MICROSTRUCTURE AND WEAR BEHAVIOUR OF MATRIX Al7075 REINFORCED WITH MICRO WC-Co PARTICULATE COMPOSITE PROCESSED BY STIR CASTING METHOD

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Abstract: - The present work dry sliding wear behaviour of Al7075 alloy matrix composite reinforced with 9Wt. % of WC-Co particulates is examined after prepared by stir casting. The dry sliding wear behaviour was studied for the composites with parameters of varying sliding speed, load and sliding distance. Microstructure characterization is done using SEM/EDX studies for the composite samples. From microstructural characterization even distribution of WC-Co particulates is observed in Al7075 matrix. DUCOM wear testing machine with EN32 steel disc is used to evaluate the wear rate of the composite. Worn out surface of the composite is subjected to SEM analysis to observe the layer formations. From the results of wear studies it is observed that the composite wear rate is reduced by restricting dislocation between the matrix and reinforcement interface.

Keywords: Al7075, WC-Co, SEM, Dry sliding wear

1. Introduction

The advancement of composite materials was fixated on the requirement for consolidated weight and improved execution properties in applications for military, car, aviation, and space vehicles. The advances in structure and computerized fabricating techniques have brought down their creation costs and extended their utilization for high volume applications in aviation and non-aviation sectors. [1-2]. Which incorporate development materials, for example, plain sheets, water tanks, restroom machines, home fittings, furniture industry, corrosion resistant compartments, angling vessels, mechanical items, portions of hardware, electrical industry, car parts, motor housings, vehicle seats and pedal mounting etc. Also, a few particulate reinforcements like SiC, Al2O3, TiC, B4C, WC and TiO2 are used for Al matrix as strengthening particulates [3]. In the aviation area, advancement or weight decrease assumes a significant job. Since, an airplane's presentation is straightforwardly relative to the airplane weight. It is in this manner important to create lighter structures or segments so as to give the essential quality and unbending nature in the base cross-sectional region. Metal grid composite has a significant influence in this specific region [4, 5]. A few processing methods like powder metallurgy, mechanical alloying and other various techniques including spray deposition technology have produced particulate strengthened metal matrix composites. Stir casting method is customary as a traditional process which is economic, the scope of procedures set up accessible for intermittent metal matrix composites. Its advantage lies in its effortlessness, adaptability and relevance for the preparing of huge amounts. It is the generally cheap of every single open course to produce metal network [6-7]. Mechanical examinations, for example, hardness, ductile, pressure and power of effect have been assessed particularly. A few parts utilized in a mechanical application experience sliding or pivoting movement, where the two segments slide together. Composites with more wear-resistance should be developed. The aim of this paper is to understand the effect on wear properties of Al7075 alloy by micro size WC, Co particle reinforcement.

Wear experiments were carried out using pin-on - disc wear devices made by DUCOM. The influence of load applied, sliding speed, and sliding speed on the behaviour of composites Al7075-WC-Co was studied.

2. Experimental Details
For the current work, Al7075 alloy is used as the base matrix alloy and WC-Co mixture is used as reinforcing materials. The chemical composition of Al7075 alloy is tabulated in Table 1.

Table 1: Chemical composition of Al7075

| Element | Si  | Fe  | Cu  | Mn  | Mg  | Cr  | Zn  | Ti  | Al  |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| wt.%    | 0.4 | 0.5 | 1.6 | 0.6 | 2.5 | 0.15| 1.5 | 0.2 | Balance |

The secondary phase materials WC and Co are blended with the Zirconia (Zr) balls to prepare the cermet mixture using planetary ball mill. During the preparation of the composite, an average size of 37μm of the WC-Co mixture is extracted using sieving analysis and used as reinforcement.

9 Wt. % WC-Co cermet particulates reinforced Al7075 alloy composites were prepared by stir casting method. A batch of calculated amount of base matrix Al7075 was melted to its liquidus temperature in a resistance furnace using graphite crucible. Degasification is performed using solid hexachloroethane \((C_2Cl_6)\) to the liquid metal and unwanted absorbed gases are removed from the melt. Mechanical stirring was performed to form a fine vortex using zirconia coated steel rod [8]. The molten metal of Al alloy was stirred at a pace of about 300rpm for around 5 to 10 minutes. The preheated calculated amount of WC-Co mixture is added with constant stirring once the molten metal reaches a superheated temperature of 780°C. Constant stirring was maintained before and after addition of reinforcing particles and homogeneity is achieved. Maintaining a steady stirring action helps the melt to evade particle agglomeration and severance. The permanent steel mould with length 140 mm and diameter Ø15 mm is preheated and kept ready in parallel. The liquid composite mixture is then poured into permanent mould and kept under normal atmospheric temperature for solidification.

The sliding wear test at normal room temperature is performed with DUCOM wear testing equipment. The samples used to check wear are prepared using standard ASTM G99. The size of the test specimens is 8 mm in diameter and 30 mm in length. The equipment used to check sliding wear is shown in Figure 1. Digital electronic weighing machine with 0.0001gram accuracy is used for weighing the samples before and after testing.

Figure 1: DUCOM wear testing equipment

3. Results and Discussions
3.1 Microstructure observation

Figure 2(a-b) represents 9Wt. % WC-Co reinforcement added Al7075 composite Scanning Electron Microscope (SEM). The uniform homogeneous distribution of the reinforcement can be observed from the SEM images without any agglomeration forming. Si and α-Al boundaries can be observed from microstructure of the composite. Elements like Co, W, C, Zn, Al, Cu, Mg and Mn are identified in EDX elemental analysis which is represented in Figure 2(c-d).

![SEM images of the composite](image1)

![EDX spectrum of composite](image2)

Figure 2. (a-b) SEM images of the composite, (c-d) EDX spectrum of composite

3.2 Wear rate for varying sliding velocity

Variation in wear rate of the composite prepared for 9Wt. % composite under different speed level conditions of 0.94, 1.87, 2.82 and 3.75 m/s are examined. The corresponding results obtained are represented in Figure 3. In this condition, the two parameters load and sliding distance are kept constant at 19.6N and 500m respectively. For the incremental in the speed the wear rate of the composite decreases both in matrix and composite sample. In compare with the matrix, composite wear rate is observed as decreased, this is mainly because as the speed increases the formation of wear debris which acts as a lubricating media between pin and disc which made wear rate as smoother [9]. Hence the combination of WC-Co particulates in the matrix has more wear resistance over different variables of speed.
Figure 3. (a) Wear rate of 9Wt% of WC-Co reinforced with Al7075 composite for varying sliding speed, (b-c) Worn out surface SEM images of the composite.
3.3 Wear rate for varying load
Variation in wear rate of the composite prepared for 9Wt% composite under variable loading conditions of 4.9, 9.8, 14.7 and 19.6N are examined. The corresponding results obtained are represented in Figure 4. In this condition, the two parameters speed and sliding distance are kept constant at 400rpm and 500m respectively. From Fig 4(a) it is clearly observed that as the load increases the corresponding wear rate is also increases. Wear rate of the composite is observed less in comparison with the matrix. The presence of hard ceramic particulates that accumulate at the boundary region of the matrix that makes composite to resist the pressure applied [10]. It can be observed from the SEM images as represented in Fig 4(b-c) that no formation of oxide layer in the direction of wear. The application of the pressure on the specimen which generates a clear adhesive wear on the sample surface.

![Graph of Wear Rate vs Load](image)

(a)

![SEM Images](image)

(b)
3.4 Wear rate for sliding distance

Variation in wear rate of the composite prepared for 9Wt% composite under variable sliding distance conditions of 250, 500, 750 and 1000m are examined. The corresponding results obtained are represented in Figure 5(a). The worn out regions are represented in Figure 5(b-c). The addition of WC-Co particulates in the matrix results in decrement of wear rate in the composite. The prolonged distance travel of the specimen leads to the worn surface of the disc part which is accumulated with the wear debris [11-12]. Further as the sliding distance increases the corresponding wear rate also increase.

![Graph showing wear rate vs sliding distance](image)

**Figure 4.** (a) Wear rate of 9Wt% of WC-Co reinforced with Al7075 composite for varying load, (b-c) Worn out surface SEM images of the composite
4. Conclusions

The conclusions made for the present work on the microstructure and wear characteristics of Al7075 matrix reinforced with 9Wt. % WC-Co particulate composite prepared by stir casting is as follows. The preparation of the composite using stir casting method by maintaining even distribution of the reinforcement is successful. Effective stirring action and proper maintenance of temperature during the process leads to the even distribution of ceramic particulates over the matrix. The same was observed from the Scanning Electron Microscope (SEM) images. The EDX spectrum analysis also confirms the presence of elements like Al, Co, W, C, Zn, Mg and Mn in the composite. The presence of hard ceramic particulates and other elements which lead to the decrement of wear rate with respect to matrix under different parameters of varying sliding speed, load and sliding distance. The application of the pressure on the specimen which generates a clear adhesive wear on the sample surface which leads to the decrement in the wear rate.
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