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Taguchi Design for Wear Behaviour of Al-Si-B4C Composites Prepared by Powder Metallurgy

Abraham Subaraj. M, Bensam Raj. J, Naveenchandran. P, Christopher Ezhil Singh. S, G.Glan Devadhas

Abstract**: *This research paper discuss about the wear loss behavior of Al-12Si-xB$_4$C composites prepared through powder metallurgy method by varying the weight percentage of reinforcement (x = 2, 4, 6, 8, and 10) content. The samples were prepared by using die and punch assembly and the lubricant used to eject the sample from the die was molybdenum disulfide. The compaction was done by using compression testing machine by applying a pressure of 800MPa. The dry sliding wear loss behavior of the sample was conducted on Pin-on-Disc machine and the experimental values of wear loss were calibrated. Taguchi design experiment was done by applying L25 orthogonal array for 3 factors at 5 levels for the response parameter wear loss. Analysis of Variance demonstrated by Mean and S/N ratio table for wear loss was discussed and from the table it can be seen that the reinforcement plays a main role, when the compared with load and Sliding Distance (SD). The normal probability plot shows that the residuals falls near to the red line, it indicate that the error values were less in the model.***

Keywords: Al-Si-B$_4$C, ANOVA, P/M, Taguchi design, wear loss.

I. INTRODUCTION

Aluminium based composites is commonly utilized in manufacturing to variety appropriates variations to improve the tribolgical in addition to mechanical properties. Al based composites is strengthened to afford extra strength to metal [1]. The light weight metal Al alloy is strengthened by some of carbide or oxide materials. Among Al alloy is the best utilized matrix metal for the planning of light weight commercial products [2]. The wear loss have been conceded out in this effort. Taguchi technique is utilized for optimization of factors and ANOVA is conceded out [4]. The friction behaviour on Al based composites utilizing Taguchi technique with load, reinforcement, sliding distance as input and output as wear loss. ANOVA demonstrates the significant factors for controlling the friction. This research work the friction behavior of Al-12Si-xB$_4$C composites prepared through powder metallurgy method by varying the weight percentage of reinforcement (x = 2, 4, 6, 8, and 10) content. Taguchi design experiment was done by applying L25 orthogonal array for 3 factors at 5 levels for the response parameter wear loss. Analysis of Variance demonstrated by Mean and S/N ratio table for wear loss was discussed and from the table it can be seen that the reinforcement plays a main role, when the compared with load and SD. The normal probability plot shows that the residuals falls near to the red line, it indicate that the error values were less in the model.

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* Correspondence Author
Abraham Subaraj. M[1], Mechanical, Bharath Institute of Higher Education and Research, Bharath University, India. Email: masubaraj@gmail.com
Bensam Raj. J[2], Mechanical, Muthayammal Engineering College, Rasipuram, India. Email: bensmech@yahoo.co.in
NAVEENCHANDRAN. P[3], Automobile, Bharath Institute of Higher Education and Research, Bharath University, Chennai, Tamilnadu, India. Email: asiriyan@gmail.com.
***Christopher Ezhil Singh. S**[4], Mechanical, Vimal Jyothi Engineering College, Kannur, India. Email: edbertefren0420@gmail.com
Glan Devadhas.G[5], Applied Electronics and Instrumentation, Vimal Jyothi Engineering College, Kannur, India. Email: glandeva@vjec.ac.in

II. EXPERIMENTAL PROCEDURE

The aluminium and silicon powder was purchased from metal powder company, Thirumagalam, Madurai, Tamilnadu, India. The particle sizes of the two powders were 40µm with purity 99.5%. The powders were mixed in high energy ball mill for 30min for homogenous mixing. The mixed powder were compacted in die and punch assembly with a pressure of 800MPa in compression testing machine. The samples with 10mm diameter and 30mm height were used for the dry sliding friction and wear on pin-on-disc machine.

III. TAGUCHI DESIGN

The influence of input parameters on the wear loss parameters was deliberate utilizing the Taguchi's method. Next leading the trial test, it was obvious to select the levels of experiments. For the current circumstance, process parameters deliberated are reinforcement, load, and SD changing at 5 levels. Wear loss trials were showed in agreement to say trial plan and response was measured as specified in Table 1. The input parameters such as reinforcement (A), load (B) and SD (C) at 5 levels were deliberated for this current work. With the design plan of L25 orthogonal array, the trial levels were obvious and revealed in Table 2.

Table 1 trials and levels

Factors	Levels				
	1	2	3	4	5
wt.% B$_4$C	2	4	6	8	10

Load (N)	8	16	24	32	40
SD (m)	400	800	1200	1600	2000

Table 2 experimental run and response parameters

wt.% B_4C	Load (N)	SD (m)	wear loss	S/N ratio
2	8	400	0.065316	23.6996
2	16	800	0.135901	17.3356
2	24	1200	0.259711	11.7102
2	32	1600	0.411146	7.7201
2	40	2000	0.453289	6.8725
4	8	800	0.084815	21.4305
4	16	1200	0.137324	17.2451
4	24	1600	0.258751	11.7424
4	32	2000	0.333335	9.5424
4	40	400	0.157106	16.0761
6	8	1200	0.113711	18.8840
6	16	1600	0.208658	13.6113
6	24	2000	0.304247	10.3355
6	32	400	0.134057	17.4542
6	40	800	0.206095	13.7187
8	8	1600	0.120682	18.3671
8	16	2000	0.159951	15.9202
8	24	400	0.083239	21.5935
8	32	800	0.153749	16.2638
8	40	1200	0.22239	13.0577
10	8	2000	0.114045	18.8585
10	16	400	0.054004	25.3515
10	24	800	0.106796	19.4289
10	32	1200	0.19062	14.3966
10	40	1600	0.243555	12.2681

IV. ANOVA FOR WEAR LOSS OF S/N RATIO

The ANOVA for wear loss of S/N ratio was discussed in Table 3 the most influencing factor that influences the wear loss were reinforcement B_4C compared to load and SD with the confidence level 95% for the S/N ratio ANOVA. The F-test value was 2.7763 which is less than the F-table value therefore all the input factors are significant. The response table for S/N ratio of wear loss was discussed in Table 4. Figure 1 shows the S/N ratio plot for wear loss.

Table 3 Analysis of Variance for SN ratios of Wear loss

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Wt.% B_4C	4	67.02	67.02	16.75	66.89	0.0
Load (N)	4	219.11	219.11	54.78	218.69	0.0
SD (m)	4	253.98	253.98	63.49	253.49	0.0
Residual Error	12	3.01	3.01	0.25	-	-
Total	24	543.12	-	-	-	-

Table 4 Response Table for Signal to Noise Ratios of wear loss (Smaller is better)

Level	Wt.% B_4C	Load (N)	SD (m)
1	**13.47**	20.25	20.83
2	15.21	17.89	17.64
3	14.80	14.96	15.06
4	17.04	13.08	12.74
5	18.06	**12.40**	**12.31**
Delta	4.59	7.85	8.53
Rank	3	2	1

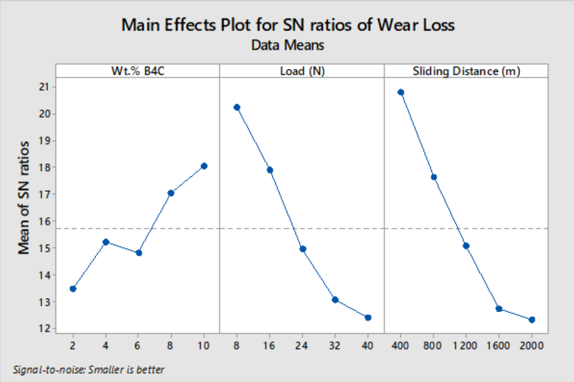

Figure1 shows the S/N ratio plot for wear loss

V. ANOVA FOR WEAR LOSS OF MEANS

The ANOVA for wear loss of means was discussed in Table 5 the most influencing factor that influences the wear loss were reinforcement B_4C compared to load and SD with the confidence level 95% for the means ANOVA. The F-test value was 2.7763 which are less than the F-table value therefore all the input factors are significant. The response table was discussed in Table 6. Figure 2 shows the mean plot for wear loss

Table 5 Analysis of Variance for Means

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Wt.% B_4C	4	0.0487	0.04870	0.01217	13.74	0.000
Load (N)	4	0.09141	0.09141	0.02285	25.79	0.000
SD (m)	4	0.10708	0.10708	0.02677	30.21	0.00
Residual Error	12	0.01063	0.01063	0.00088	-	-
Total	24	0.25783	-	-	-	-

Table 6 Response Table for Means of wear loss

Level	Wt.% B_4C	Load (N)	SD (m)
1	0.26507	**0.09971**	**0.09874**
2	0.19427	0.13917	0.13747
3	0.19335	0.20255	0.18475
4	0.14800	0.24458	0.24856
5	**0.14180**	0.25649	0.27297
Delta	0.12327	0.15677	0.17423
Rank	3	2	1

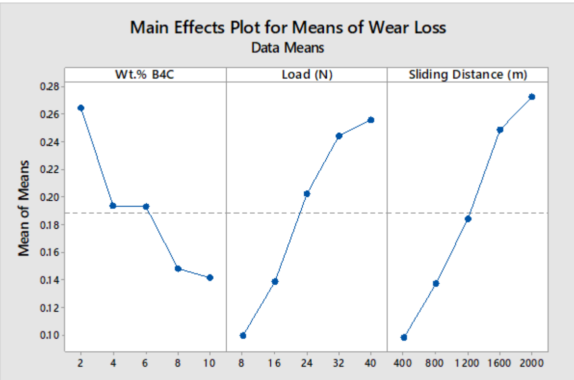

Figure 2 shows the mean plot for wear loss

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VI. INTERPRETATION OF RESIDUAL GRAPHS

The normal probability plot of the residuals to check the normality of the S/N ratio and means wear loss of figures 3(i) & 4(i) show the normal probability plot for Al-Si-B_4C composite. This probability plots evidently specifies that the perceived trial values lies very close to the red line deducing that the errors are ignored and the model is sufficient. The dissemination of residuals for all the elucidation (25 runs) is demonstrated in the histogram. Nearly bell formed symmetrical histogram could be incidental from Figs. 3(ii) & 4(ii). The residuals versus the fitted values for the S/N ratio and means wear loss are plotted in Figs. 3(iii) & 4(iii). The sprinkling of the residuals are arbitrarily about zero which designates that the errors are negligible having constant variance. Figures 3(iv) & 4(iv) demonstrate the plots of the residual value and the order of the conforming trial values. The outcomes are effect by the order of the runs that takes place when a line order is utilized to gather the data.

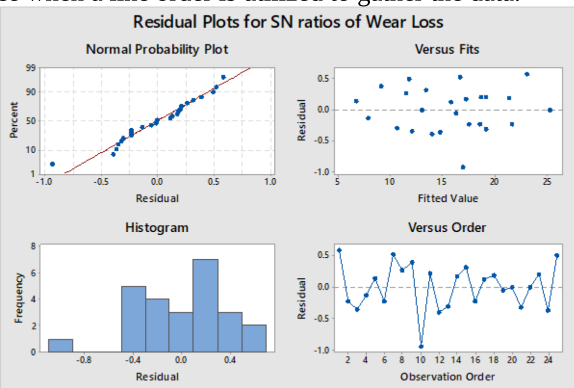


Figure 3 demonstrates the S/N ratio of wear loss for normal probability, residual vs fits, histogram and Residual vs order

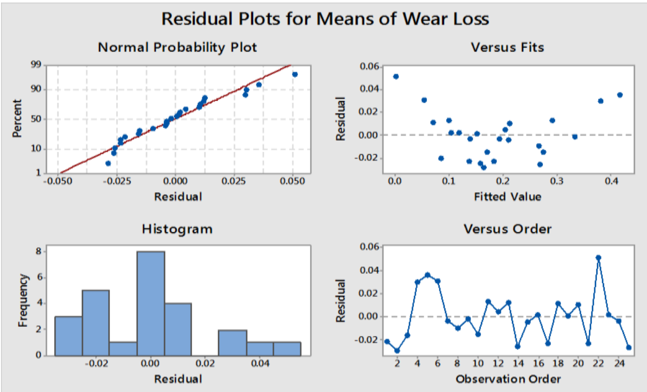
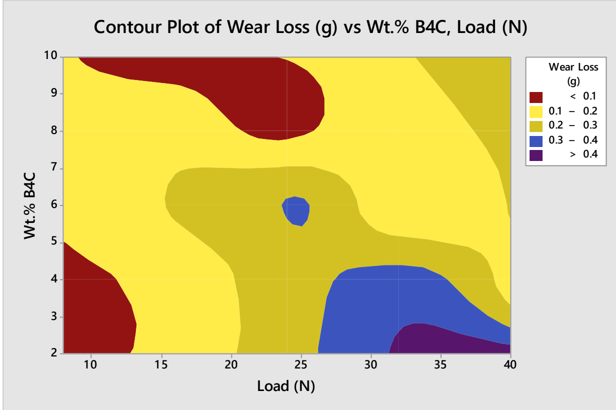


Figure 4 demonstrates the Means of wear loss for normal probability, residual vs fits, histogram and Residual vs order

VII. INTERACTION EFFECT OF WEAR LOSS

Figure 5(a–c) demonstrates the collaborating influence of B_4C wt% and the loads of 8, 16, 24, 32 and 40 N on wear loss. Figure 5(a) is the wear loss map for reinforcement vs load. The perceived wear loss region was low and medium, the violet distribution was dominant. While increasing the B_4C wt% at loads, the wear loss is less for the 400 m SD and marginally rises in wear loss for all SD. Figure 5(b) demonstrates the map for reinforcement vs SD, the brown and violet distributions are identified. In lower sliding distance and higher reinforcement the brown region was identified, which confirms that increasing the SD, wear loss also improved. Figure 5(c) shows the joined influence of load and SD on wear loss for map at all reinforcements, the violet and brown region performed. Higher wear loss for lower wt% of B_4C at different loads is owing to the rise in SD. This another time authorizes that the B_4C is the main supervisory factor on the wear loss of the composites. For the entire Al-Si- B_4C composite samples the wear loss improved with the rise in the SD and load.



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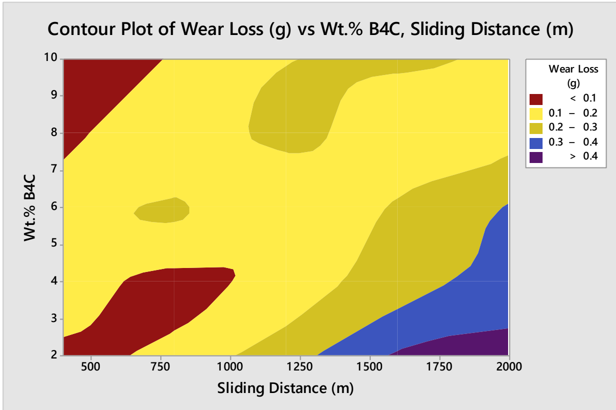

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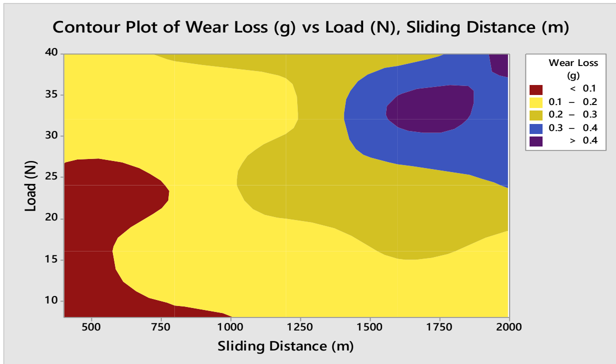

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VIII. CONCLUSION

This current research work was focused on the dry sliding wear of Al-Si-B_4C composites under powder metallurgy method using Taguchi method. Analysis of Variance demonstrated by Mean and S/N ratio table for wear loss was discussed and from the table it can be seen that the reinforcement plays a main role, when the compared with load and sliding distance.

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AUTHORS PROFILE

Abraham Subaraj. M joined as Research Scholar in the year 2014 as a part time scholar in Department of Mechanical Engineering, Bharath Institute of Higher Education and Research, India. I have completed my Bachelor Degree in Mechanical Engineering from MVJ College of Engineering, Bangalore, Karnataka from Bangalore University in the year 1990 and I have worked in VILCO Coimbatore as Production Engineer from 1999 to 2000 and Master Degree in Thermal Engineering from Mohamed Sathek Engineering College, Kilakarai, Tamilnadu under Madurai kamaraj University in the year 1999. I am currently working as Associate Professor in Bethelaham Institute of Engineering, Karungal, Kanyakumari, Tamilnadu, India. I have Published 5 Journal Papers in reputed journals.

Bensam Raj. J, Professor in the Department of Mechanical Engineering, Muthayammal Engineering College, Rasipuram, India. I have completed my Bachelor Degree in Mechanical Engineering from RVS College of Engineering and Technology, Dindugal, Tamilnadu from Madurai Kamarajar University in the year 1999 and Master of Engineering from Annamalai University, Chidambaram, Tamilnadu in thr year 2000. I have pursued my Ph.D from Anna University. I have worked as Professor in Nadar Saraswathi Engineering College, Rasipuram, Tamilnadu, India. Under my guidance 13 Ph.D scholars pursuing and registered under reputed universities. Eight Scholars completed Ph.D under my guidance. I have Published 17 Journal Papers in reputed journals.

Dr.Naveenchandran. P, Professor & Head, Department of Automobile Engineering, Bharath Institute of Higher Education and Research, Bharath University, Chennai, Tamilnadu, India. I have completed my Bachelor Degree in Mechanical Engineering from Annamalai University, Chidambaram, Tamilnadu, India and Master of Engineering in Thermal Power from Annamalai University, Chidambaram, Tamilnadu, India. I have completed my Ph.D from Universiti Teknologi, Petronas, Malaysia. I have worked as Lecturer in Department of Mechanical Engineering, Bharath Institute of Higher Education and Research, Tamilnadu, India. I have worked as lecturer in Department of Mechanical/ Automotive Engineering, Kolej WIT, Port Kiang, Malaysia. I have worked as Professor & Head in Department of Mechanical Engineering. Loyola Institute of Technology, Tamilnadu, India. I have published more than 40 Journal Papers in reputed journals.

Dr.S.Christopher Ezhil Singh, Professor, Department of Mechanical Engineering, Vimal Jyothi Engineering College, Kannur, Kerala, India. I have completed my Bachelor Degree in Mechanical Engineering from Noorul College of Engineering, Thuckalay, from Manonmaniam Sundaranar University, Tirunelveli and Master of Engineering in Computer Aided Design from Hindustan College of Engineering, Chennai, Tamilnadu under University of Madras, Chennai. I have completed my Ph.D from Mepco Schelnk College Engineering, sivakasi, Tamilnadu, India under Anna University. I have worked as Associate Professor in Bethelaham Institute of Engineering, Karungal, Kanyakumari, Tamilnadu, India. I have worked as Associate Professor in Maria College of Engineering and Technology, Attoor, Kanyakumari, Tamilnadu, India. I have Published 35 Journal Papers in reputed journals.

Dr G.Glan Devadhas is presently working as a Professor in the Department of Electronics & Instrumentation at Vimal Jyothi Engineering College, Kerala,. He has received his B.E. degree in Instrumentation and Control Engineering, M.E. degree in Process Control and Instrumentation and Ph.D in Intelligent Controller Design during 1998, 2001, 2013 respectively. He is having more than 15 Years of experience in teaching and research as Lecturer, Assist Professor, Associate Professor, HOD, Board of studies chairman, Academic council member, Research Supervisor, Doctoral committee member and Professor in various Engineering Colleges and Universities. He is the reviewer of many journals includes International Journal of Naval Architecture and Ocean Engineering, Journal of Water Process Engineering, Int. J. of Modeling, Simulation & Scientific Comp etc. He has published 130 articles in various indexed journals. He has attended more than 50 seminars in national and international level. He has organized three IEEE international Conferences, 1 national conference and 10 national level seminars. He has guided 30 B.E projects 12 ME projects and guiding 8 Ph.D scholars. He is the member ISA,ISTE, IEEE professional bodies. He is the executive member of IEEE India CAS Chapter. He has involved in the project of Developed Attitude and Orbit Control System (AOCS) for a Nano Satellite. His main area of interest are Soft computing, Intelligent controller Design, System Identification, Adaptive systems, Smart Systems.