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Effect of Reinforcements on Specific Wear Rate of Al 7075 / Tib_2/ Cr_2O_3 Hybrid Composites

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Abstract: ***A composite material contains different reinforcing elements added to the major material that forms the base matrix. In this work Aluminium 7075 matrix was reinforced with 12% TiB2and 4%, 6% and 8% Cr2O3 and the wear behavior of this composite was studied. The composite material was prepared by the process of stir casting. The rate of specific wear was measured for different reinforcements under varying velocity and load. The Scanning Electron Microscope images of the worn-out surfaces were used to investigate the wear pattern. The wear rate could further be extrapolated using fuzzy logic and were compared with the experimental results.***

Keywords: ***Hybrid composites, Stir Casting, Fuzzy Logic, Specific Wear rate, Pin on disc, Micro hardness, Impact Strength***

I. INTRODUCTION

Lot of researches carried out in the field of composite materials has resulted in better material properties as compared to the conventional materials. Aluminium is an abundantly available metal which can be manufactured at low cost and with relative ease, which makes its composites popular in automobile and aerospace industries. And stir casting is the most popular manufacturing method used for the production of Aluminium composites.

The prolong use of component will cause wear. This will decrease the effeciency and reliability of the machine.

According to Baradeswaran et al. [2] the elongation and hardness is increased with the addition of reinforcemnts in AA 7075 alloy. Munisamy et al. [7] concluded that the hardness can be improved with the addition of Zircon sand and boron carbide particles. The work done by Kuldeep et al. [5] concluded that rate of wear as well as tensile strength is increased with the presence of boron nitride and zirconium dioxide in Al7075 alloy.

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Sharma and Kumar [11] reported that addition of Al2O3-SiC Graphite reinforcement are increased, there is an appreciable improvement in mechanical properties in metal matrix composites. Dirisenapu et al. [1] concluded that hardness as well as tensile strength is increased with the addition of B4CClicon Carbide and Boron Carbide Nanoparticles in AA 6061 alloy.

The work done by Khan et al. [4] concluded that hardness was increassed due to the presence of quaiscrystals as well as boron nitride. Senel et al. [10] reported that the hardness and compressive strength was enhanced due to the addition of SiC and GNPs. Marikkannan and L [6] concluded that the hybrid composites showed improved mechanical and wear resistance suitable for engine cylinder liner applications, with the addition of Al2O3 and SiC. Roy et al. [9] concluded that the mechanical and wear properties are improved with the presence of SiC and CB in aluminium 7075 matrix. James et al. [3] concluded that the presence of SiC and Al_2O_3 will improve the rate of wear in Aluminium alloy. Palanivel et al. [8] reported that hardness was incresed with the presence of BN nanoparticles in AA6082.

In this work experiment was conducted to understand the wear resistance rate of the hybrid composite of Aluminium-7071, TiB_2 and Cr_2O_3 was made in this work. Also, a better understanding of wear rates is done using SN ratio analysis. The most influencing factor was identified from this analysis.

II. MATERIAL SELECTION AND MANUFACTURING PROCESS

Liquid metallurgy process was adopted for composite preparation. TiB_2 and Cr_2O_3 were chosen as reinforcements to increase mainly the mechanical properties of Aluminium 7075 base matrix. The composite moulds were prepared by process called as stir casting. A three phase electric furnace melted the Aluminium ingot. Gases from the atmosphere for example Hydrogen could get easily absorbed by the metal during the melting process. In order to absorb the dissolved gases a small amount of Hexachloroethane (C2C16) was also added. Reinforcements were preheated prior to the addition in the base material. The Aluminium alloy on molten state was stired constantly at 500 RPM with an stirrer. The preheated reinforcements were mixed with the melt base material at about 760^{o}C and stirring was continued to obtain homogeneous distribution. The molt was then poured to the metal-moulds and let cool.

Later, the material was removed from the mould. Desired dimensions were obtained out of it by cutting and machining. The composition in composite is shown in Table I

TABLE I: Composition of reinforcements

Samples	TiB_2 in Weight %	Cr_2O_3 in Weight %
Specimen 1	12 %	4 %
Specimen 2	12 %	6 %
Specimen 3	12 %	8 %

III. SEM IMAGE ANALYSIS

From the SEM image the reinforcement can be seen in Aluminium matrix. From the Fig. 1 and The Fig. 2 one can understand that the reinforcement is distributed in fairly uniform manner. A small fraction of agglomeration can be seen in the Fig. 3. This indicates that the matrix is saturated with the addition of reinforcements. There is also no indication of voids or cracks in the matrix reinforcement interface.

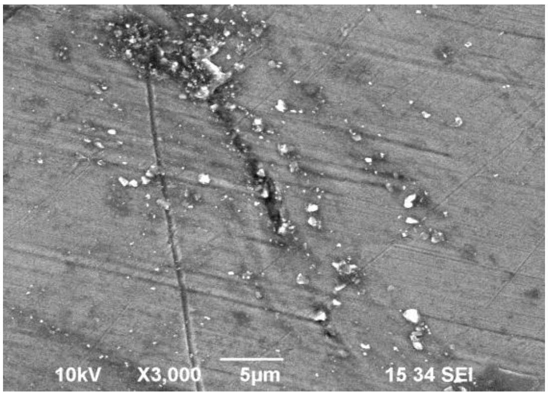

Fig. 1: Specimen 1 image using SEM

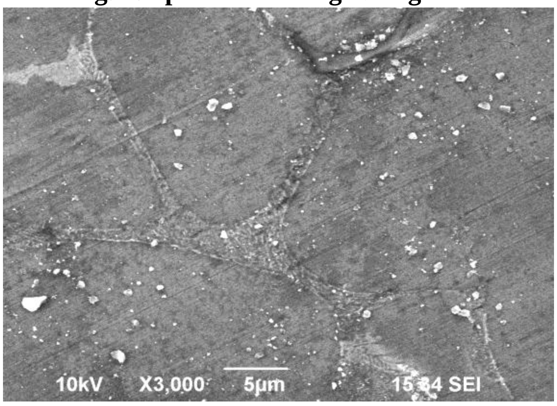

Fig. 2: Specimen 2 image using SEM

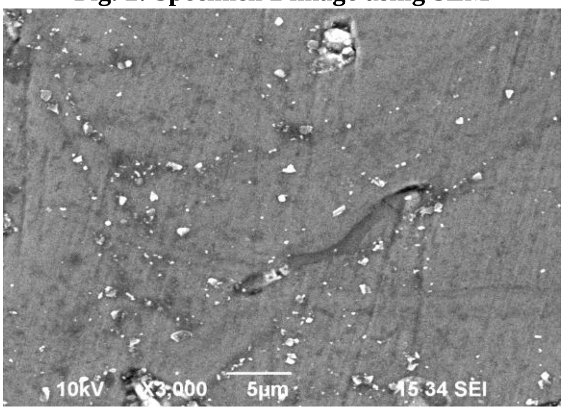

Fig. 3: Specimen 3 image using SEM

IV. IMPACT TEST

Impact test was conducted based on ASTM E23 standard. A V-notch was provided at an angle of 45 degrees. The specimen area was 100 mm^2. The type of test conducted was Izod test. The Fig. 4 shows the result obtained from the impact test. It can be observed that the as the more reinforcement is added the strength against impact force is increased. The reinforcement will act as a barrier for the deformation and thereby increasing the strength.

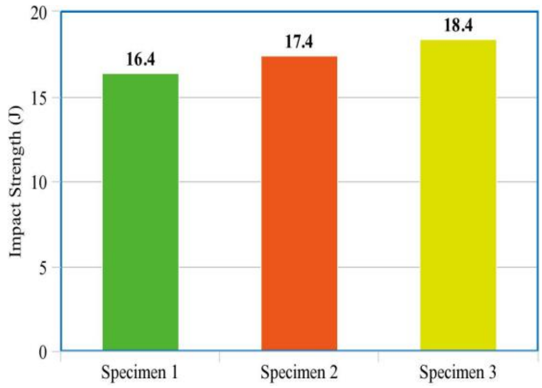

Fig. 4: Impact Test Result

V. WEAR TESTING

The wear rate was measured using Pin-on-Disc of make DUCOM and ASTM G99 standard was followed. The size of the specimens of varying weight percentage used was 10 mm X 20 mm dimesion. Prior to the test, the test-specimen and the disc were cleaned well with Acetone. The initial weight of each specimen was noted down. Load of 30, 40 and 50 kg was applied at 0.5, 1, and 1.5 m/s velocity and the distances taken were 500, 1000 and 1500 m. After each test the weight of specimens were again noted down and volume loss was calculated. The specific wear could be calculated from the volume loss. The results are shown in Table II.

TABLE II: Wear Test Results

Runs	Cr2O3 wt%	Load (N)	Velocity (m/s)	Distance (m)	Specific Wear rate (m^3/m)
1	4	30	0.5	500	11.03
2	4	40	1	1000	13.55
3	4	50	1.5	1500	16.01
4	6	30	1	1500	12.43
5	6	40	1.5	500	13.69
6	6	50	0.5	1000	12.59
7	8	30	1.5	1000	10.56
8	8	40	0.5	1500	11.9
9	8	50	1	500	12.7

VI. SEM IMAGE ANALYSIS OF WEAR SPECIMEN

An irregularity in the surface can be observed in the Fig. 5, Fig. 6 and Fig. 7 This is an indication of erosive type wear. A thin oxide layer is formed on the surface.

This can be observed as thin white lines. This oxide layer will reduce the wear rate as a result of reduction in friction. The materials will be transferred from pin to disc due to asperities on the disc material. This transfer will be increased with the increase in load. After a careful observation one can see a ploughing action in the wear surface. This is a clear indication of delamination type wear mechanism.

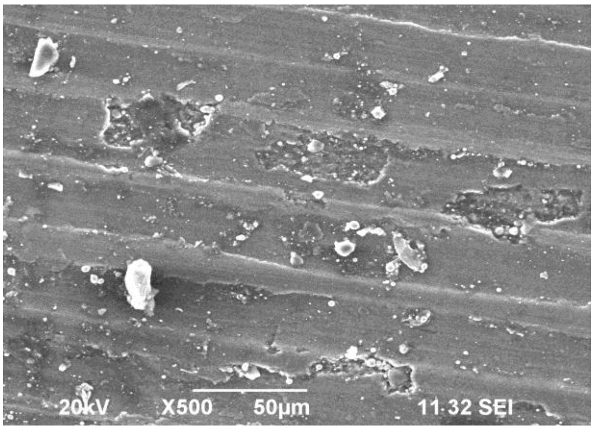

Fig. 5: Wear Specimen 1 image using SEM

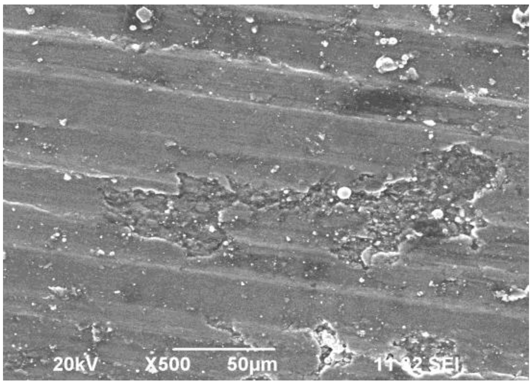

Fig. 6: Wear Specimen 2 image using SEM

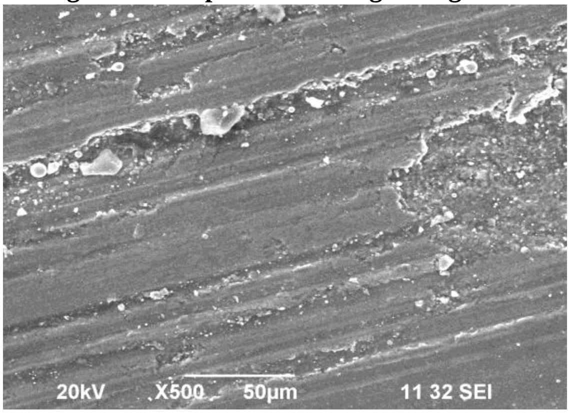

Fig. 7: Wear Specimen 3 image using SEM

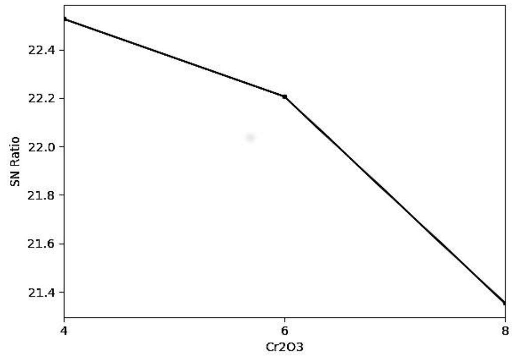

Fig. 8: SN ratio of Cr2O3 Weight %

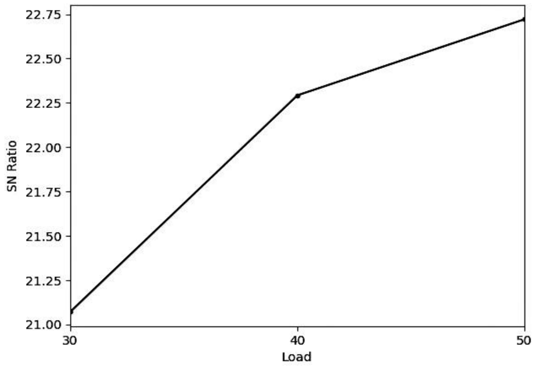

Fig. 9: SN ratio of Load

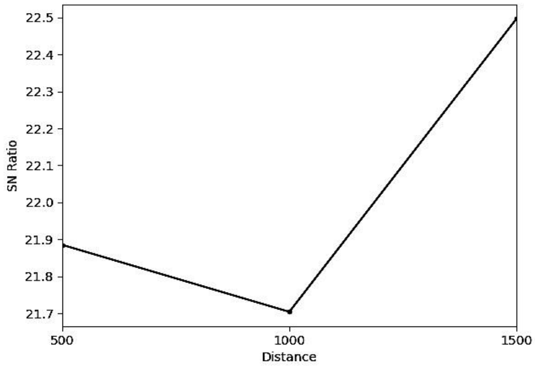

Fig. 10: SN ratio of Distance

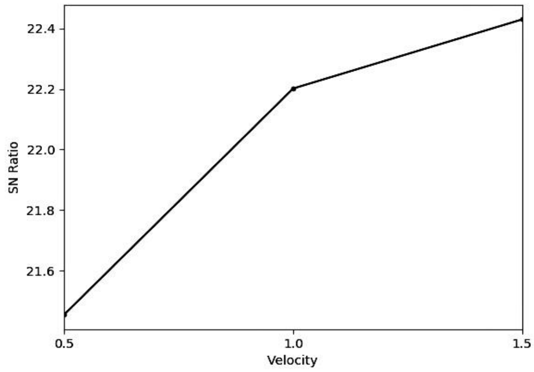

Fig. 11: SN ratio of Velocity

All the SN ratio analysis was done based on the condition lower the better. From Fig. 8 it can be seen that the rate of wear is improved with the increase in weight % of Cr_2O_3. The Fig. 9 shows that the rate of wear is directly proportonal to the load. The Fig. 10 indicates that the wear rate first decreases and then increases.The Fig. 11 indicates an improvement in rate of wear with the velocity.

VII. CONCLUSION

The present work can be concluded as follows

1. Development and characterization of hybrid composite Aluminium 7075/ TiB2/ Cr2O3 was carried out.
2. The agglomeration of reinforcements in the matrix indicates that further additon of reinforcement will not improve the properties of the composite
3. It was clear from the investigations that addition of Cr2O3 there is an increase in hardness of the material.
4. The rate of wear is improved with the presence of Cr_2O_3. The rate of wear is proportional to the distance, velocity and load.
5. The wear rate SEM analysis shows delamination type wear mechanism.

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