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Dry Sliding Wear Analysis of Aluminium2618 by Tauguchi Method

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Abstract: Research is a continues process which always finds better solutions to many complex problems, man always eager to find new things and it is natural. The research on material is also a continues process which leads to find new type material which is necessary for some specific applications. Today aerospace industries and automobile industries need high strength materials with low weight and higher resist to fatigue, wear, and high temperature. This can be fulfilled by composite technology; composites are the material with blend of two or three materials with varying magnitude.There are many methods to manufacture composite but getting uniform distribution reinforcement particle is a big challenge which can accomplished by stir casting technology. For this project we selected aluminium (Al2618) as a matrix material, Boron Carbide (B_4C) and Graphite (Gr) as reinforcement material. Three types of composite manufactured

1. Al2618,
2. AL2618+7B_4C,
3. Al2618+7B_4C+3Gr.

For all three type of composite hardness test and OM analysis were carried before and after wear, the hardness of composite increases with increase in the percentage of reinforcement and in reversely density decreases. The wear test carried on pin on disk machine for all 3 composite by considering load, sliding speed, sliding distance as a parameter. The analysis was done using a Tauguchi technique (L9) and ANOVA by using Minitab software and the percentage of contribution on wear rate by each parameter is calculated. From the analysis it was conclude that as the load and sliding distance increases the wear rate also increases and wear rate decreases with increase in speed.

1. Composites

Composites are the natural or artificial materials with wide range applications in automobile and aerospace industries. When any material added to the monolithic materials then it is called as a composite, thus composite material is a combination of any two materials or more than two materials. If more than two materials added at different percentages to monolithic material then it is called as hybrid composites. In many applications monolithic materials alone are not useful; in order to enhance its mechanical properties we usually add some materials at some proportion. The base materials are called matrix and the adding element are called reinforcement.

MMC are very important type of composite materials used in aerospace, automobile industries and in other industrial applications. MMC are very light in weight compare to other materials and higher resistance to oxidation, wear, corrosion. MMC have higher stiffness and higher strength compare to their monolithic materials. The fabrication of MMC are costlier, this can be reduced by the casting technology. Obtaining a good uniform distribution of reinforcement material in base matrix material is big challenge which is directly related to properties and quality of that composite material. Aluminum is the most widely used as a matrix material because of its availability and has lighter weight. It gives excellent strength improvement and co efficient of thermal expansion, the properties of aluminum can be varied by varying the type of reinforcement, and percentage of reinforcements.

2. Material Selection

2.1 Aluminum 2618

Aluminum 2618 is high ductile and high corrosion resistance material. It starts to melt at lower temperature with constant heat supply. At lower temperatures their strength can drastically improved.

2.2 Composition of Al 2618

Table 2.1: Chemical composition of Al 2618

Element	Content (%)
Aluminium	93.7
Copper (Cu)	2.30
Magnesium(Mg)	1.60
Iron(Fe)	1.1
Nickel(Ni)	1.0
Silicon(Si)	0.18
Titanium (Ti)	0.07

3. FABRICATION BY STIR CASTING TECHNOLOGY

The stir casting machine is extensively designed for the fabrication of ALMMCs. Many researchers conclude that this production method gives better dispersion than any other production methods. It consist a cylindrical graphite crucible as it withstand against very high temperature up to 900^0C. And also graphite is not reacting with aluminum alloys. Around this crucible there is a muffle made of ceramic aluminum and on the periphery of muffle heating element is wounded. The furnace is electrically heated which heat up to 900^0C within one hour.

4. PROCEDURE FOR FABRICATION

1. Stick anti coating for inner chamber of curable, stirrer, mould box to avoid sticking of aluminum to chamber or die
2. Switch on the main power
3. Wait until temperature mould reaches 750^0C
4. Weight the aluminum alloy as per die requirements, for the die which we were used requires 900gms including over flow
5. Weight the reinforcements in terms of percentage that is 5% of aluminum alloy
6. After mould attending 750^0C add measured aluminum alloy to crucible
7. Parallel put die for pre heat in a heater at 400^0C up to 1 hour
8. Place reinforcement chamber to pre heat at 150^0C for 1 hour
9. After melting of aluminum move stirrer in up and down direction
10. Feed the reinforcement with uniform velocity and continue stirring action
11. Press the mould open button

5. WEAR TESTING PROCEDURE

1. Clean the specimen with the cleaning agent who is non-filming, non- chlorinated and remove all traces of fluid that is pin should be dry
2. Measure an appropriate weigh of pin to the nearest value 0.0001 g.
3. Fix the disk which is perpendicular to the axis of the resolution.
4. Insert the pin in holder and adjust so that the pin is perpendicular to the counterdisk surface when in contact.
5. Load a proper mass to lever for pressing the pin specimen against the disk.
6. Switch on the motor and adjust the required speed.
7. Set the revolution counter (counting device) to the required number of revolutions.
8. Start the test with pin in contact under load and testing should not be interrupted or restarted
9. After finishing of test remove the pin
10. Remeasure the specimen weight to the nearest 0.0001 g.

Repeat the test to get sufficient data for better results

6 WEAR TEST OF ALUMINIUM 2618

Table 6.1: Experimental parameter array

Experiment no	Load (Kg)	Speed (rpm)	Sliding distance(m)
1	3	250	500
2	3	500	1000
3	3	750	1500
4	4	250	500
5	4	500	1000
6	4	750	1500
7	5	250	500
8	5	500	100
9	5	750	1500

The first column has the experiment number second column has the load parameter third column has sliding speed and last column has sliding distance.

6.1. Wear Rate Calculation

Wear rate =

$$= \frac{Differenceinweight}{\text{Densityofcomposite}} * \frac{1}{Slidingdistance}$$

Difference in weight = weight of composite before wear-weight of composite after wear

For case 1

Weight loss = 0.01574

Wear rate = (0.01574/2.5420)*(1/500)

= 0.02532 mm^3/m

6.2. Signal-To-Noise Ratio

The experiment was conducted by considering three parameters such as load, speed, sliding distance, by varying them for three levels.

The DOF for selected array was 9 which are always greater than the wear parameter considered. The number of level and its response decide the selection of array.

The S/N ratio that is signal-to-noise ratio collects all multiple data and evaluates them based on their characteristics. There are many types of S/N ratio.

For our project we selected smaller the better and it is given by

$$S/N = -10 \frac{\log 1}{n} *(Y_1^2{}_+ Y_2^2 + Y_3^2 + ...\ Y_n^2)$$

Where Y_1 Y_2 Y_3 is the response and n is the number of remarks.

Table 6.2: Wear test of al 2618

Experiment no	Load (Kg)	Speed (rpm)	Sliding distance(m)	Wear rate (mm^3/m)	S/N Ratio
1	3	250	500	0.02532	31.9376
2	3	500	1000	0.00904	40.8766
3	3	750	1500	0.00371	48.5981
4	4	250	1000	0.17414	15.1691
5	4	500	1500	0.13592	17.3355
6	4	750	500	0.01821	34.4986
7	5	250	1500	0.57540	4.8006
8	5	500	500	0.23261	12.6679
9	5	750	1000	0.25587	118692

7. ANALYSIS BY MEANS OF S/N RATIO

Conduct the experiment according to the selected array and tabulate the wear rate for each level of experiment. The individual influence of the parameter on wear rate is given by S/N ratio. Parameter which is having highest S/N ratio is having lower wear rate.

Table 7.1: Response table

Level	Load (Kg)	Sliding velocity(rpm)	Sliding distance
1	40.468	17.302	26.468
2	22.434	23.627	22.638
3	9.7779	31.752	23.575
Delta	30.689	14.450	3.830
Rank	1	2	3

Delta = highest value of S/N ratio –lowest value of S/N ratio

The ranking is assigned according to the value of delta, the parameter with highest value of delta is said to be rank1. Wear rate is greatly affected by a parameter which has highest value of delta. And from the table it clear that load has higher consequence on wears next by the sliding distance and sliding speed

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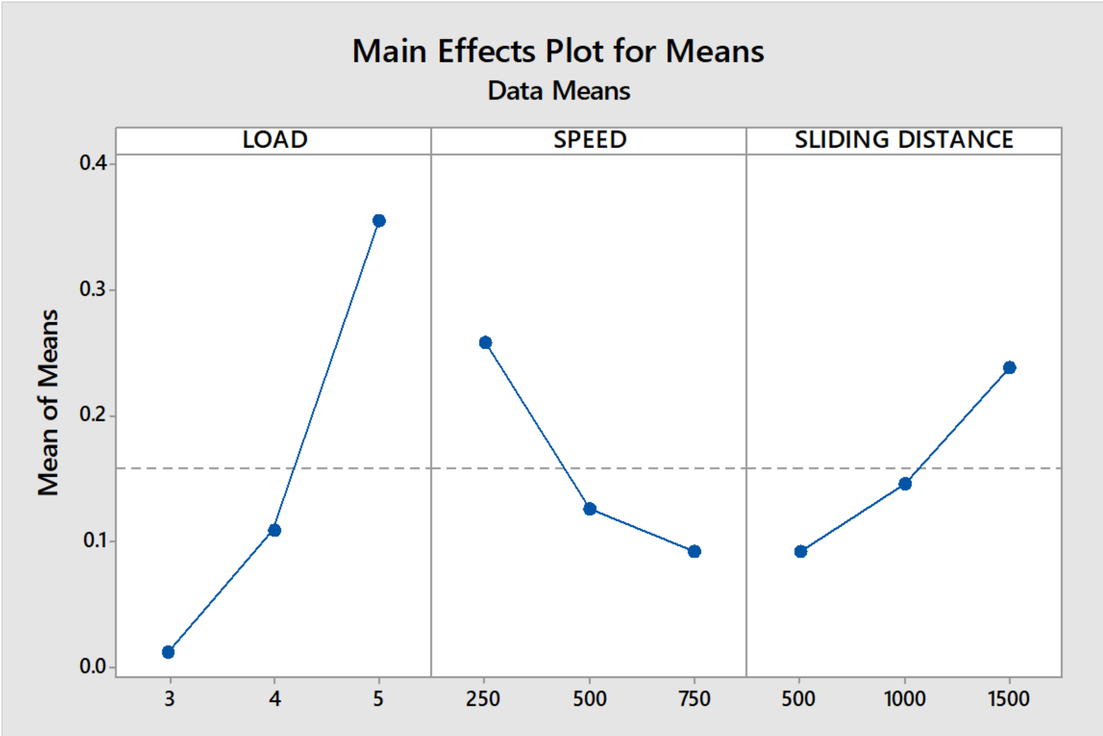

Fig 7.1: Wear rate v/s parameter

From the graph it understandable that as the load increases wear rate also increases and wear also increases with increase of sliding distance but wear rate decreases with increase in the sliding speed this is due to reality that the there is oxide formation due chemical composition composite and steel plate and less contact moment in time involving disk and sample decrease.

8. VARIANCE ANALYSIS

Table 8.1: ANOVA table

Source	DF	Seq SS	Adj SS	Adj MS	F	P	P%	Remarks
L	2	1427.15	1427.15	713.57	20.59	0.565	0.046	Significant
S	2	314.82	314.82	157.41	4.54	0.232	0.812	
SD	2	23.91	23.91	11.96	0.35	0.74	0.743	
ERROR	2	9.31	9.31	4.65				
TOTAL	8	1835.19						

L = Load
S = Speed
SD = Sliding distance
DF = Degrees of freedom
Seq SS = Sequentialsum of square
Adj SS = Adjusted sum of square
Adj MS = Adjusted mean square
P = Percentage of contribution

9. CONTOUR PLOT ANALYSIS

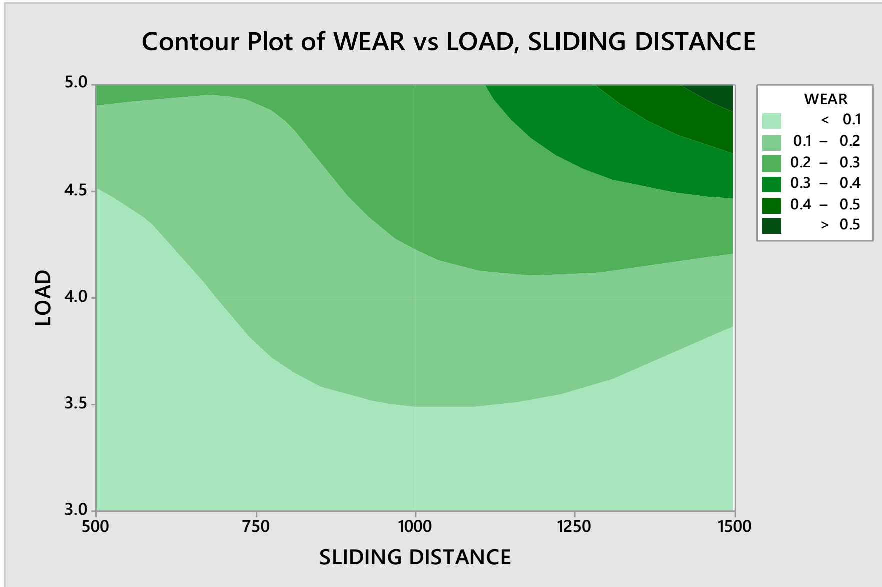

Fig 8.1: Wear rate v/s load, sliding distance.

From the plot it is clear that at load 5kg and sliding distance 1500m has highest wear rate and at load 3kg and a distance 500m has less wear rate

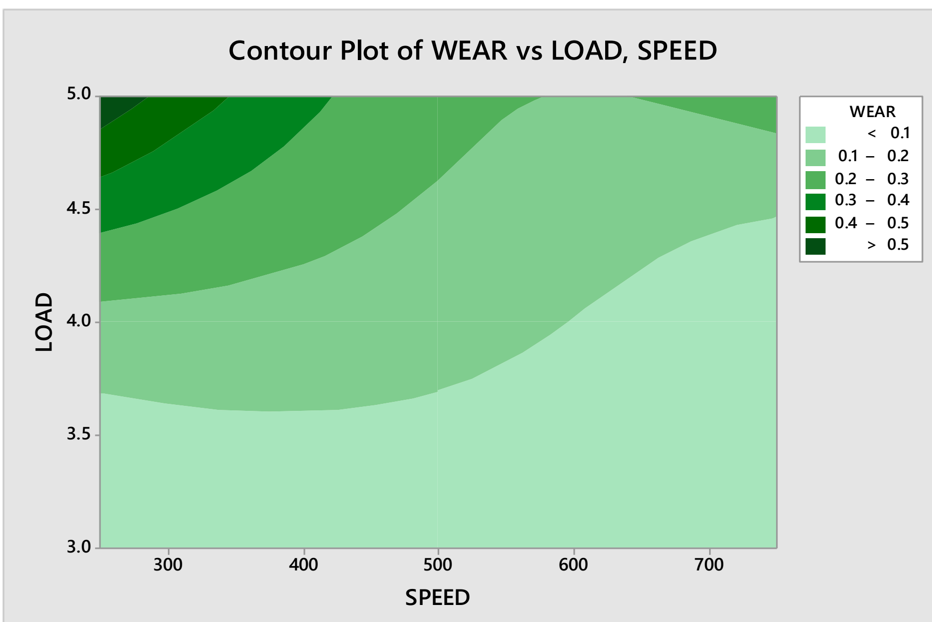

Fig 8.2: Wear rate v/s load, speed.

From the fig it evident that at superior speed 750rpm has low wear rate at 250 rpm and 5 kg has higher wear

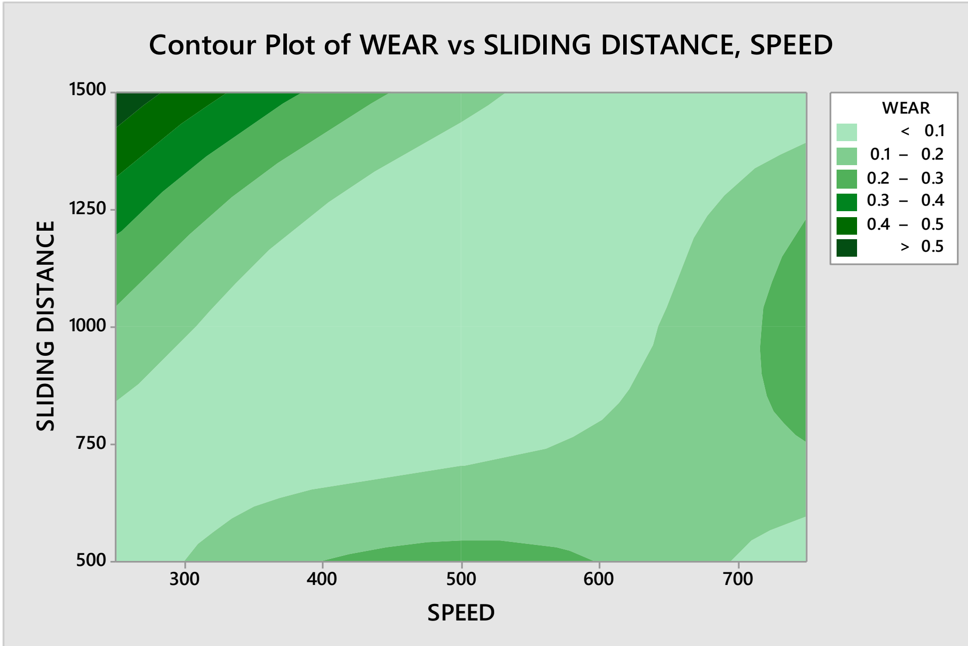

Fig 8.3: Wear rate v/s sliding distance, speed.

At higher speed up to 750rpm even though there is a higher sliding distance the wear is smallest amount, at low speed only there is high wear.

10.CONCLUSION

1. The hardness of aluminium alloy 2618 is increases with increase in percentage of the boron carbide up to certain level.
2. For the hybrid AMMMCs the addition o 3% graphite with 7% of boron carbide will also increases the hardness of the composite
3. The addition of the reinforcement cause decrease in the density of composite
4. The wear test revels that wear rate of Al2618 is higher compare to the two composites, again wear rate decreases with addition of graphite
4. Load has highest impact on wear of the composites.
5. As the sliding speed increases the wear decreases this is due the fact that there is no time for sufficient contact between the steel disk and specimen, and also there is oxide formation which avoids the contact.
6. Sliding distance is directly proportional to wear as it increases the wear also increases
5. The Tauguchi technique revels that load has highest percentage of contribution on wear rate of the composite and speed has lowest percentage of contribution.
6. By the SEM analysis it is clear that there is good dispersion using bottom pour stir casting machine
7. After wear the hardness of composite is increased because of the mechanically mixed layer (MML), MML has the many chemical composition as the interaction of aluminum 2618 and its constituents, boron carbide, graphite and steel plate wear testing machine

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