Parametric Optimization of Wear Test on Al6082/ZrSi Using Taguchi Method

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***Abstract*: Metal matrix composites are engineered materials with a combination of two or more dissimilar materials, (at least one of which is a metal) to obtain enhanced properties. Aluminium Zirconium Silicate metal matrix composite using stir casting method and various tests carried out and their outcomes. In the present investigation Al6082 alloy was used as the matrix and Zirconium Silicate (ZrSi) as reinforcements. The Zirconium Silicate (ZrSi) was added in 0%, 2.5%, and 5% by weight (equal proportion) to the molten metal and experiment has been investigated by making the pins of material using stir casting process. The wear has been tested on LRT Setup experimental setup. Various tests are conducted to evaluate the performance of the composite and the results obtained are discussed.**

***Keywords*: LTR Setup, ZrSi, Wear Rate, Al6082, Composite.**

1. Introduction

World is developing rapidly and so the needs of composite materials for different applications. Composite materials are widely used over the world as they have enhanced properties than the original base materials. In the composite materials category metal matrix composites are widely used all over the world. In specific, aluminium alloys are widely used because of their low cost, high strength, wear resistance and corrosion resistance properties. Composite materials have replaced the traditional materials due to high strength and low weight applications. They also possess high tensile strength at high temperatures, great strength to weight ratios and toughness. The slight change in the composition of the material by the addition of reinforcement changes the properties of the materials suitable for other applications.

Aluminium alloy is the most commonly used composite as it is available on the earth in abundant quantity and it has low density which is useful in many applications ranging from food industries to automobile sector and aerospace sector. And changes in the aluminium alloy by adding reinforcement increases its properties.

Wear is the phenomena which mean the removal of the material from the surface due to the friction between the materials or due to chemical or electrical action. Currently, lot of research is going on to reduce the wear by using different techniques like heat treatment, coating, using composites, etc. High load, velocity and temperature are some of the factors responsible for high wear. To overcome this composite material are used.

Aluminium alloy is the as cast alloy which is used in the automobile sector for the applications like piston, alternative as piston ring, engine block, etc. Abrasive wear occurs at these places due to sliding action between parts. So it is important to find out the amount of wear taking place with and without the addition of zircon powder in them. The material will be tested under various operation conditions on pin-on disk machine at dry sliding condition. Taguchi method is used to design the experiment and the data thus obtained will be used to analyze the results and to find out the optimum conditions to reduce the wear.

2. Experimental Design

A designed experiment is the simultaneous evaluation of two or more factors (parameters) for their ability to affect the resultant average or variability of particular product or process characteristics. To accomplish this in an effective and statistically proper fashion, the levels of the factors are varied in a strategic manner, the results of the particular test combination are observed, and the complete set of results is analyzed to determine the influential factors and preferred levels, and whether increases or decreases of those levels will potentially lead to further improvement. It is important to note that this is an iterative process; the first round through the DOE process will many times lead to subsequent round of experimentation. The beginning round, often referred to as a screening experiment, is used to find the few important, influential factors out of the many possible factors involved with a product or process design. This experiment is typically a small experiment with many factors at two levels. Later rounds of experiments typically involve few factors at more than two levels to determine conditions of further improvement.

Tribological tests under dry condition is carried out on LRT Setup gives information about various measurement apparatus, Sample specimen size, operating range values. The tests are carried out at the elevated temperature under dry operating conditions. Wear specimen (pin) of size 10 mm diameter and 15 mm length was cut from as cast samples machined and then polished metallographically. A single pan electronic weighing machine with least count of 0.0001 g was used to measure the initial weight of the specimen. The cylindrical pin flat ended specimens of size 10 mm diameter and 15 mm length were tested against EN31 steel disc by applying the load. After running through a fixed sliding distance, the specimens were removed, cleaned with acetone, dried and weighed to determine the weight loss due to wear. The difference in the weight measured before and after test gave the sliding wear of the composite specimen and then the wear rate was calculated.

Fig. 1. Schematic setup of LTR setup machine

3. Performance analysis

Experiments are performed efficiently by using a statistical approach. The Taguchi design method is a statistical method resulting in accurate conclusion.

A. OVAT for % Reinforcement

Table 1
OVAT for % Reinforcement

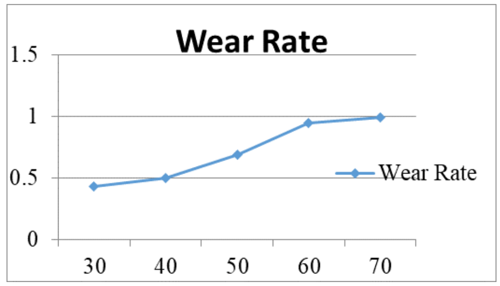
S.No.	% Reinforcement	Load (N)	Temperature (ºC)	Specific Wear rate x10^{-3} mm^3/N-m
1	0	30	50	0.8811
2	2.5	30	50	0.5239
3	5	30	50	0.4016

From Graph we can see that as %Reinforcement of composite increases the wear rate decreases and attains a minimum point at 5% and further increase in the % reinforcement does not decrease in the wear rate significantly. Therefore, levels of reinforcements 2%, 2.5%, and 5% are selected.

B. OVAT for load

Table 2
OVAT for load

Sr No.	% Reinforcement	Load (N)	Temperature (ºC)	Specific Wear rate x10^{-3} mm^3/N-m
1	0	30	50	0.4312
2	0	40	50	0.5023
3	0	50	50	0.6906
4	0	60	50	0.9456
5	0	70	50	0.9924

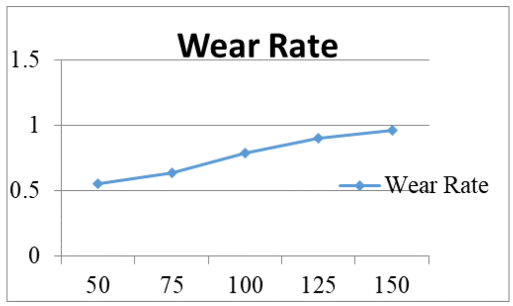


The maximum variation in slope is between load 40N to 60N so, levels 40N,50N, and 60N are selected.

C. OVAT for temperature

Table 3
OVAT for Temperature

S. No.	% Reinforcement	Load (N)	Temperature (ºC)	Specific Wear rate x10^{-3} mm^3/N-m
1	0	30	50	0.5563
2	0	30	75	0.6353
3	0	30	100	0.7906
4	0	30	125	0.9056
5	0	30	150	0.9624



From the above table it can be observed that the maximum variation in slope is Between 75 to 125 ºC. Therefore, levels of temperature are selected from the slope with higher magnitude in variation i.e. 75,100 and 125ºC.

D. Model Analysis for SR

L_9 orthogonal array with repeat measurement of responses for runs one to nine. Repeats of response measurement technique is used overcome the drawback of saturated design in MINITAB software. It also shows that the SN ratio for run one and ten are same as it is calculated for the repeats measurement.

Table 4
Model Analysis for SR

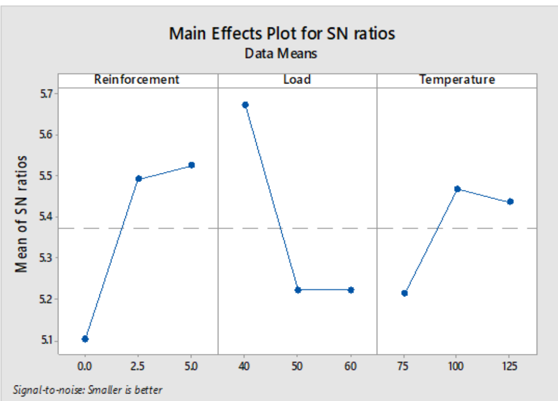
S. No.	% ZrSi	Load	Temp	Specific Wear Rate (10^{-3}) (mm^3/N.m)	S/N Ratio
1	0.0	40	75	0.5412	5.33284
2	0.0	50	100	0.5575	5.07510
3	0.0	60	125	0.5692	4.89470
4	2.5	40	100	0.5149	5.76554
5	2.5	50	125	0.5312	5.49484
6	2.5	60	75	0.5489	5.21014
7	5.0	40	125	0.5061	5.91527
8	5.0	50	75	0.5562	5.09538
9	5.0	60	100	0.5272	5.56049

Table 5
Analysis of variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value	% Contribution
% ZrSi	2	0.001277	0.000638	4.43	0.0184	36.31
Load	2	0.001527	0.000764	5.30	0.0159	43.43
Temperature	2	0.000524	0.000212	1.47	0.0405	14.90
Error	2	0.000188	0.000144			5.36
Total	8	0.003516				

E. Main Effect Plots for SN ratios

The graph shows the main effect plot for S/N ratio for Al6082 composite with ZrSi. The level of a factor which having highest SN ratio is selected as optimum respond measured. The optimum parameter for wear rate were 2.5% ZrSi (level 3), 40N of load (level 1), 100◦C temperature (level 2).



F. Analysis of Variance

ANOVA result of wear for Al6082 with ZrSi composite. It is clear from the table that reinforcement (36.31%) has great influence on lowering the wear rate followed by applied load (43.43%), temperature (14.90%) which indicates that there is appreciable increase in wear rate by increasing load and temperature of the experimentation.

G. Optimum level of input parameters

Table 6
Optimum level of input parameters

Sr. No.	Parameter	Optimum level
1	% ZrSi	5 %
2	Load	40 N
3	Temperature	75°C

4. Conclusion

1. Wear resistance of the composite is better than the base alloy Al6082 metal as the Wear rate of the composites decreases significantly due to addition of zirconium silicate powder which refines the structure.
2. The optimum conditions obtained are load 40N, Temperature 75◦C and % reinforcement 5%.
3. The most affecting parameters were firstly load 43.43%, secondly % reinforcement 36.31% and lastly Temperature with contribution of 14.90%.

5. Future Scope

1. Mechanical properties like tensile strength, toughness of the Al6082 alloy can be tested with the addition of reinforcement.
2. Experiment can be done on the wear of Al6082 alloy under wet lubrication conditions.
3. Temperature, sliding velocity factors can be taken for the experimentation and analysis can be done on how much they affect on the wear rate of the alloy.

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