Wear Behaviour and Microstructure Analysis of Al-7075 alloy reinforced with Mica and Kaolinite

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Abstract. In the present work, an attempt is made to investigate wear behaviour of Al-7075 alloys made of Mica and Kaolinite. Specimens are prepared using stir casting technique in a temperature range of 800 to 850°C. Influence of Mica and Kaolinite reinforcements on the wear characteristic of the composite is analysed using experiments. Wear behaviour under constant load of 40 N is investigated using pin-on-disc test at room temperature, under dry condition. Experiments are conducted for different proportions of reinforcements used (2%, 4%, 6% and 8%). Results were found to predict an increase in wear behaviour with increase in weight percentage of reinforcements.

Key words: Al-7075, Mica, Kaolinite, Stir casting, Microstructure analysis and Wear behaviour.

1. Introduction

Al-7075 is often used in transport applications, including marine, automotive and aviation. The principle reasons for using Al-7075 alloys are their good cast ability, high corrosion and low density. A limited research work has been reported on Al-7075 with Mica and kaolinite, because both reinforcements are found to have high toughness and high elasticity. On account of their low density values, increase in proportions of these reinforcements lead to small variations in density of composites. The volume fraction of reinforcement is low for 5% and high for 20% of powder mica and kaolinite [1]. The aluminium matrix gets strengthened when it is reinforced with the hard particles of Al₂O₃ and mica.

Mica and kaolinite have low density and high hardness than silicon carbide, thus opted as reinforcement for high performance metal matrix composites (MMCs). The wear resistance of aluminium alloys is mainly dependent on the composition, applied load and speed of machining [2]. The microstructure images revealed the homogeneous dispersion of mica and kaolinite particles in the matrix. Liquid metallurgy is more economical for MMCs and non-metallic composites [3].

2. Literature Review

2.1 Materials and Fabrication
The aluminium alloy matrix used in this work is an Al-Zn-Mg-Cu. In Al-7075, Zn is the primary alloying element. Mica and kaolinite are added to provide good thermal insulating stability, low density (2.88gm/cm³), workability and prevent cracking. However, the main purpose of adding kaolinite is to provide gloss to the composites. Mica and kaolinite reinforced aluminium matrix composite has gained more attraction with low cost casting techniques [4, 5]. Fabrication of composite is carried out by stir casing technique. Fabrication cost is cut down by 1/10th when compared to other techniques [6]. The aluminium alloy is initially placed inside a graphite crucible and heated to 800°C in a resistance heated furnace. Molten metal is stirred with the help of mechanical operated stirrer. At this stage, preheated mica and kaolinite particles (heated at 800°C for 1hr) are added to the stirred metal with varying proportions (2%, 4%, 6%, and 8%). The speed of stirring was 300 rpm for 5minutes, with a final temperature maintained around 750°C. After stirring, the melted composite is poured into cast steel moulds of 15 and 25mm diameter respectively and allowed to cool.

2.2 Microstructural Analysis

Aluminium composites can be fabricated using different casting techniques. Often, stir casting methods are considered to be economical for fabrication of aluminium matrix composites [7-9, 11]. In general, evaluation of a composite material is made using its mechanical properties and microstructural characterization. Micro-hardness and tensile strength are the most sought after mechanical properties for better-quality composite materials [10]. Microstructural analysis is often expected to reveal the distribution patterns of reinforcements in the matrix [11-13]. Research focus is on accomplishment of superior micro-hardness and higher tensile strength from composite materials, by addition of suitable reinforcements.

2.3 Wear Behaviour

Wear behaviour is an important aspect of a composite, when it originates to application aspects [15]. Enhanced wear resistance is often reported in case of metal matrix composites than unreinforced alloys [16-18]. In general, two types of wear situations (sliding/abrasive) are considered for wear analysis of a material. In the case of particle reinforced matrix, abrasive wear resistance is found to increase with particle volume fraction [19, 20]. Increase in hardness of materials is quoted as major reason for improved wear resistance [21]. With all these facts intact, an attempt is made in this paper to analyse the wear behaviour of the Al-7075 composite.

3. Experimental Details

3.1 Wear Tests

Wear tests of composites is performed using a Pin-on-disc tribometer under ambient temperature. The machine contains a steel disk of diameter 160 mm and thickness of 8 mm with a controller to maintain the speed up to 800 rpm. During tests the disk (specimen) is made to spin at a speed of 350rpm, and the pin is placed at a distance of 40 mm from the rotation centre. A load of 40 N is applied on the specimen without any lubrication. The tests are repeated for five trials of each specimen with different timings.

3.2 Metallographic Observations

The SEM microstructure of the composite is shown in Figures. 1, 2, 3 and 4. The results indicate a homogeneous reinforcement distribution into matrices and no evidence of agglomerate. Clean interfaces of particle reinforced aluminium matrix composites are frequently observed in the specimen produced by powder metallurgy technique.
Figure 1. Al+2%mica+2%kaolinite

Figure 2. Al+4%mica+4%kaolinite

The dark patches indicate reinforcement phase and light one indicates matrix phase. In addition, the composite is found to be free from voids and porosity.

Figure 3. Al+6%mica+6%kaolinite

Figure 4. Al+8%mica+8%kaolinite
4. Results and Discussions

Table 1. Results of Wear and Frictional Force

| Composition (%) | Time in min. | Load in ‘N’ | Frictional force in ‘N’ | Wear in ‘µm’ |
|-----------------|--------------|-------------|------------------------|--------------|
| Al+0%mica+ 0%kaolinite | 3 | 40 | 0.2 | 13 |
| 6 | 0.3 | 14 |
| 9 | 0.4 | 18 |
| 12 | 0.6 | 20 |
| Al+2%mica+ 2%kaolinite | 3 | 40 | 0.4 | 14 |
| 6 | 0.6 | 13 |
| 9 | 0.8 | 17 |
| 12 | 0.9 | 20 |
| Al+4%mica+ 4%kaolinite | 3 | 40 | 0.7 | 12 |
| 6 | 0.8 | 12 |
| 9 | 0.8 | 14 |
| 12 | 1.1 | 20 |
| Al+6%mica+ 6%kaolinite | 3 | 40 | 1.1 | 12 |
| 6 | 1.1 | 11 |
| 9 | 1.3 | 14 |
| 12 | 1.4 | 18 |
| Al+8%mica+ 8%kaolinite | 3 | 40 | 1.2 | 11 |
| 6 | 1.2 | 11 |
| 9 | 1.5 | 13 |
| 12 | 1.8 | 16 |

Fig. 5 shows the effect of mica and kaolinite on different Al composites. The wear loss in composites with larger volume percent of mica and kaolinite are observed to decrease at a slower rate. From the graph it is found that weight loss decreases with increases in the composition percentage (wear resistance increases). The presence of mica and kaolinite in the matrix of Al-7075 tend to increase wear resistance due to increase in grain boundaries.

![Figure 5. Wear losses vs. Time of wear](image_url)
5. Conclusions

The following conclusions are arrived at based on the experimental results.

- The work displays successful fabrication of the Al-7075 composites with mica and kaolinite reinforcements using stir casting technique.
- The presence of mica and kaolinite in the matrix decreased wear loss by increasing wear resistance.
- Microstructure analysis of the composite reveals uniform distribution of reinforcement particles in the matrix.
- The presence of mica and kaolinite in the Al-7075 matrix increases the wear resistance up to 8% of the reinforcement.

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