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INFLUENCE OF REINFORCEMENT RATIO AND TAP SIZE IN THREADING OF AA2219- TIB2/ZRB2 IN-SITU COMPOSITES

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ABSTRACT

Aluminum matrix composite is a ductile-brittle interface system, and receives the attentions of numerous researchers. In-situ composites are the synthesized with the objective of enhancing the mechanical properties with minimal reinforcement ratio. Assembly of machine components requires the fastening. It is unavoidable to the use of elements with external and internal thread for making the engineering components. Tapping is one of the important processes to make the thread on the components. The present paper studies the influence of reinforcement ratio and tap size on in threading of AA2219- TiB2/ZrB2 in-situ composites. Delamination, pitch of the thread and depth of the thread are considered as responses. The analysis of the result shows that the reinforcement ratio has significant influence on the responses of the thread.

Key words: *In-situ composite, Tapping, delamination, Pitch of the thread, Depth of the thread.*

1. Introduction

Composites are a combination of two or more phases that are mechanically mixed on a macroscopic level. Composite materials can be considered in engineering applications where the monolithic alloy cannot provide the specific set of properties that are required. The composites have flexibility to tailor made and able to produce a set of properties that are unique and cannot be provided by the individual elements [1].

Aluminum matrix composites widely used in aerospace, automotive and structural application because of their improved mechanical properties, wear resistant, damping capacity and reduced density[2].The composites produced by ex-situ process are limited in application due to poor wetting between the matrix and reinforcement, cluster formation of the reinforcements, diverse microstructure, coarse reinforcement and non-uniform distribution of reinforcements[3]. Heterogeneous mechanical property at matrix, reinforcement and, matrix-reinforcement interface of the composite causes the uneven deformation when forming the engineering components [4]. Presence of coarse and erosive nature of the reinforcements damage the cutting tool and results excessive tool wear and poor surface finish during machining of the ex-situ composites [5]. The composites synthesized by in-situ chemical synthesis route may be the suitable candidates to conquer the above mentioned limitations. The reinforcements are formed by exothermic chemical reaction. Hence, in -situ composites have fine and small reinforcements, strong interfacial bonding between the matrix and reinforcement, homogeneous microstructures and thermodynamic stability [6]. These advantages offer improved mechanical properties and homogeneously distributed reinforcement, which promotes the machinability and formability. Parametric study of cutting parameters becomes more important to control dimensions of work piece without compromising the rate of production. Flex assisted synthesis is a very cheap and easy route for making TiB_2, ZrB_2 and TiC reinforced in-situ composites [7].V.Anandakrishnan and A. Mahamani [8] studied the machinability behavior of the in-situ Al6061-TiB_2 composites. The influence of speed, feed and depth of cut on flank wear, cutting force and surface roughness are analyzed. It is found from the investigation, the presences of small and fine TiB_2 particles offered significant improvement on machinability. Mahamani et al [9] proposed a multi response optimization of turning parameters in machining of Al 6061-6% ZrB_2 in-situ metal matrix composite with multiple performance characteristics by using grey relational analysis. Analysis of result indicates that the feed rate has the strongest effect on responses. The confirmation experiment indicates that there is a good agreement between the estimated value and experimental value. Senthil et al. [10] attempted to investigate the machinability characteristics of homogenized Al–Cu/TiB_2 in-situ metal matrix composites. They observed that better surface finish is

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obtained at higher cutting speed and low feed. They observed that the chip breakability is improved due to the presence of fine reinforcement. Mahamani et al [11] synthesized AA2219-TiB_2/ZrB_2 in-situ metal matrix composite by flux assisted synthesis. Quantitative elemental analysis report confirms the presence of reinforcements and Al_2Cu phase with the proposed contribution. Mahamani [12] aimed to optimize the turning parameters to minimize the cutting force and surface roughness in turning of AA2219-TiB_2/ ZrB_2 in-situ metal matrix composite. Taguchi L27 orthogonal array and analysis of variance were employed to investigate the effect of turning parameters. Domblesky and Feng [13] studied the influence of the process parameters on material flow and thread profile in external thread rolling of large diameter blanks. They also developed a finite element code by using DEFORM to analyze the effect of varying thread form, friction factor, flow stress, and blank diameter on effective strain and thread height. It is found from the analysis the blank diameter has minimal effect on the thread performance whereas other parameters have significant influence on the on effective strain and thread height. Hayama [14] developed an empirical formula for finding the maximum value of torque experienced in internal thread forming. The each tooth tap or rollers of thread head come into contact with the work-piece material deform the work material and deformed material flows upwards along the faces of the tooth or rollers. The successive tooth or rollers forms the thread at desired depth of cut [15]. Forces generated during the rolling process are the combined effect of the deformation of work-piece and resulting flow of deformed material along the faces of the tooth [16]. The literature review shows that, the studies on the tapping of the composites are scarce. Therefore, an attempt has been made to investigate the influence of reinforcement ratio and tap size on delamination, pitch of the thread and depth of the thread in threading of AA2219- TiB2/ZrB2 in-situ composites.

2. Synthesis and Characterization

Flex assisted synthesis method is followed to produce composites. AA2219 was used as the matrix material. Three types of halide salt, namely potassium hexa fluorotitanate (K_2TiF_6), potassium hexafluorozirconate (K_2ZrF_6) and potassium tetrafluroborate (KBF_4) were used to synthesize the TiB_2 and ZrB_2 reinforcements [14]. The quantity materials required to produce the composite is shown in the Table 1. During the synthesis, the preheated halide salts introduced into the aluminum alloy melt at 850°C. The melt is stirred up to 15 minutes and allowed for chemical reaction. Molten aluminum alloy reacts with halide salts by exothermically, and releases the temperature up to 1300°C.

Table 1. Amount of materials required for producing MMC

S. No	Name of materials	Quantity (Grams) 0% TiB_2/ZrB_2	3% TiB_2/ZrB_2	6% TiB_2/ZrB_2
1	AA2219	2250	2250	2250
2	K_2TiF_6	Nil	40	80
3	K_2ZrF_6	Nil	45	90
4	KBF_4	Nil	30	60

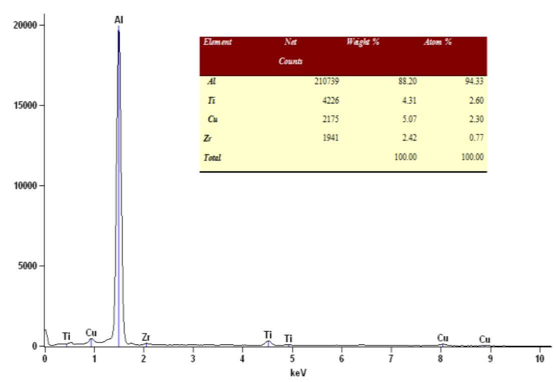

Fig. 1 EDAX pattern of the AA2219- 6% TiB_2/ZrB_2 in-situ composite

Due to this exothermic reaction, the TiB_2 and ZrB_2 particulates are formed and dispersed in the aluminum grain boundaries. $KAlF_4$ and K_3AlF_6 formed by the chemical reaction are removed as slag. Then the molten composite is poured into graphite-coated cast iron mold. Quantitative elemental analyses of in-situ AA2219- TiB_2/ZrB_2 metal matrix composites are carried out by using Hitachi S-300H EDAX analyzer and shown in Fig.1. Aluminum, copper, Titanium boride and zirconium boride elements are detected in the pattern and 4.31 % titanium boride and 2.42 % zirconium boride elements are observed in the detected in the AA2219- 6 % TiB_2/ZrB_2 sample. Microstructure of the AA2219-6%TiB_2/ZrB_2 sample is recorded by using JEOL6360 LV Model scanning electron microscope and shown in the Fig.2and 3. The Fig.2 also indicates that there is good interfacial assimilation between the reinforcements, Al_2Cu and Aluminum matrix. TiB_2 and sub-micron ZrB_2 reinforcement distribution is observed in the Fig.3. These reinforcement particles are observed at 5000 X magnification. The average size of TiB_2 particle is measured about 1µ whereas the size of ZrB_2 is 0.7 µ. Microstructure and EDAX analysis shows that there is no impurity and any

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undetectable interface is observed in the microstructure and EDAX pattern.

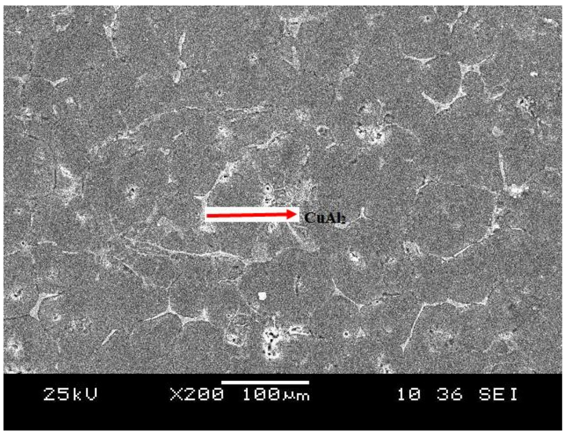

Fig. 2 SEM image of the AA2219- 6% TiB2/ZrB2 in-situ composite (200 X)

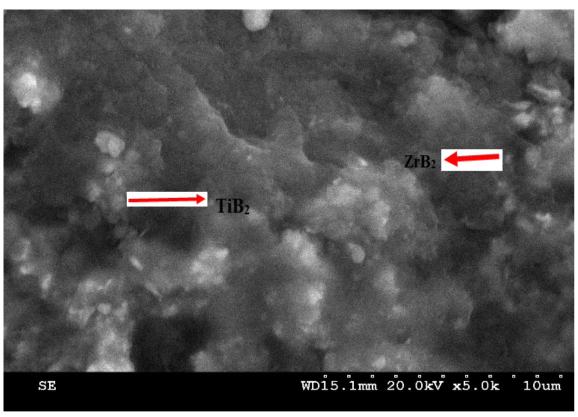

Fig. 3. SEM image of the AA2219- 6% TiB2/ZrB2 in-situ composite (5000 X)

3. Experimental Work

Speed, feed rate, drill bit diameter, point angle and reinforcement ratio are considered as machining parameters. The response to be studied here is reinforcement and delamination. The level of the machining parameters is given in the Table 2. Metallurgical microscope is used for measuring delamination. The composites specimens before the experimental work are displayed in Fig. 4. Experimental work was carried out as per the given scheme and the drilled and tapped composites are shown in Fig. 5. The cross section view of the internal thread is shown in Fig.

Table 2. Factors and Levels of Experimental Work

Factor	Notation	Unit	Level 1	Level 2	Level 3
Drill bit diameter	D	mm	7.3	8.4	12.3
Reinforcement ratio		%	0	3	6
Spindle speed	N	Rpm		695	
Feed rate	F	mm/rev		0.15	
Point Angle	PA	degree		120	

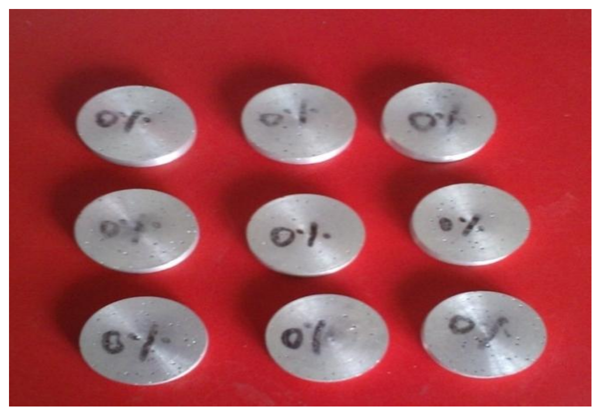

Fig. 4 (a) Work piece before drilling 0% composite

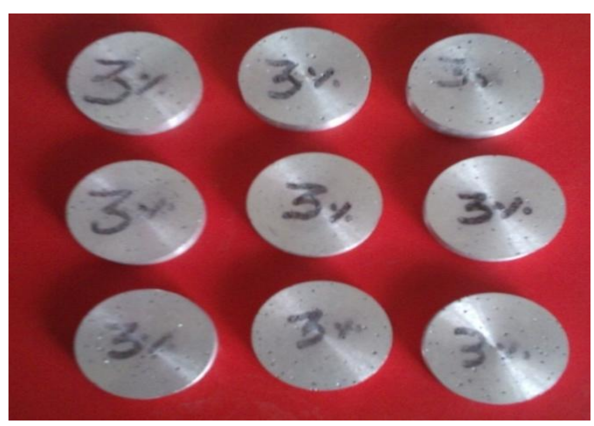

Fig. 4 (b) Work piece before drilling 3% composite

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Fig. 4 (c) Work piece before drilling 6% composite

Fig. 5 Work Piece after drilled and tapped composite

Fig. 6 Cross sectional view of thread tapping in AA2219- TiB2/ZrB2

4. Results and Analysis

The edge of the drill and tap bit gets bending, when feeding against the work piece. Inaccuracy in the size of the hole is observed at the top of work piece. There is a small enlargement in the hole is called delamination. The delamination factor was measured by metallurgical microscope (Metzer optical instruments private limited, India). Experimental work is carried out as per Table 2 and reported in the Fig's 7-9.

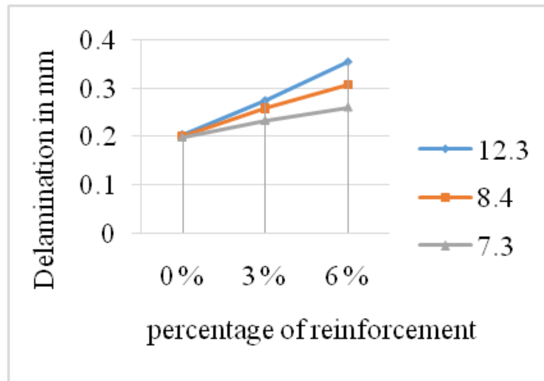

Fig. 7 Effect of Reinforcement ratio on delamination

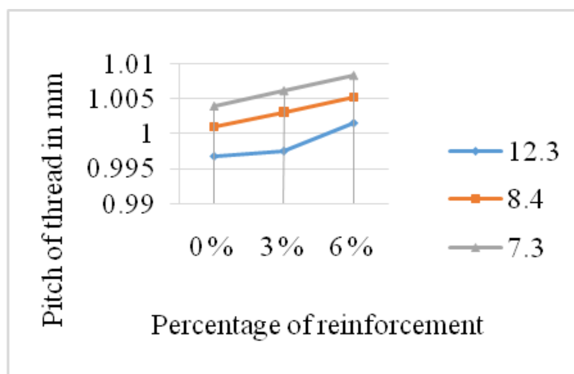

Fig. 8 Effect of Reinforcement ratio on Pitch of the thread

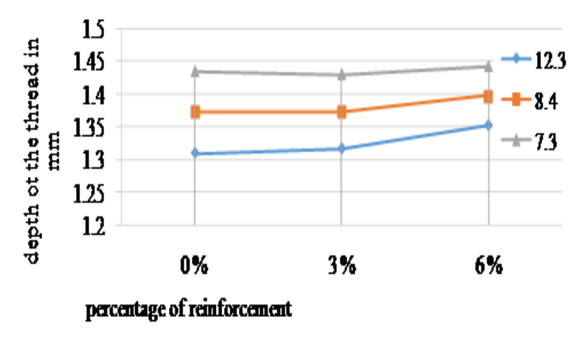

Fig. 9 Effect of Reinforcement ratio on Depth of the thread

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Fig. 7 shows that the influence of the reinforcement ratio of the composites on delamination at the top surface of the hole. It is observed from the Fig. 7, the delamination for unreinforced alloy is less than composites and also seen from the Fig. 7, the increase in reinforcement ratio increase the delamination. Detachments of the particles are increased at higher reinforcement ratio and leads to increased delamination.

Fig. 7 also depicts that the value of the delamination is increased by increasing the size of the tap. More torque is applied for tapping the bigger size hole generation. Application of the excessive torque will enlarge the size of delamination.

The influence of the reinforcement ratio on the pitch of the thread is displayed in the Fig. 8. Fig.8 shows that, the increase in reinforcement ratio increase the pitch of the thread. It is observed from the same figure the pitch of the thread for monolithic alloy is less than composites and the pitch of the thread is increased by increasing the reinforcement ratio. The reinforcement particle and Al2Cu pulling will be more at higher reinforcement ratio. This pulling effect extends the size of the pitch. The Fig. 8 also indicates that, the pitch of the thread is more when using the smaller diameter tap and increase in tap size decreases the pitch of the thread.

The Fig. 9 depicts that the influence of reinforcement ratio on depth of the thread. It is seen form the Fig. 9, the depth of the thread for the unreinforced alloy is less than the composites. As the reinforcement ratio increases, the depth of the thread is increased. It may be attributed that the increase in reinforcement ratio increases the presence of ceramic phase in the material. The removal of reinforcement and Al2Cu due to the torque, cause more depth of thread. Fig. 9 also discloses that, the increase in tap size decrease the depth of the thread. Similar observation also made for pitch of the thread. Owing to the larger diameter of the tap reduces the load on the material. Hence the pitch and depth of the thread is decreased when using the larger diameter tap.

5. Analysis of the Microstructure

Fig. 10 and 11 discloses the scanning electron microscope image of thread made on unreinforced alloy and 3% composites respectively. These threads are formed by using 7.3 mm size tap. It is found from these images; the thread formation on the unreinforced alloy is clear and scratch free whereas the 3 % composite has more scratches due the reinforcement particles, deposition of the Al2Cu and broken debris. This effect enlarges the delamination, pitch and depth of the thread. The micro image of the thread formed by 8.4 mm tap on 6 % composite is shown in Fig. 12, which depicts more scratches and more deposition of the Al2Cu on the threads.

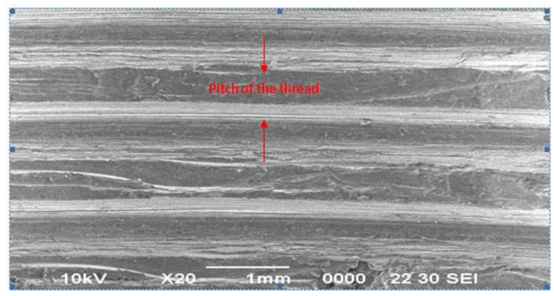

Fig. 10 SEM Image of 0% composite (7.3 mm Tap)

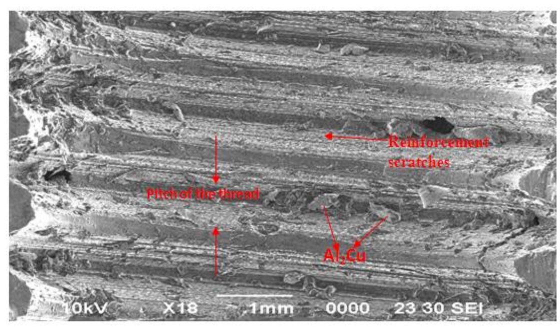

Fig. 11 SEM Image of 3% composite (7.3 mm Tap)

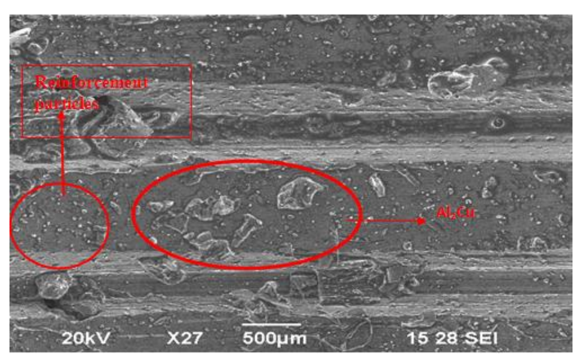

Fig. 12 SEM View of 6% Composite (8.4 mm Tap)

Presence of more reinforcement particles in 6 % composite shears more quantity of the Al2Cu and deposits the on the thread surface. Figs 13 and 14

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clearly bring out the influence of tap size on thread. The thread is made on 6 % composites. Fig. 13 and 14 depicts that the thread is made with 7.3 mm tap and 12.3 mm tap respectively. More Al2Cu deposition is observed in the Fig. 14 than Fig. 13. Area of contact is more for 12.3 mm tap and shears more quantity of the Al2Cu and deposited over the thread. Hence, the pitch and depth of the thread is less when using the 12.3 mm tap.

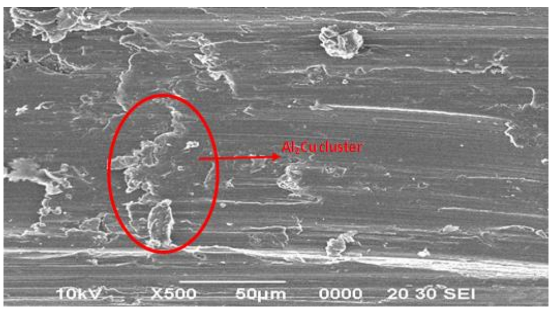

Fig. 13 SEM Image of thread formed by 7.3 tap size (6 % Composite)

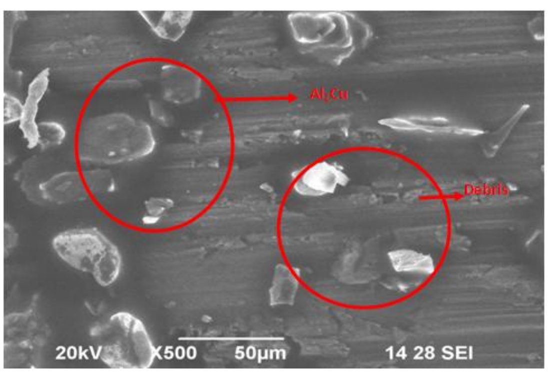

Fig. 14 SEM image of thread formed by 12.4 tap size (6 % Composite)

6. Conclusion

The influence of the reinforcement ratio in threading of AA2219- TiB2/ZrB2 in-situ composites is investigated. Based on experimental results and discussions the following conclusions are drawn.

1. The increase in reinforcement ratio is increased the delamination.
2. As the reinforcement ratio increases the pitch and depth of the thread are increased.
3. Pitch of the thread and depth of the thread is increased by increasing the tap size.
4. Analysis of the results shows that the reinforcement ratio and tap size have significant influence on the delamination, pitch and depth of the thread.
5. Microstructure analysis points out the deposition of the Al2Cu and reinforcement scratches on the thread surface.

These findings will help the material designer to control the dimension thread under different reinforcement ratio.

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