

Journal of Materials and Engineering Structures

Research Paper

Evaluation of Mechanical, Wear and Fracture Behavior of Silicon Carbide Particulates Reinforced Al7075 Composites using Response Surface Methodology Technique

M. Ravikumar^{a,*}, Rudra Naik^a, Y. S. Rammohan^b, S. Raghavendra^c, R. Suresh^d

^a Department of Mechanical Engineering, B M S College of Engineering, Bangalore - 560019, India

^b Department of Aerospace Engineering, B M S College of Engineering, Bangalore - 560019, India

^c Department of Mechanical Engineering, Sai Vidya Institute of Technology, Bangalore - 560064, India

^d Department of Mechanical Engineering, M S Ramaiah University of Applied Sciences, Bangalore - 560054, India

ARTICLE INFO

Article history :

Received : 3 May 2023

Revised : 29 September 2023

Accepted : 13 October 2023

Keywords:

Al7075

Silicon carbide

Mechanical properties

Tribological behavior

Taguchi technique

ABSTRACT

High-strength composite materials have been created as a result of the rising need for materials to improve the performance of civil, aeronautical and marine components. Among these, Al Metal Matrix Composites are commonly used to meet engineering requirements. The present research works focuses on manufacturing and exploring Al7075 alloy micro-structure, mechanical and wear characteristics of Silicon Carbide (SiC) particulates with weight percentages of 3, 6 and 9 respectively. Al7075-SiC composites have been produced by using metallurgical route. The microstructural study revealed a uniform distribution of SiCp. The existence of SiC has been affirmed by Energy Dispersive Spectroscopy (EDS) analysis performed on the developed composite (Al7075-9 wt. % SiCp). To study the loss of wear, experiments were performed on a tribometer attached to a hard steel disk. The wear parameters were optimized using the central composite design in response to the surface technique. The obtained results indicated that the mechanical properties of composites improved when SiCp was added. The developed model effectively predicted the wear rate with 95% reliability and results of all models were confirmed by ANOVA (Analysis of Variance).

1 Introduction

Cast iron and steel elements can be replaced with lightweight Metal Matrix Composites (MMCs), particularly when aluminium (Al) is utilized as the base material. Al alloy has garnered a lot of interest for use in aircraft applications due to

* Corresponding author. Tel.: 8105678747.

E-mail address: ravikumar.muk@gmail.com

its superior strength-to-weight ratio, low density, and higher specific strength when compared to standard Al alloy. It is generally used in aircraft parts like fuselage and skin under tension. Al alloy of 7XXX series is also called Al-zinc alloy due to the presence of zinc in quantity of 5.1 - 6.1 percent. Al-7XXX series was developed first by Sumitomo Metal, a Japanese company, in the year 1942-43, for the production of airframe for Navy [1, 2]. Al7075 has a wide range of engineering applications and due to this it is required for addition of reinforcements. Al alloy is used as the base material and it offers numerous characteristics by adding required single / multiple reinforcement particles, which exhibit higher strength compared to base alloy. The MMCs have better strengthening mechanisms, which improve the properties of material. Aluminum alloys in Al composites is called the matrix phase. Another constituent used in these alloys, which is added as reinforcement is typically ceramic reinforcements such as SiCp / Al_2O_3 . Addition of SiCp particulates in Al alloy generally increases the material properties like improved strength, better wear resistance, good corrosion resistance and low density over base alloy. Continuous fiber reinforced composites are not considered due to their high cost and they also pose a health hazard, on the other hand, short fibre reinforced composites are effective and efficient due to their anisotropic properties. Thus, it is necessary to develop particulates reinforced Al-based composites with low density, good formability and isotropic properties.

The composites reinforced with the ceramic particulates like Silicon Carbide (SiC), Boron carbide (B_4C), Titanium dioxide (TiO_2) and Aluminium oxide (Al_2O_3) [3-5] reveal better strength, though they suffer from high drawback of low ductility. The decrease in ductility is due to the fragility of the products of the interfacial reaction, clusters of particles, poor wetting, as well as the lack of porosity and contact at the interface between the particles and the matrix. Loss of wear is one of the most common problems that lead to damage in components and assemblies. This usually reduces the efficiency of the metal components and leads to regular replacement of components. Thus, it is vital to study the wear characteristics of industrial materials. V. Bharath et al. [6] compared the mechanical properties of alloys with a low percentage of hard ceramic particulates in relation to alloys with a high percentage of hard ceramic particulates, which show high resistance and ductility. 15% hard ceramic particulates reinforced alloy led to a reduced tensile strength and the major reason for reduction in tensile strength was primarily because of an increase in the percentage of reinforcement content in the alloy to a high degree. There are a significant number of papers available which are generally report the wear characteristics of Al composites reinforced with various types of reinforcing particulates [7].

The wear characteristics of Al composites are higher than that of monolithic material. Mathematically different models can be prepared to define the required output variables and to determine the interaction between the input and output parameters with minimum number of tests [8]. Taguchi technique can be successfully applied to determine the relationship among the independent parameters like load, reinforcement/s content and sliding distance to investigate the wear behavior of the developed composites. Kwok and Limb [9] studied the wear behavior of Al-SiC composites and found that wear resistance increased by enhancing the load and movement speed. Also, regarding the wear rate of SiC reinforced Al composites, Sahin [10] studied the effect of the load, sliding distance and particulates size using a Taguchi approach. It was observed that, by increasing the sliding distance, load and size of particles the rate of wear of these MMCs increased. Acilar et al. [11] found that there was an increase in wear due to increasing load and sliding distance in Al-/SiCp MMCs. Though, oxidation of SiC particulates is highly effective in high wear resistance of the developed MMCs. From the above literature study, it was found that, reinforcement volume fraction is a major factor which influences AMCs. High reinforcement volume fraction contributed towards strength enhancement of AMCs. In summary, higher volume fraction of SiCp composites results in improvement of material properties such as tensile and hardness strength, with decrease in ductility. Though, addition of high wt. % of SiCp results in degradation of mechanical strength. Typically, the production of Al-SiC composites becomes a very difficult part for investigators without agreeing on the optimistic effect of solid ceramic reinforcement [12]. This research is aimed at studying the properties of Al7075 + SiCp reinforcing compositions prepared by the method of stir-casting.

The novelty of the research work is to parametric optimization of wear parameter in SiC reinforced Al 7075 composites. The main aim of the present study is to do an evaluation on possible application of Al7075-SiC composites, especially in automobile and aerospace materials applications in which the seizure resistance is important. To achieve this objective, it is necessary to find out (i) the effect of varying the wt. % of SiC particles addition on the microstructure and (ii) mechanical and wear behavior of Al7075 alloy and its composites. Taguchi wear modeling was adopted, as well as regression analysis was applied using ANOVA to optimize wear loss in the composite and reduce the total number of experimental trials. Al7075 general application was done in aircraft industries, generally, to reduce the wt. of the aerospace components like frames, stringers and overlapping regions.

2 Material and fabrication of the composites

Due to its strong corrosion resistance, the 7075 Al alloy is frequently used in civil, automobiles, aircraft, and marine engineering. SiC is an excellent abrasive particulate and is highly resistant to acids, alkalis and molten salts up to 750°C [13]. SiC particulate form a protective coating at 1250°C, and also generally, remains up to 1650°C. High strength, high thermal conductivity, and low thermal expansion make this material suitable for use in heat shock resistant [14]. For the production of Al7075-SiCp composites, Al 7075 alloy (bright extruded bar) was used as the base material and the SiC particulates of micro size an average of 25 - 30 μm were used as the reinforcement content. The chemical compositions of the matrix material are presented in Table 1. Stircasting method is the significant technique used in the fabrication of Al composites. This method is used to melt metals such as aluminum, magnesium and copper. This is one of the most effective and prominent methods used to make metal matrix composites [15].

In this present research work, SiC particulates were preheated to 650°C and added into the molten melt inside the crucible placed in the coke furnace. Micro-SiCp powder of 0, 3, 6 and 9 % were added to the molten metal. The furnace temperature was of 750°C and the stirring process was continued for 2 minutes to maintain a uniform mixture of melt at a stirring speed of 100 rpm. Stirring at high temperature enables dissolving of agglomerates. Molten metal was then poured into a metal die and allowed to solidify, and later the castings were removed from the mold box. This procedure was repeated with varying wt. % of reinforcements of other samples. The microstructure of the surfaces was examined after preparing by using through 200 - 1000 grit size emery papers and then polished with 0.5 μm of diamond paste. Microscopic examination of the developed composites was carried out by an optical microscope. According to ASTM E82 standards, the hardness of developed MMCs was checked using a diamond indenter with a load 10 kg. To study the mechanical strength of the MMCs, tensile tests and compression tests were carried out by UTM as per ASTM E8 standards. UTM machine with continuous loading for the interval of 10 N during the tensile test. Impact strength was evaluated as per the ASTM-D256 standards by Izod method. Wear test on composite specimens of 8 mm dia and a 30 mm long were performed using a pin-on-disc tribometer in accordance with ASTM-G99 standards. Wear surface were prepared with 2000 grit size of emery paper and wear rate was measured by using weight loss method. The levels of each input factor are shown in Table 2.

Table 1 – Experimental design with responses [4].

Content	Zn	Cu	Mg	Si	Fe	Mn	Ni	Sn	Cr	Al
Wt. %	5.424	1.480	2.306	0.059	0.256	0.052	0.052	0.012	0.28	Remaining

Table 2 – Input levels of process parameters [4].

Sl. No.	Parameters	Levels
1	SiC (wt. %)	3, 6, 9
2	Load (N)	10, 20, 30
3	Sliding Distance (m)	500, 1000, 1500

3 Results and Discussions

3.1 Microstructural study

The micrographs of developed MMCs are depicted in Fig. 1. Uniform distributions of reinforced particles were observed. Reinforced particulates inhibit the growth of dendrites, resulting in improved mechanical behavior. Micrographs of all composites with an interface show a good bonding between SiCp particles and Al alloy. It is desirable to distribute the particulates evenly to achieve wear and mechanical properties. Mixing of the slurry resulted in a high rate of deformation and uniform distribution of reinforcement in the molten metal. This can be seen from optical micrographs where, as the wt. percentage of microparticles increases, the granular size of the matrix decreases and such behaviour is due to the high level of grain boundary, which prevents the growth of grain. SiC particulates were uniformly distributed in Al7075, and a homogenous microstructure was obtained by using stir casting technique.

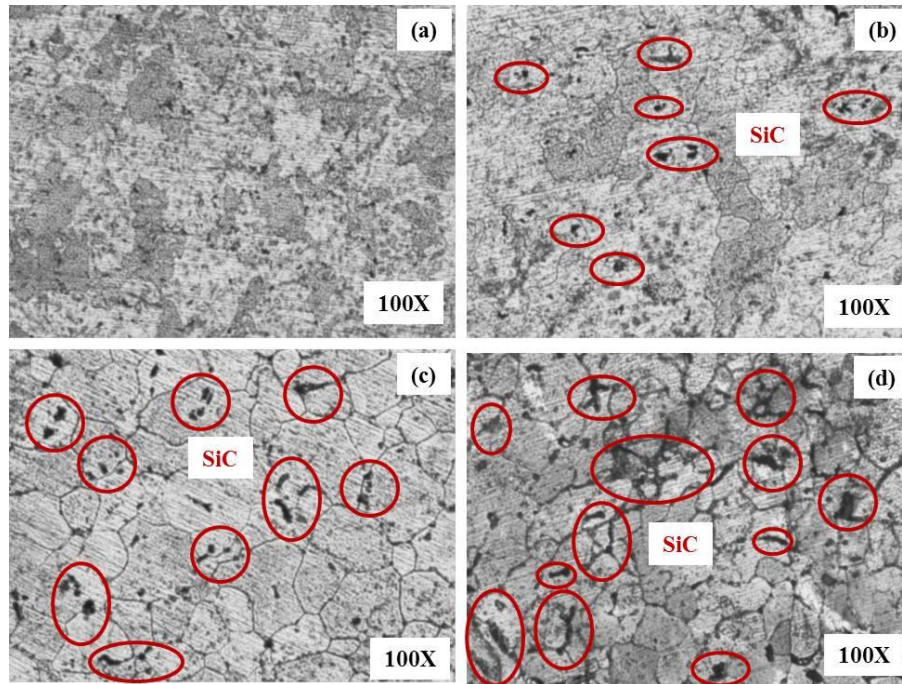


Fig. 1 – Optical microscopic images of Al7075 alloy and composites: (a) 0 wt. % of SiC, (b) 3 wt.% of SiC, (c) 6 wt.% of SiC and (d) 9 wt.% of SiC.

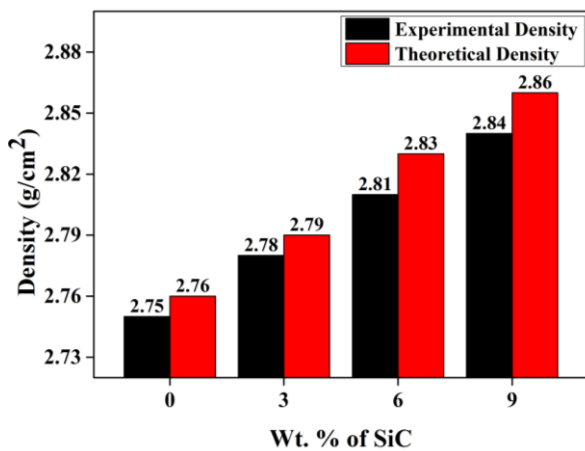


Fig. 2 – Theoretical and experimental densities of Al7075-SiC composites.

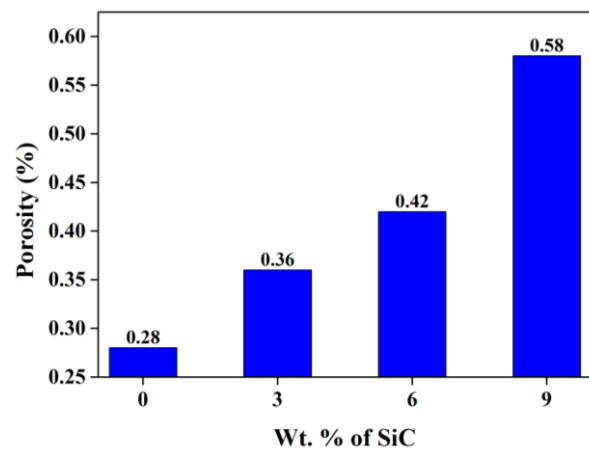


Fig. 3 – Porosity percentages of Al7075-SiC composites.

3.2 Density and porosity

Fig. 2 depicts the density of the developed MMCs based on experimental and theoretical values. It is observed that the experimental and theoretical values of density closely match with each other. So, it can be concluded that stircasting is suitable for effective preparation of MMCs. It is found that, density of the developed MMCs increases with increasing reinforcement composition [8]. The increase in density may be due to the higher density of SiC particulates compared to Al7075 alloy. The experimental density of composite samples calculated with Archimedes' principle apparatus (water displacement method). The theoretical density of developed MMCs was calculated based on the research paper [15]. The standard density of Al7075 (2.7 g/cm^3) and density of SiC (3.21 g/cm^3) with varied wt. % of 0, 3, 6 and 9 % of SiC the theoretical density of developed MMCs were calculated. The theoretical results for densities values were obtained by using Equation 1.

$$\text{Theoretical density} = (\text{density of Al7075} + 3 \text{ wt.\%} * \text{density of SiC}) \quad (1)$$

Fig. 3 depicts the variation of porosity of developed MMCs with respect to wt. % of SiC content. The % of porosity of the developed MMCs increases with increasing reinforcement. This increase in porosity value may be because of the addition of SiC particles to the matrix alloy or it may be due to the presence of impurities in the MMCs.

3.3 Hardness

Micro hardness tests with a load of 10 kg were performed on samples of Al7075-SiCp compositions. Fig. 4 depicts the effect of micro sized particles of silicon carbide on the hardness of the cast MMC. Hardness of the developed MMCs with high wt. % of SiC content is higher when compared to base matrix, due to the uniform dispersal of SiC particulates in the melt during stirring process. The reinforcement and base matrix bonding are good due to preheating of the reinforcing particulates. Similar outcomes were observed by Dipankar Dey et al. [16]. Hardness improvement is due to the fact that SiCp possesses high hardness and owing to its presence in the MMCs the hardness increased. An increase in hardness may also be related to a decrease in grain size.

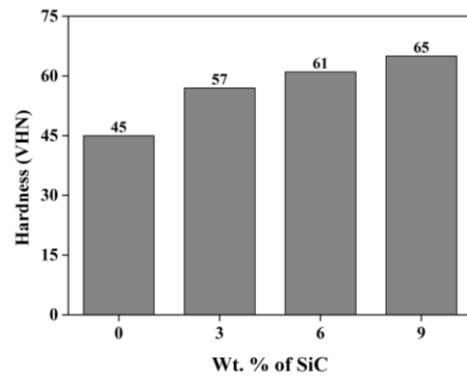


Fig. 4 – Hardness of composite.

The addition of SiC particulates into Al alloy improved the density of dislocation at the interface of reinforcement and matrix. The improvement in density of the dislocation occurred due to the difference in the coefficient of thermal expansion of the reinforcement and matrix, which led to enhanced hardness in developed MMCs.

3.4 Tensile test

In accordance with ASTM E8 standards, tensile test was performed on the test samples of Al7075-SiC composites and the results were plotted on a graph. Fig. 5 depicts the tensile strength of developed MMCs with different wt. % of SiCp content. Better strength in composites was observed, may be due to the uniform dispersal of particles. Strength improvement was achieved by strengthening and bearing of high loads by reinforcing SiC particles. As the wt. % of the reinforcement increased, most of the load fell on the reinforced particles, which also improved the strength. Similar outcomes were observed by Dipankar Dey et al. [17], where the tensile strength of the developed MMCs was considerably enhanced compared to monolithic. This is due to the fact that, fine SiC particulates facilitate good bonding with the matrix. Secondly, changes in the coefficient of thermal expansion also affect the mechanism of strengthening the MMCs. In general, while composites manufactured by the addition of SiC particulates showed an improvement in strength but showed a decrease in ductility, and SiC particulates acted as initiators of microcracks in the process of deformation. Generally, SiC particulates are brittle in nature and have better strength.

Throughout deformation, two types of micro-cracks are triggered by the SiC particulates. Firstly, if the interface unit between the SiC particulates and the matrix material is strong, then the dislocation density and the local strain and stress reach critical values with high concentration. Secondly, if the interfacial bond among the SiC particulates and the matrix material is weak, the decoction between the SiC particulates and the matrix material occur with nucleated micro-cracks before the SiC particles break. Therefore, strong interface increases the flexibility and strength of developed MMCs, as weak interface nucleate micro cracks at low external stress. Fig. 6 shows the development of elongation with wt. % of SiC particles.

It is observed that the elongation of the developed MMCs decreased with increasing wt. % of SiC particulates. The decrease in elongation of developed MMCs is due to the reduction in the dislocation of slip distance with increasing SiC content. [17-20]. Fig. 7 shows the fractured surfaces of Al7075-SiC composites. Fig. 7(a) base material, it clearly shows that the fractured surface of matrix consists of number of dimples, thereby indicating that the nature of failure could be ductile. However, the fractured surfaces of SiCp reinforced MMCs consists of grooves within the matrix phase and also decohesion of reinforcements from the matrix phases (Fig. 7(b)-(d)). The presence of the dimples can be attributed to fusion and nucleation of cavities caused by de-cohesion of reinforcement and shear deformation due to the strength and ceramic fragmentation under the influence of stress concentration. SiC particles confirmed the occurrence of elongation and brittle fracture in the case of MMCs compared to fractured surface of monolithic. Finally, it can be found that the adding SiC particulates in Al matrix leads to reduction in the ductility [16-18].

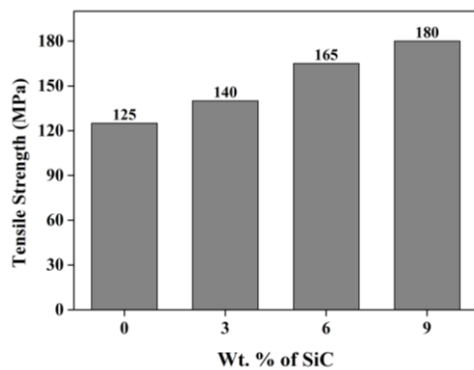


Fig. 5 - Tensile strength of composite

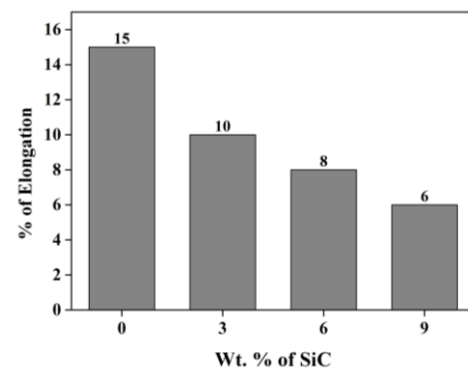


Fig. 6 - Elongation (%) of composite

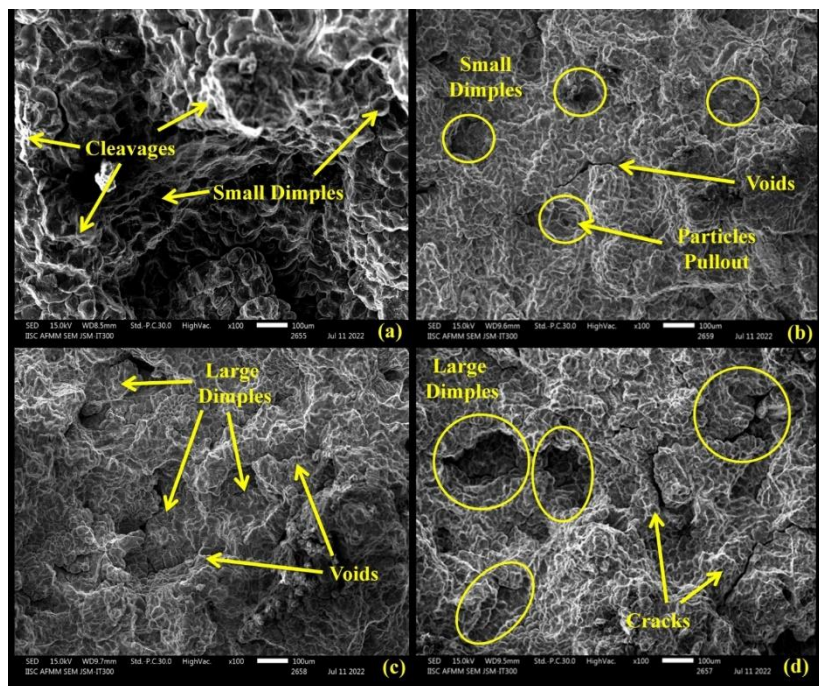


Fig. 7 – SEM fractographs of composites with various volume fractions of SiC particles: (a) 0%; (b) 3%; (c) 6%; (d) 9%.

3.5 Toughness (Impact test)

The energy absorbed by the sample in the event of a sudden load was measured by using an impact test process in accordance with ASTM D256 standard. This test is a test where the strength value can be used to measure the amount of energy in a material at break. From Fig. 8, the impact strength of MMCs increased by the adding of SiCp content. It is

observed that the sample of 9 % SiCp absorbed more energy compared to other samples due to uniform dispersal and moderate quantity of reinforcing particles. Similar outcomes were observed by Mulugundam Siva Surya & S. K. Gugulothu [21] who concluded that, the reason for higher ductility was due to uniform dispersal of SiC particulates in the base matrix and better interfacial bonding.

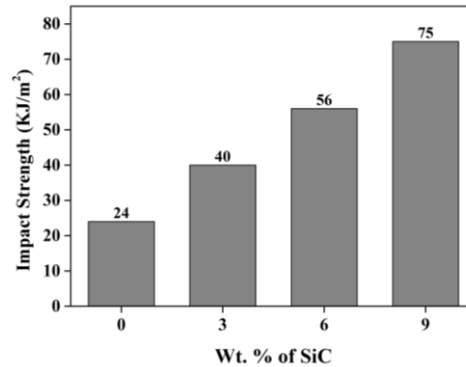


Fig. 8 – Impact strength of composite.

Table 3 – Experimental design with responses.

Sl. No.	SiC (wt. %)	Load (N)	Sliding Distance (m)	Wear Loss (Gms)
1	3	10	500	0.089
2	3	10	1000	0.085
3	3	10	1500	0.093
4	3	20	500	0.092
5	3	20	1000	0.085
6	3	20	1500	0.095
7	3	30	500	0.091
8	3	30	1000	0.095
9	3	30	1500	0.097
10	6	10	500	0.064
11	6	10	1000	0.071
12	6	10	1500	0.080
13	6	20	500	0.075
14	6	20	1000	0.090
15	6	20	1500	0.094
16	6	30	500	0.086
17	6	30	1000	0.085
18	6	30	1500	0.070
19	9	10	500	0.055
20	9	10	1000	0.060
21	9	10	1500	0.070
22	9	20	500	0.051
23	9	20	1000	0.062
24	9	20	1500	0.068
25	9	30	500	0.074
26	9	30	1000	0.070
27	9	30	1500	0.065

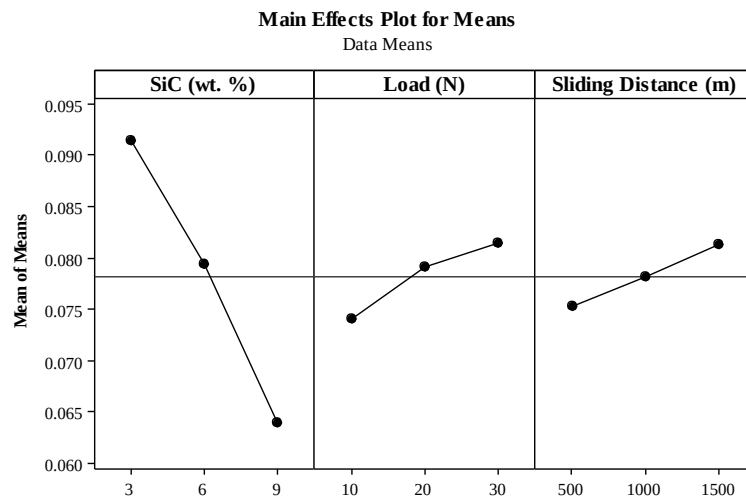


Fig. 9 – Main Effects Plots for wear loss.

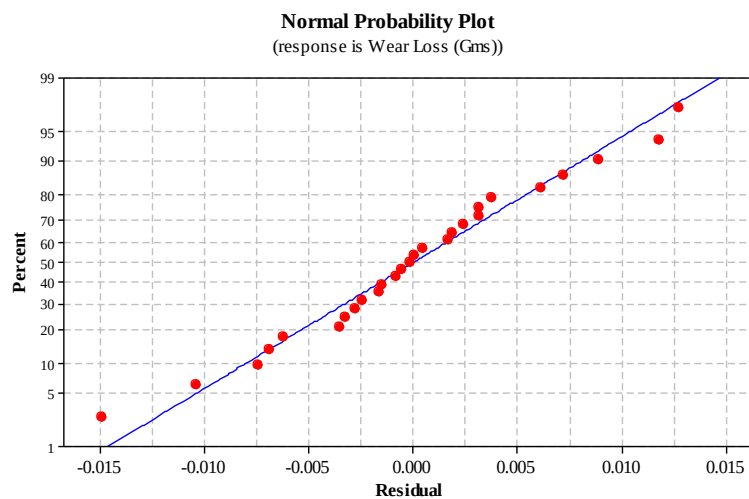


Fig. 10 – Normal probability graph for wear loss.

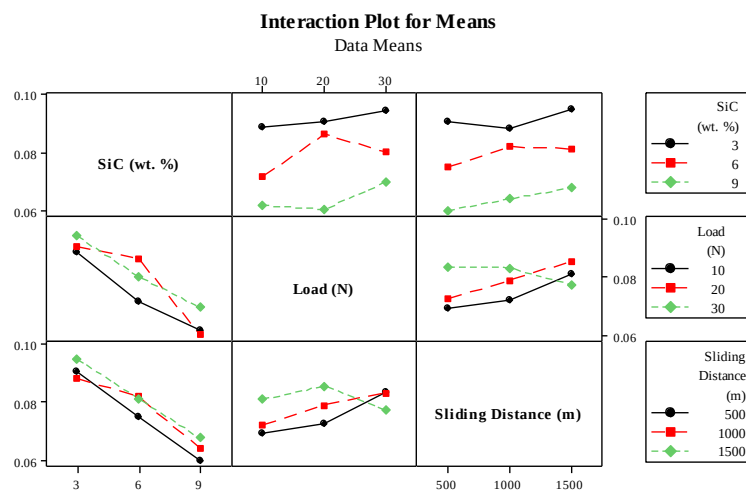


Fig. 11 – Interaction plot for wear loss.

3.6 Modeling of wear behavior by Taguchi technique

Experimental studies on wear behavior were examined on three different wt. % (3, 6 and 9) SiC reinforced Al MMCs. Wt. loss (wear rates) of the Al 7075 and composite were determined. Wt. loss for the SiC reinforced Al composite was considerably lesser than the base matrix material. Wear rate was influenced by the wt. % of SiCp, load and sliding distance [22]. Taguchi model was adopted to study effect of varying parameters on wear behavior of produced MMCs. Statistical analysis was performed by the modeling program MINITAB-16. Major contribution of each parameter was studied by ANOVA analysis. The wear behavior was studied using different statistical plots such as normal probability, contour plots and main effect plots. Wear loss depended on test conditions, like wt. % of SiCp, load and sliding distance. Due to the limited number of test samples, the main parameters were adopted on the basis of observations. The significant factors identified were wt. % of the SiC, load and sliding distance. The experimental design with response is shown in table 3.

Table 4 – Analysis of variance results for Wear Loss.

Source	DF	Seq SS	Adj SS	Adj MS	F	P	Cont. (%)	Remarks
SiC (wt. %)	1	0.0033894	0.0033894	0.0033894	75.4493	0.0000000	70.13	Significant
Load (N)	1	0.0002420	0.0002420	0.0002420	5.3870	0.0295056	5.00	Significant
Sliding Distance (m)	1	0.0001681	0.0001681	0.0001681	3.7410	0.0654892	3.47	Insignificant
Error	23	0.0010332	0.0010332	0.0000449			21.37	
Total	26	0.0048327					100	

Model Summary: R-Sq = 78.62% & R-Sq (adj) = 75.83%

Table 5 – Response table for means.

Levels	Wt. %	Load (N)	Sliding Distance (m)
1	0.09133	0.07411	0.07522
2	0.07944	0.07911	0.07811
3	0.06389	0.08144	0.08133
Delta	0.02744	0.00733	0.00611
Rank	1	2	3

The experiential model exhibited desired good results which were studied and analyzed through RSM. Relationship between the dependent response and the parameters was explained by linear regression models. The important parameters were resolute, and the final model was expressed based on the selected parameters. The outcomes of ANOVA for wear loss are depicted in Table 4. ANOVA was used for analysing the developed model. The values of P-value less than 0.05 shows that model terms are highly significant. The model terms like wt. % of SiC and Load are very significant. If the P-values are higher than 0.05, then it means that the model terms are not significant. R², the determination coefficient is a suggestion of good-ness of fit for the model. The obtained results are listed like Anova table and R-Sq values. R-Sq value is calculated for independent variable is insignificant. Whereas, adjusted R-Sq values increases only when independent variables is significant and affects dependent variable. This means that while comparing the input variables with the acquired replies, the statistical analyser only takes the R-Sq values into account. However, adjusted R-Sq is considered rarely due to the factor is significant and influence on the process. From the ANOVA results, the determination coefficient “R²” is 78.62 and Adjusted R²: 75.83 which indicate that the model is highly significant. In Table 4, the 8th column indicates the % of contribution of each of the parameters. In Table 4, it can be observed that the wt. % SiCp with a 70.13% ratio followed by load (N) and sliding distance (m), has high impact on the wear loss. Effects of the load (N) and sliding distance (m) variables on the wear loss are small. Equation 2 shows the regression analysis equations for wear loss of produced composites. The expression for the wear rate concerning wt. % of SiCp, load and sliding distance variables, is given by:

$$\text{Wear Loss (Gms)} = 0.0922222 - 0.00457407 \text{ SiC} + 0.000366667 \text{ Load} + 6.11111\text{e} - 006 \text{ Sliding Distance} \quad (2)$$

From Table 5 it is seen that wt. % of reinforcement is the most effective factor on wear behavior which is followed by load and sliding distance. The factor sliding distance has the least effect on the wear rate. Fig. 9 depicts the main effect plot

(MEP) of three control parameters (factors) on wear loss. From this, MEP for signal to noise ratio (S/N) ratio, revealed that level 3 in SiC, level 1 in load and level 1 in sliding distance gives minimum wear loss. This suggests the selection of 9% SiC reinforcement, 10N load and 500m sliding distance for minimum wear loss.

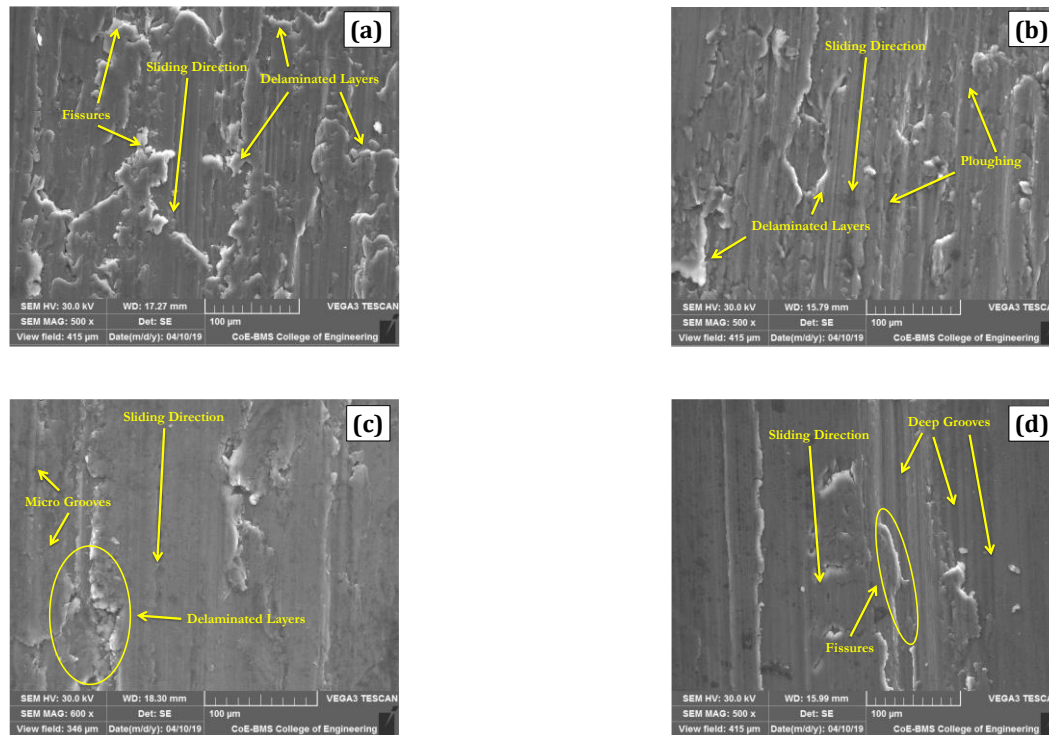


Fig. 12 – Worn out surface images of (a) Monolithic (b) 3 % SiC composite (c) 6 % SiC composite (d) 9 % SiC composite.

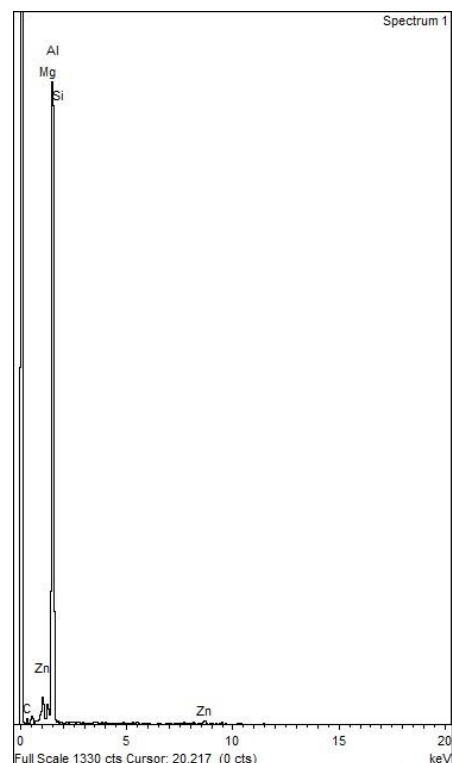


Fig. 13 – EDS spectrums of 9 % SiC composite.

For checking the compliance of the model, three steps were followed, which are: checking the independency, normality of data and ANOVA. Normal probability graphs were used for testing data normality. Fig. 10 shows the normal probability plots of residuals. From these normal probability plots, it is observed that residuals are plotted in straight lines, which show that, the errors are normally distributed.

The results of interaction are normally influenced by the parameters used in the investigation. Generally, the interaction plots (graphs) depict the influence of wear parameters. Other researchers [23, 24] revealed that, the process parameter with maximum inclination line gave greater significance. If the lines in the interaction graphs are not-parallel, then it is concluded that there is a better interaction among the parameters. The interaction graph for wear loss is represented in Fig. 11, it can be observed that the lines intersect with each other (non-parallelism). Thus, it can be concluded that, there is a good interaction among the parameters [25].

The SEM images of monolithic and MMCs worn out surface are shown in Fig. 12. The worn out surface images of monolithic (Fig. 12 (a)) display some degraded areas that contribute to coarse debris formation. Fig. 12 (a) also reveals the existence of extreme plastic deformation and deeper grooves, showing a high wear rate. And the composites reinforced with 3, 6 and 9 % SiC particulates show fine grooves formed on the wornout surface (Figs. 12 (b, c & d)). Also, by increasing the SiC content, the ratio of the scale of these grooves was better, thus confirming the reduction of the wear rate by adding SiC particles. The presence of SiC particulates leads to an improvement in the wear resistance. The presence of wear debris on the wornout surfaces is exhibited in all the SEM images, which indicate abrasive wear and incidence of adhesive during the wear studies [26]. It can also be found that, the SEM image of worn surface of 3% SiC reinforced MMCs with load of 10 N and sliding distance of 500 m indicates the sever plastic deformation and confirms the evidence of adhesion wear. Similarly for the 6% and 9% of SiC sample attributed the improved hardness and the strength which leads to abrasion wear mechanism along the sliding direction. The SEM images indicates the deeper grooves and micro ploughing along with wear undeformed wear debris and pores in the worn surface of the samples. It reveals the abrasion wear mechanism and reduces the possibility of particle agglomeration and prevents the metal deformations. The EDS spectrums of Al7075-SiC composites are depicted in Fig. 13. Peaks of Al, Mg, Si, C and Zn were detected in the spectrums, which confirm the existence of SiC in Al7075-9% SiC composites [27].

4 Conclusion

In the present work, the micro-structure, mechanical and wear behavior of Al7075-SiC MMCs (with 0, 3, 6 and 9 wt. % reinforcement) were examined. Modeling of wear behavior was carried out by using Taguchi technique and tested for its adequacy. The following inferences are drawn:

Stir-casting is one of the most suitable methods applied in the production of Al7075-SiC composites. Microstructural, mechanical and wear behavior of SiC reinforced Al composites were investigated. SiCp was uniformly dispersed in Al7075 alloy by stircasting method. Good dense structure was formed with the improved mechanical and tribological properties. Density and porosity of the produced MMCs enhanced linearly with an increment in SiC content. Mechanical properties like hardness, tensile and impact strength of the developed MMCs were found to be better with 9% of SiC reinforced MMCs. Central composite design with Taguchi technique was used to select optimum number of experimental trials and to predict the abrasive responses of the wear loss. Wt. loss of Al7075/9Wt. % SiC reinforced MMCs decreased considerably compared to 0, 3 and 6 Wt. % SiC composites. On the other hand, wear loss of the developed MMCs increased with increasing load and sliding distance. ANOVA shows that Wt. % of SiC has major impact on the wear behavior. Morphological study of wear surfaces show that wear mechanism was delamination with the mild abrasion in nature. Thus, it can be said that 9 % SiC reinforced Al composite are most suitable material for aircraft components like skin and fuselage under tension.

Acknowledgements

The authors are grateful for the experimental facilities provided by BMS College of Engineering and Ramaiah University of Applied Sciences and also acknowledge the continuous support in completion of this research work.

REFERENCES

- [1]- M. Imran, A.R.A. Khan, Characterization of Al-7075 metal matrix composites: a review. *Journal of Materials Research and Technology*, 8(3) (2019) 3347-3356. doi:10.1016/j.jmrt.2017.10.012.

- [2]- S. Pradeep Devaneyan, R. Ganesh, T. Senthilvelan, On the Mechanical Properties of Hybrid Aluminium 7075 Matrix Composite Material Reinforced with SiC and TiC Produced by Powder Metallurgy Method. *Indian Journal of Materials Science*, 2017 (2017) 3067257. doi:10.1155/2017/3067257.
- [3]- M. Patel, S.K. Sahu, M.K. Singh, D.P. Sahu, Investigation of tribological properties of stir cast AA5052/B4C MMC under different loads. *Jurnal Tribologi*, 34 (2022) 69-86.
- [4]- M.S. Surya, G. Prasanthi, S.K. Gugulothu, Investigation of Mechanical and Wear Behaviour of Al7075/SiC Composites Using Response Surface Methodology. *Silicon*, 13(7) (2021) 2369-2379. doi:10.1007/s12633-020-00854-y.
- [5]- K. Velavan, B. Mohan, G. Anbuchezihiyan, N. Senthilkumar, Implications of SiC/Al₂O₃ Reinforced Al-Mg-Zn Alloy Hybrid Nano Composites Using Vacuum Sintering Method. *Silicon*, 13(10) (2021) 3639-3647. doi:10.1007/s12633-020-00928-x.
- [6]- V. Bharath, V. Auradi, M. Nagaral, S.B. Boppana, S. Ramesh, K. Palanikumar, Microstructural and Wear Behavior of Al2014-Alumina Composites with Varying Alumina Content. *Transactions of the Indian Institute of Metals*, 75(1) (2022) 133-147. doi:10.1007/s12666-021-02405-4.
- [7]- S. Suresh, G.H. Gowd, M.L.S.D. Kumar, Mechanical and wear behavior of Al 7075/Al₂O₃/SiC/mg metal matrix nanocomposite by liquid state process. *Advanced Composites and Hybrid Materials*, 2(3) (2019) 530-539. doi:10.1007/s42114-019-00101-y.
- [8]- J. Liu, B. Zhou, L. Xu, Z. Han, J. Zhou, Fabrication of SiC reinforced aluminium metal matrix composites through microwave sintering. *Materials Research Express*, 7(12) (2020) 125101. doi:10.1088/2053-1591/abc8bf.
- [9]- J.K.M. Kwok, S.C. Lim, High-speed tribological properties of some Al/SiCp composites: I. Frictional and wear-rate characteristics. *Composites Science and Technology*, 59(1) (1999) 55-63. doi:10.1016/S0266-3538(98)00055-4.
- [10]- Y. Sahin, Wear behaviour of aluminium alloy and its composites reinforced by SiC particles using statistical analysis. *Materials & Design*, 24(2) (2003) 95-103. doi:10.1016/S0261-3069(02)00143-7.
- [11]- M. Acilar, F. Gul, Effect of the applied load, sliding distance and oxidation on the dry sliding wear behaviour of Al–10Si/SiCp composites produced by vacuum infiltration technique. *Materials & Design*, 25(3) (2004) 209-217. doi:10.1016/j.matdes.2003.09.015.
- [12]- R. Bauri, M.K. Surappa, Sliding wear behavior of Al–Li–SiCp composites. *Wear*, 265(11) (2008) 1756-1766. doi:10.1016/j.wear.2008.04.022.
- [13]- S. Krishna Prasad, S. Dayanand, M. Rajesh, M. Nagaral, V. Auradi, R. Selvaraj, Preparation and Mechanical Characterization of TiC Particles Reinforced Al7075 Alloy Composites. *Advances in Materials Science and Engineering*, 2022 (2022) 1-11. doi:10.1155/2022/7105189.
- [14]- A. Szweczyk-Nykiel, Microstructure and Properties of Sintered Metal Matrix Composites Reinforced with SiC Particles. *Technical Transactions*, 114(6) (2017) 179-190. doi:10.4467/2353737XCT.17.098.6574.
- [15]- J. Pattar, D. Ramesh, A Study of Density Calculation For Composite Materials Aluminum Alloy 6063 Reinforced WithTiO₂ And B4C Hybrid MMC's. *European Chemical Bulletin*, 12(8) 754-761 doi:10.48047/ecb/2023.12.si8.056
- [16]- D. Dey, A. Bhowmik, A. Biswas, Effect of SiC Content on Mechanical and Tribological Properties of Al2024-SiC Composites. *Silicon*, 14(1) (2022) 1-11. doi:10.1007/s12633-020-00757-y.
- [17]- V.J. Allien, H. Kumar, V. Desai, Dynamic analysis and optimization of SiC reinforced Al6082 and Al7075 MMCs. *Materials Research Express*, 6(5) (2019) 056528. doi:10.1088/2053-1591/ab038e.
- [18]- T. Nallusamy, S. Vijayakumar, Reinforcements, Manufacturing Techniques, and Respective Property Changes of Al₂O₃/SiC Based Composites: A Review. *Silicon*, 14(7) (2022) 3129-3146. doi:10.1007/s12633-021-01108-1.
- [19]- H.M. Mahendra, G.S. Prakash, K.S. Keerthi Prasad, S. Rajanna, Fatigue and Fracture Behaviour of Al6061-Al₂O₃ Metal Matrix Composite: Effect of Heat Treatment. *IOP Conference Series: Materials Science and Engineering*, 925(1) (2020) 012042. doi:10.1088/1757-899X/925/1/012042.
- [20]- P. Pugalenth, M. Jayaraman, V. Subburam, Study of the microstructures and mechanical properties of aluminium hybrid composites with. *Materiali in tehnologije*, 53(1) (2019) 49-55. doi:10.17222/mit.2018.118.
- [21]- M.S. Surya, S.K. Gugulothu, Fabrication, Mechanical and Wear Characterization of Silicon Carbide Reinforced Aluminium 7075 Metal Matrix Composite. *Silicon*, 14(5) (2022) 2023-2032. doi:10.1007/s12633-021-00992-x.
- [22]- M. Mahali, N.K. Sinha, I.N. Choudhary, J.K. Singh, S. Mohan, Effect of Al₃Ni and SiC on Mechanical and Wear Behaviour of Al-Ni-SiC Composite. *Silicon*, 15(9) (2023) 3897-3908. doi:10.1007/s12633-023-02306-9.

-
- [23]- S. Ghosh, P. Sahoo, G. Sutradhar, Wear Behaviour of Al-SiCp Metal Matrix Composites and Optimization Using Taguchi Method and Grey Relational Analysis. *Journal of Minerals and Materials Characterization and Engineering*, Vol.11No.11 (2012) 10. doi:10.4236/jmmce.2012.1111115.
- [24]- M.N. Shaikh, A statistical analysis of wear behaviour of fly ash reinforced Al-Sic hybrid composites. *Journal of Powder Metallurgy & Mining*, 7(1) (2018) 190-194. doi:10.4172/2168-9806.1000190.
- [25]- U. Soy, F. Ficici, A. Demir, Evaluation of the Taguchi method for wear behavior of Al/SiC/B4C composites. *Journal of Composite Materials*, 46(7) (2012) 851-859. doi:10.1177/0021998311410510.
- [26]- V.S.S. Venkatesh, A.B. Deoghare, Microstructural Characterization and Mechanical Behaviour of SiC and Kaoline Reinforced Aluminium Metal Matrix Composites Fabricated Through Powder Metallurgy Technique. *Silicon*, 14(7) (2022) 3723-3737. doi:10.1007/s12633-021-01154-9.
- [27]- B.M. Girish, B.P. Shivakumar, M.B. Hanamantraygouda, B.M. Satish, Wear behaviour of hot forged SiC reinforced aluminium 6061Composite materials. *Australian Journal of Mechanical Engineering*, 20(2) (2022) 425-432. doi:10.1080/14484846.2020.1714353.