinforced material. The hardness values of welded Al 2618 composites are shown in table 4.

Table 4 Micro hardness test results

ZONE	LOAD (Kg)	REGION 1 (HV)	REGION 2 (HV)	REGION 3 (HV)	AVERAGE (HV)
WELD ZONE	1.0	76.0	79.8	82.9	79.5

3.4 X-Ray Diffraction

XRD test is taken to obtain the intermetallic phases formed in the specimen. In the XRD results, highest peaks are referred the aluminium-rich phase. The nitride phases are noticed nearer to the Al peaks in the XRD plot. Zirconium diboride and silicon nitride phases are seen from the minor peaks of the XRD plot. The XRD test result is shown in Fig. 6. Different phases such as Al, Si_3N_4, AlN, and Zrb_2 phases are found in the Al 2618 composite.

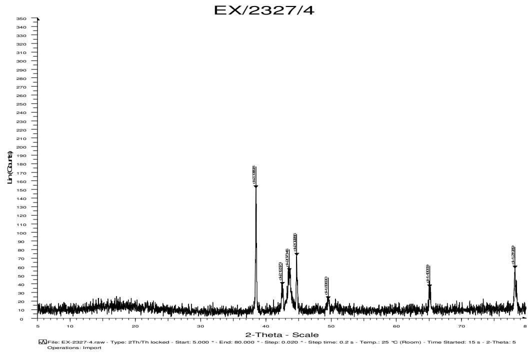

Fig.6 XRD result of test specimen

3.5 Impact test

The test specimen is exposed to the notch-impact tests with the charpy method and the specimen is prepared as per the standards. The results of the impact test of specimen were collected in terms of impact energy shown in table 5. The impact results exhibited that the resistance to impact energy of composite was significantly increased by the reinforcement particles.

Table 5 Impact test results

Zone	**Notch-impact toughness (J/cm^2)**
Weld zone	≅ 30.5

3.6 EDS analysis

EDS analysis is used to assess the quantitative and qualitative elemental analysis of Al 2618 reinforced composite. The result for the EDS of Al 2618 composite is shown in Fig. 7. It is found to have a number of compositions of various particles than that of Al 2618. Weldment surface of the Al 2618 composite is analyzed using EDS analysis. Higher peak density denotes the Al, Si, and Zn elements in the composite. These elements are the reason for the higher bonding achieved in the composite.

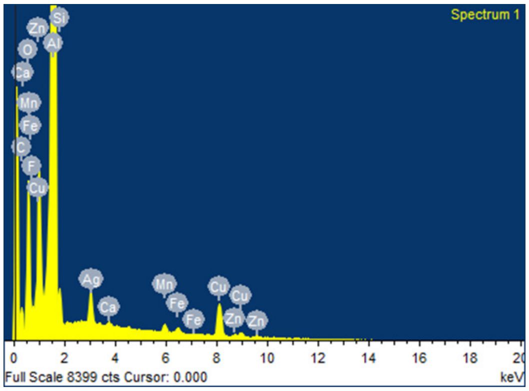

Fig.7 EDS spectrum of weld zone

4. Conclusions

Successful friction stir welding is achieved on the ceramic particles reinforced Al 2618 composite. Enhanced properties are attained in the friction stir welded composite as compared to parent metal. Optimum parameters improved the weldability of the composite. Defect-free friction stir weld is attained in the Al 2618 composite.

- The microstructure was noticed with dynamically recrystallized grains in the stir zone than that of the parent metal.
- Results from SEM and OM depict the existence of reinforcement and uniform distribution of composite throughout the stir zone.
- The microhardness in the weld zone of reinforced Al 2618 composite was higher than that of the Al 2618 composite.
- The EDS has proved the chemical composition of Al 2618 composite and the XRD was used to confirm the reinforcement presence in the Al 2618 composite.

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