Experimental Investigation of Hardness and Wear Behaviour of Al6061/Rock Dust Metal Matrix Composite

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Abstract - *Aluminium metal matrix composites (MMCs) are plays a vital role in automobile and aerospace application for their excellent wear and hardness behaviour. Al6061 alloy exhibits good toughness, Wear and strength characteristics when it reinforces with rock dust particulate. MMCs are fabricated by using stir casting technique and reinforced with rock dust with weight percentage 4, 8, 12 and 16% of rock dust. Vickers Hardness Test (VHN) and wear test are carried out for Al6061 reinforced with 4,8,12 and 16% rock dust samples. Experiment confirms that 16% rock dust sample gives good hardness and less wear rate behaviour because of higher constraints to localized matrix deformation.*

***Key Words*: Metal matrix composites, Stir casting, Hardness and Wear rate.**

1. INTRODUCTION

Composite materials are one of the promising concepts available today in the field of engineering and technology. Nowadays most of the structure in field of aerospace, automobile and marine etc. is built by using composite material because of its wide range of flexibility of materials and the characteristics. Microstructure uniformity is achieved when large particles of reinforcement is used in small sized matrix material thereby increase in hardness and also applied pressure [1].Wear resistance and hardness increases of Al6061 Albite particulate composite compared to Al6061 alloy[2]. 2%wt Ti metal powder with Al7075 alloy composites gives less wear rate compared with 0and 1Wt%. [3].Al7075-TiB2 hot rolled alloy and composites exhibited and considerable enhancement in hardness of the materials [4]. Aluminium 2024 alloy reinforced with B4C, hardness is found to increase with the increase in wt. % of the reinforcement [5]. Fabrication of 5083 aluminum alloy with reinforced layers of boron carbide (B4C) through FSP was carried out, nano particle reinforcement exhibited better properties in hardness, tensile behaviour and wear resistance compared to the behaviour of the base metal [6]. It was observed from the review of available literature that a lot of work has been done on aluminium based metal matrix composite with different types of reinforcements, different sizes and manufactured techniques and then subjected to study the behaviour. Alloy composition and its condition influence the behaviour. As the amount of boron carbide particles increases the hardness and wear resistance of the composite materials increases.

2. Objectives

Investigation of Al6061/rock dust behaviour by conducting following tests.

1.   Hardness Test

2.   Wear Test.

3. Casting Procedure

The simplest and the most cost effective method of liquid state fabrication is stir casting. In this work stir casting technique is employed to fabricate, which is a liquid state method of composite materials fabrication, in which a dispersed phase (reinforcement particulates) is mixed with a molten metal by means of stirring. The base metal Al6061 was melted at 720^0C in an induction furnace. An appropriate amount 4, 8, 12 and 16wt% of the rock dust slowly added to the molten metal then the rock dust pre heated up to 600^0C . Simultaneously, the molten metal was stirred thoroughly at a constant speed with a stirrer. High temperature molten metal was poured into the pre-heated graphite moulds to get the required specimens.

4. Experimental Setup

The different composition of various specimens along with specimen number as shown in the

Table 4.1: Tabular Column for Casted Specimen

No of composition	Aluminium-6061	Rock dust
1	100% - 350gm	0% - 0gm
2	96% - 366gm	4% - 14gm
3	92% - 322gm	8% - 28gm
4	88% - 308gm	12% - 42gm
5	84% - 294gm	16% - 56gm

4.1 Hardness Test

Differences between fabrics and surface indentation are called hardness. The composite micro hardness evaluates the power of the boundary bond between strengthening particles and matrix. Experiment has been conduct by changeable weight fraction of rock dust (0%, 4%, 8%, 12%, and 16%). Hardness is record and tabulate. Hardness test have been conduct on each sample by

means of a load of 5 kgf and Pyramidal Diamond indenter whose faces are set at a 136 degree angle from one another. Dimension of impression prepared by indenter have been predict by microscope. The equivalent value of hardness (VH) was calculated from standard formula.

Place the specimen on the anvil so that its surface will be normal to the direction of the applied load. Note the type and size of the indenter. Adjust the weights on the plunger according to the type of the test whether it is Rockwell shown in charts by load selection disc. Keep the lever the position at A. Raise the anvil and test specimen by turning the hand wheel clockwise so that specimen will push the indenter and the small pointer in the dial starts to move. Continue to raise the specimen until the small pointer comes to set position. This indicates that the minor load of 5kgf is acting upon the specimen. Turn the lever from the position A to B slowly so that total load is brought in to action without any jerks. The indenter starts to go down into the specimen and the long pointer of the dial gauge reaches a steady position when indentations complete. Take back the lever to position A slowly. Read the position of the pointer on selected scale, which gives the number as per the selected type of test. Turn back the hand wheel and remove the specimen. Carry out the same procedure for the entire specimen. Figure 4.1 shows the Hardness specimens

Figure 4.1: Hardness Specimens

4.2 Wear Test

The pin was loaded against the disc through a dead weight loading system. The wear test for all specimens was conducted under the constant speed of 400rpm at different loads of 1kg, 2kg, 3kg and 4kg. The pin samples were 40 mm in length and 10 mm in diameter. The surfaces of the pin samples was slides using emery paper prior to test in ordered to ensure effective contact of fresh and flat surface with the steel disc. The samples and wear track were cleaned prior to and after each test. The wear rate was calculated from the weight loss technique and expressed in terms of wear volume loss per unit sliding distance. In this experiment the test was conducted with the following parameters

1.   Load (1kg, 2kg, 3kg and 4kg)

2.   Speed (400rpm)

3.   Time (5min)

In the present experimental, the parameters such as load are varying and speed and time are kept constant at the different trials. Figure 4.2 shows wear specimens

Figure 4.2: Wear Specimens

5. Calculations

A. Equation to calculate the VHN

Test parameters

- Machine: Vickers hardness tester
- Specimen dimension: 22mm dia×15mm length
- Test load: 5 Kg
- Hardness indention angle: 136^0
- Magnification of optical microscope: 70X
- Dwell time: 10sec

$$\text{Hardness (VHN)} = 1.854 \times \frac{P}{d^2}$$

Where

P=applied load in kg

d=diagonal indentation in mm

B. Equation to calculate wear rate

Test parameters
1. Machine: DUCOM Pin On disc tribo meter
2. Specimen dimension: 40mm length × 10mm dia
3. Disc material: EN 31 Steel
4. Disc diameter(D): 0.1m
5. Time (T): 5 minutes
6. Speed of disc (N): 400 RPM
7. Temperature: Room temperature

The above parameters are constant for all compositions of wear specimen, but load varies from 1kg to 4kg

Sliding distance (S) of the specimen can be calculated using formula

$S = \Pi \times N \times T \times D$

$S = \Pi \times 400 \times 5 \times 0.1$

$S = 628.3$ m

Wear rate is evaluated using the formula

Wear rate = $\frac{\text{Specimen weight loss}}{\text{sliding distance}}$

6. Results and Discussion

6.1. Hardness

Figure 6.1 shows that hardness number for different specimen and it clearly indicates that the amount of rock dust increases the hardness will increases due to the presence of extremely harder rock dust particles in the aluminium alloy matrix and higher constraint to the localized matrix deformation during indentation and variation of Vickers Harness linear.
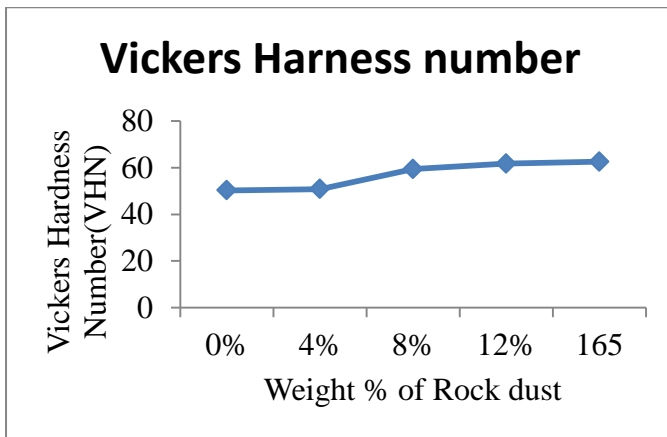

Figure 6.1: VHN for Casted Specimen

6.2. Wear Rate

From the figures 6.2 shows that the amount of rock dust particles increases the wear rate due to uniformly distribution of rock dust hard particles in the matrix Al6061, thereby increases the wear resistance .When the materials become harder this resists the wear more hence wear rate decreases.
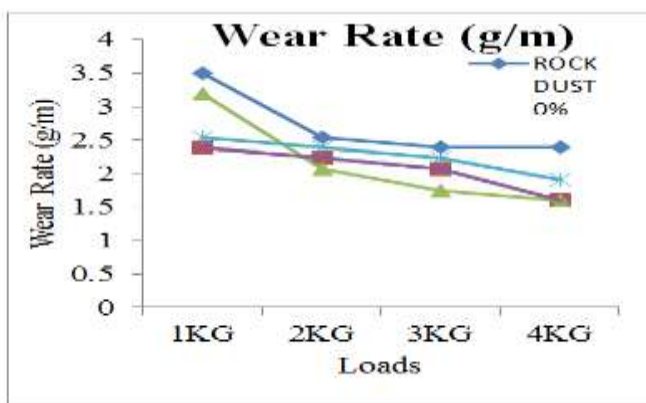

Figure 6.2: Variation of wear rate for different specimen at constant Speed

7. Conclusions

1. Hardness of the Aluminium alloy goes on increases as the addition on rock dust due to less local deformation of harder material.

2. The findings verified that stir formed Al alloy 6061 with composites strengthened with rock dust is obviously superior to base Al alloy6061 in the comparison of hardness, i.e. hardness improves after addition of rock dust particles in the matrix.

3. Maximum hardness of 62.55 VHN acquired for 16 percent weight of rock dust, whereas base metal hardness Al-6061 is 50.26VHN.

4. Wear rate is discovered to tend to reduce with growing particles wt. The proportion that confirms the addition of rock dust is useful in decreasing the wear rate of MMCs.

5. Wear Rate decreases due to highly cohesive bond between rock dust particulates.

8. References

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