Experimental Investigation of Hardness and Wear Behaviour of Al7075/B_4C/Al_2O_3 Hybrid Composite

Govardhana V[1], Tejas K S[2], Shilpa P C[3]

Assistant Professor[1], PG Scholar[2, 3]
Department of Mechanical Engineering,
[1]Hyderabad Institute of Technology and Management, Hyderabad, Telangana, India.
[2]University Visvesvaraya College of Engineering, Bangalore, Karnataka, India.
[3]University B.D.T. College of Engineering, Davanagere, Karnataka, India.

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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. Al7075 alloy exhibits good toughness, Wear and strength characteristics when it reinforces with B_4C and Al_2O_3. MMCs are fabricated by using stir casting technique and reinforced with B_4C and Al_2O_3 with weight percentage 1, 2 and 3% of B_4C.Briness Hardness Test(BHN) and Wear Test is carried out for Al7075 reinforced with 1,2 and 3% B_4C samples by keeping Al_20_3(1%) constant. Experiment confirms that 3% B_4C sample gives good hardness and less wear rate behaviour because of higher constraints to localized matrix deformation.

Keywords – Hybrid 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 Al7075 Albite particulate composite compared to Al7075 alloy[2]. 2%wt Ti metal powder with Al7075 alloy composites gives less wear rate compared with 0and 1Wt%. [3].Al7075-TiB_2 hot rolled alloy and composites exhibited and considerable enhancement in hardness of the materials [4]. Aluminium 2024 alloy reinforced with B_4C, 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 (B_4C) 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 Al7075/B4C/Al2O3 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 Al7075 was melted at 750^0C in an electric furnace. An appropriate amount (1wt% of the base metal) of boron carbide powder was then added with a constant Al_2O_3(1 wt% of the base metal). Slowly to the molten metal. Carbide powder was then added with a constant Al_2O_3(1 wt% of the base metal). Slowly to the molten metal. Simultaneously, the molten metal was stirred thoroughly at a constant speed with a stirrer. The high temperature molten metal was poured into the pre-heated (600C) cast iron moulds to get the required specimens. The same procedure is followed to produce 2% and 3%.

The different composition of various specimens along with specimen number as shown in the Table 3

Table 3: Tabular Column for Casted Specimen

Specimen Number	%of Al7075	%of Al_2O_3	%of B_4C
0	100	---	---
1	98	1	1
2	97	1	2
3	96	1	3

4. Experimental Setup

4.1 Hardness Test

Hardness test is conducted by using Rockwell and Brinell hardness testing machine. For the testing the ball type indenter made of steel of diameter 2.5mm is selected with a load of 100kgf is applied to the specimen.

Test Procedure:

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 or Brinell 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 10kgf 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 loads of 5kg at different speeds of 300rpm, 400rpmand 500rpm. The pin samples were 70 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
2. Speed
3. Time

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

Figure 4.2: Wear Specimens

5. Analytical Calculations

A. Equation to calculate the BHN

$$BHN = \frac{2F}{\pi D(D-\sqrt{D^2-d^2})}$$

Where, F= Load in Kgf

D= Indenter Dia in mm

d= Indentation Dia in mm

B. Equation to calculate wear rate

$$K = \frac{\Delta G}{\Delta S} \quad (\text{gm/mm})$$

Weight Loss, ΔG=Initial weight (G_1) - Final Weight (G_2)

Sliding Distance,ΔS =$2\pi RN(t_2-t_1)$

Where, G1 and G2 are the Initial and Final weight (gm)

N= Speed (rpm)

t_1 and t_2= Start and Finished time (min)

R= Distance (mm)

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 boron carbide increases the hardness will increases due to the presence of extremely harder B_4C particles in the aluminium alloy matrix and higher constraint to the localized matrix deformation during indentation and variation of Brinell Harness linear.

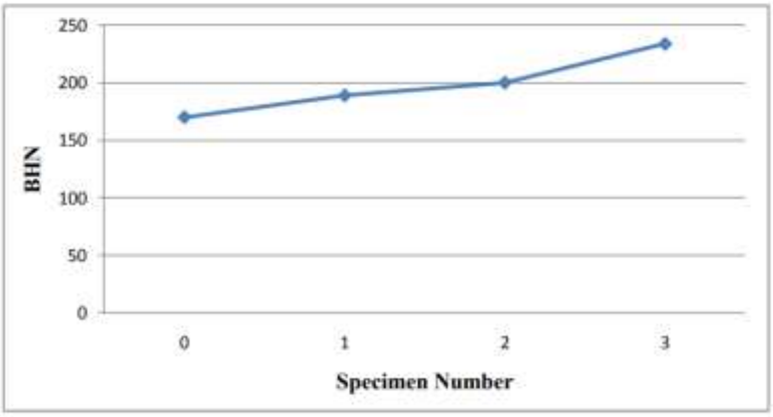

Figure 6.1: BHN for Casted Specimen

6.2. Wear Rate

From the figures 6.2(A) and 6.2 (B) shows that the amount of boron carbide particles increases the wear rate due to uniformly distribution of boron hard particles and Alumina in the matrix Al7075, thereby increases the wear resistance. When the materials become harder this resists the wear more hence wear rate decreases.

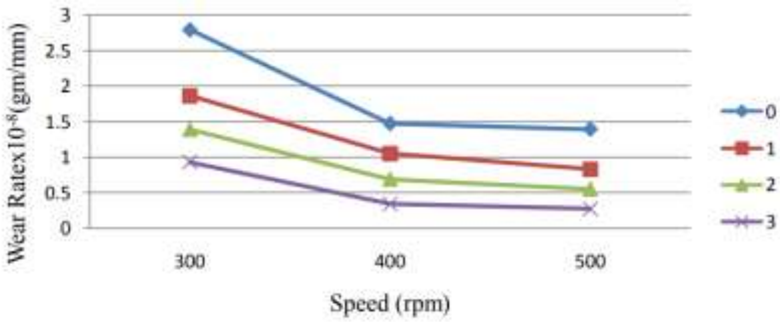

Figure 6.2(A): Variation of wear rate for different specimen at constant load

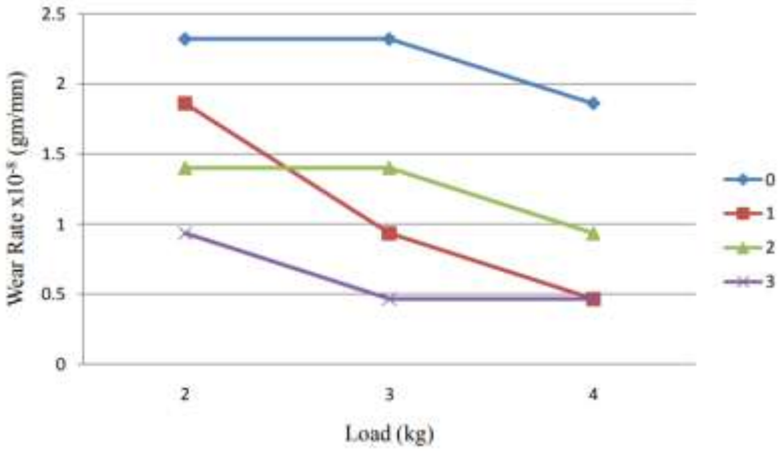

Figure 6.2(B): Variation of wear rate for different specimen at constant Speed

7. Conclusions

1. Hardness of the Aluminium alloy goes on increases as the addition on boron carbide due to less local deformation of harder material.
2. Wear Rate decreases due to highly cohesive bond between boron and Aluminium.

8. References

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