The Effect of Microstructure, Mechanical and Wear Properties of Al2024 Reinforced Rutile MMCs

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ABSTRACT: In the present study, Al2024 alloy is reinforced with different percentage of rutile sand (3% and 5%) is fabricated by the liquid metallurgy and studied for an microstructure, mechanical and the wear properties. Microstructure revealed even dispersal of rutile particles in the grid resulting in an enhancement in mechanical and wear properties compared to as-cast 2024 alloy. Fractography surfaces of the as-cast alloy and its composites were examined using Optical and Scanning electron microscope. Al2024 alloy+ 3% Rutile (3Ru) composites showed good mechanical properties followed by Al2024 alloy+ 5% Rutile (5Ru) composites.

Keywords: Rutile Particles, A2024 alloy, Microstructure, Hardness, Tensile, Ductility and Fractography.

I. INTRODUCTION

Today in Modern day innovation there is a regularly expanding request in materials which accomplishes great quality, strength, solidness and thickness. However, customary solid materials have restrictions in accomplishing these blends. Compound is a strong arrangement of at least two materials with a solitary strong stage microstructure while in a composite the two segments are isolated by an unmistakable interface at the microscopic and macroscopic structure. Alloys can be heterogeneous or homogeneous whereas composites are generally heterogeneous. Also, alloys can exhibit both isotropic and anisotropic properties whereas composites are generally anisotropic in nature. The physical properties such as density, Young's modulus and thermal conductivity may not differ from those elements, but in the case of composites, the addition of reinforcement into the metal grid shows a considerable increase in the above-mentioned physical properties. Composites give better stiffness and have a higher strength to weight ratio. A wider range of reinforcement materials to use in composites hence they have a broad range of properties. This project aims to design and develop an aluminium-based MMC to suit the requirements of aircraft materials. In this direction, an exhaustive literature review has been undertaken to develop a trail model of

MMC [3-4].Subsequently, the testing methodologies being required to experimentally confirm the various properties are identified. In the end, the possible design of a new MMC is proposed for fabrication and validation. The word "composites" literally means "made of several parts". Composite materials are planned or regularly happening materials created utilizing at any rate two constituent materials with basically special physical or invention properties when stood out from the system which remain autonomous and specific at the naturally visible or microscopic scope inside the completed structure [5].Composites are known for their low density with high strength, stiffness, thermal stability, and improved fatigue properties and wear resistance, In the current examination Al2024 compound was picked as grid material as a result of its more extensive aviation and automotive applications in ventures, similarly as the recreational things. At present little details is obtainable in the Alumina strengthened Al2024 amalgam composites. As such, the current assessment attempts to incorporate the Alumina reinforced Al2024 combination composites by blend tossing methodology. Later these composites will be depicted similar to their Optical Microscope, SEM considers, hardness, wear and the mechanical properties.

II. EXPERIMENTAL PROCEDURE

In the current study, the Al2024-rutile reinforced Al-MMC's is produced in the stir casting process. While the fabrication of the Al2024/rutile composite. Rutile of particle size of 15µm was selected after conducting sieve analysis for the present investigation. Two different composites of different reinforcement percentage (3% & 5%) weight percent were fabricated by the stirring process. The casting set up assembly is shown in fig below

Table 1: Chemical composition of Al2024 alloy (weight percentage)

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others	Balance
0.50	0.50	3.8-4.9	0.1	0.30-0.9	0.10	0.25	0.15	0.05	Aluminium

Figure 1: Stir casting set-up assembly

The composite made by this examination will contain fluctuating rate bit of rutile (3 percent and 5 percent) throughout formation of the Al2024/rutile composite rutile of particle sizes of

~15µm were picked for the current assessment. In this examination plans to look at the effect of assortment of the rate structure of Al2024/rutile composites to imagine the wear and the Mechanical Properties of MMCs and differentiate the result.

Table 2: Designation of Rutile Reinforced Alloy

S/No	Alloy/Composite	Designation
1	As-Cast (Al2024 alloy)	Ac
2	Al2024alloy + 3%Rutile	3Ru
3	Al2024 alloy + 5%Rutile	5Ru

III. EXPERIMENTAL DETAILS

3.1 Microstructure Study

The microstructure of composites is taken from the OM .The Keller's reagent is used as an etching agent. We have used sandpapers of grid size 220µm, 400µm, 600µm, 800µm and 1000µm and grade 1.0, 2.0, 3.0, 4.0 & 5.0 are respectively used to polish to get mirror surface for microstructure analysis.

3.2 Hardness and Tensile Test

The tensile tests and the hardness test were be determine as per the standards ASTM E10 and ASTM E8M-15a norms using Brinell Hardness Tester and UTM respectively.

3.3 Wear Test

The Dry sliding wear tests were coordinated by ASTM-G99 norms. The wear rate relied upon the typical estimation of 3 tests. Five loads of 10N, 20N and 30N at a sliding pace of 1.5m/sec and sliding detachment of 1802m.

IV. RESULTS AND DISCUSSIONS

4.1 Micro structural Characterization using Optical Microscope

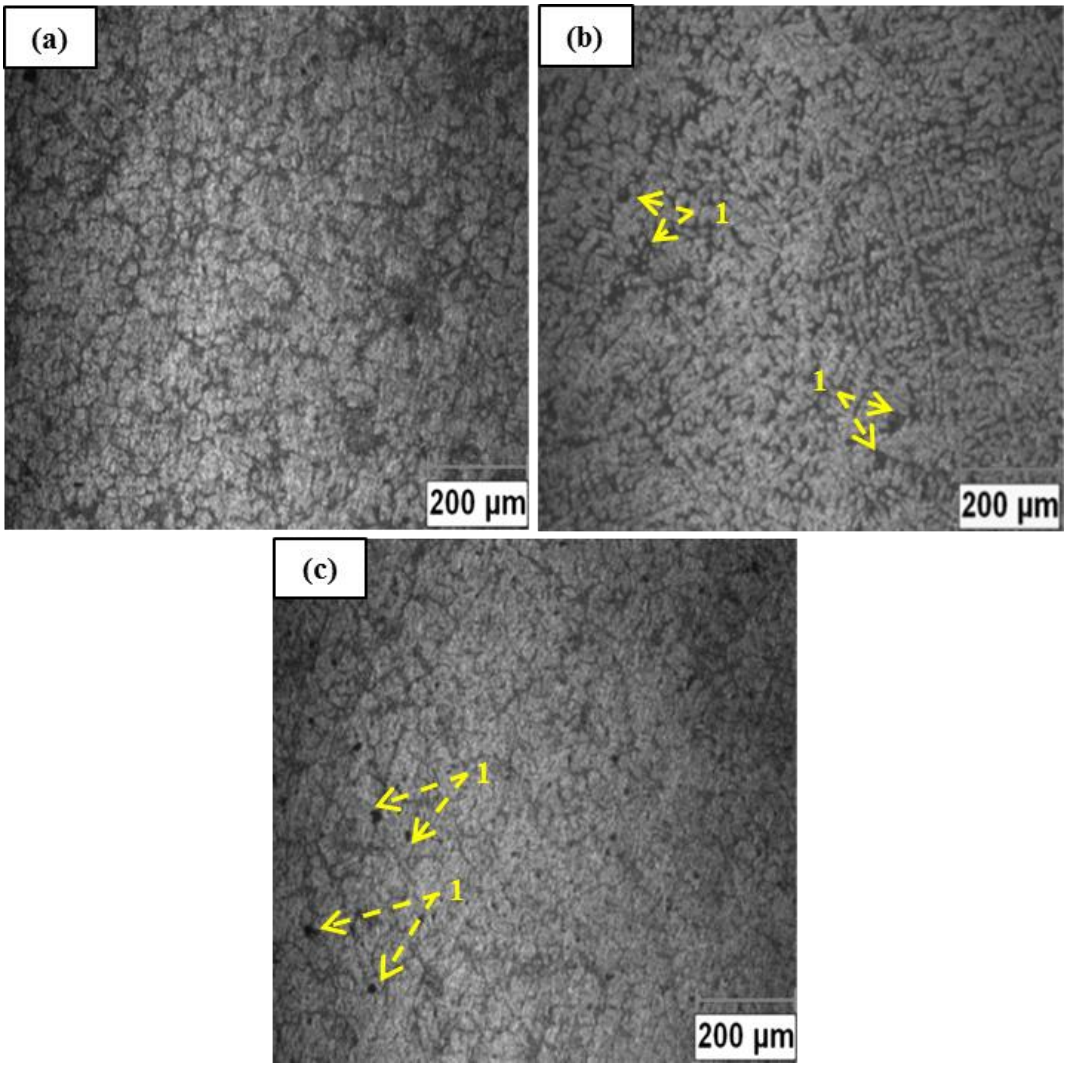

Figure 2: Optical Micrographs of A2024 and its Rutile composites where (a): As-cast 2024 alloy, (b) As-cast 2024 +3% Rutile, (c) As-cast 2024 +5% Rutile

Figure 2(a), 2(b), 2(c) shows the small scale images of the grid compound Al2024-rutile and its composites. The microstructure shows a constant dissemination of support with immaterial equivalent in the network mix in all cast composite lattice considered. The microstructure involves fine empowers in a lattice of dendrite Aluminum solid course of action. Confinement or porosity isn't found in the portion. By far most of the rutile particles are arranged inside the lattice itself which shows that it has been wetted better in light of the extension of Mg as a wetting administrator.

4.2 Hardness test result of Al2024 alloy and its Composites

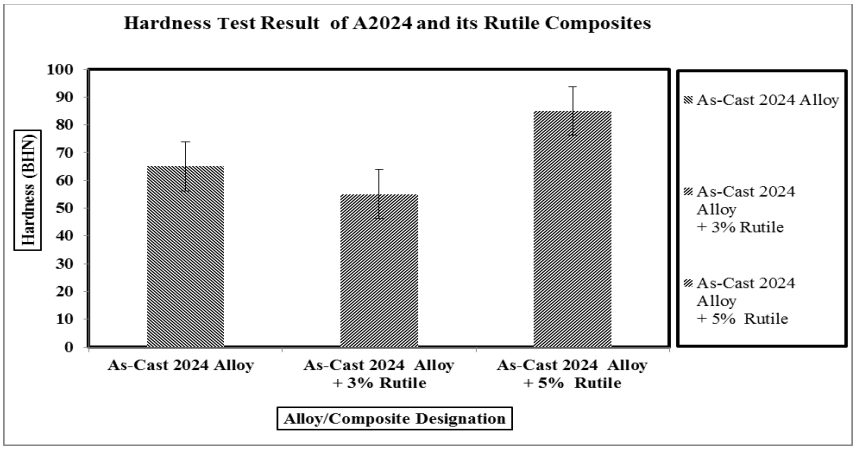

Figure 3: Hardness values of Al2024 alloy and Its Composites

From the Figure 3: it is shows that the hardness increases with the increasing Rutile content in the material. As compared to as-cast alloy (Al2024),and addition of 3% Rutile shows an increase of 4.9 BHN (6.08%). In the contrast, addition of 5% Rutile shows an increase of 7.7 BHN (9.56%) respectively. This improvement in the hardness in threw composites might be credited to the uniform appropriation of a reinforcement (Rutile) in the grid material. Similar trends were observed by several researchers [6-7].

4.3: Tensile test result (UTS) of Al2024 alloy and its Composites

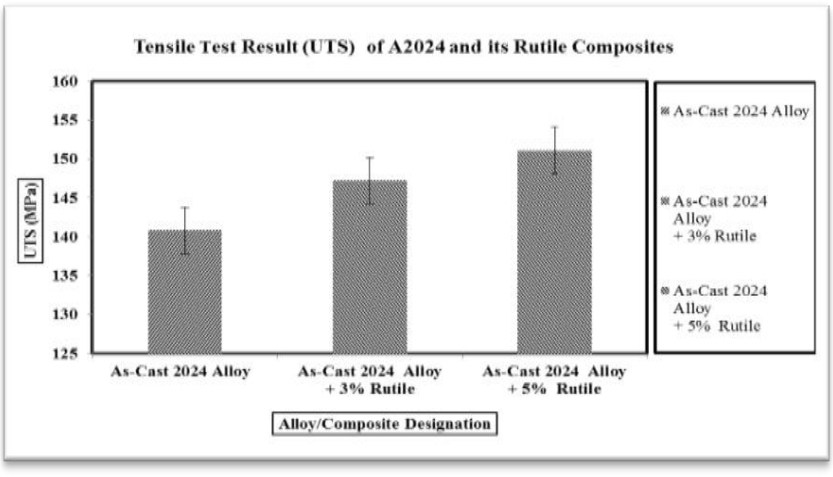

Figure 4: UTS test results of Al2024 alloy and its Composites

From the Figure 4: it shows the tensile test result (UTS) with the increasing Rutile content in the material. As differentiate to the as-cast alloy (Al2024), and addition of 3% Rutile shows an increase of 6.4 MPa (4.54%). In contrast, 5% Rutile addition shows an increase of 10.3

MPa (7.31%) respectively. This improvement in the tensile strength (UTS) in the casted composites may be attributed to the constant sequence of an reinforcement (Rutile) in the grid material. Similar trends were observed by several researchers [7-8].

4.4: Tensile test result (YS) of Al2024 alloy and Its Composites

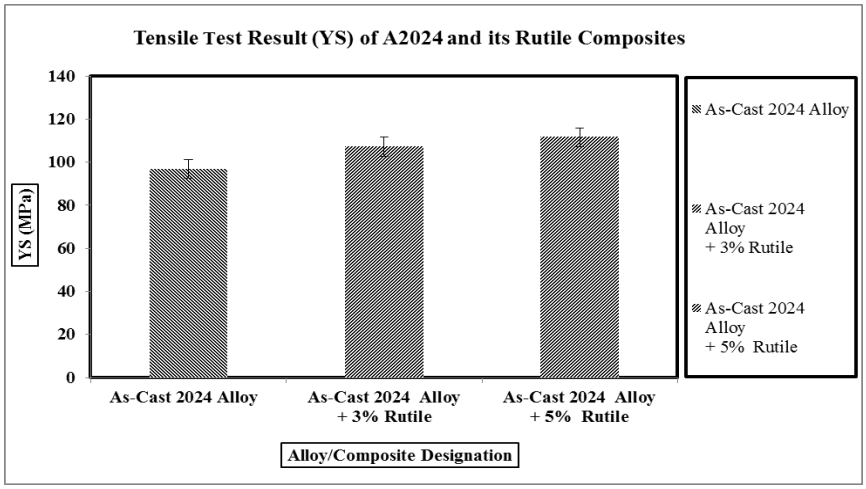

Figure 5: YS test results of Al2024 alloy and its Composites

From the Figure 5: it shows that the tensile test outcome (YS) with expanding in the Rutile content in the material. When contrasted with the as-cast combination (Al2024) and expansion of 3% Rutile shows an expansion of 10.4 MPa (10.4%). In the differentiation, and the expansion of 5% Rutile shows an expansion of 14.8 MPa (15.28%) individually. The improvement in rigidity (YS) is casted composites may be credited to the consistent conveyance of support (Rutile) in the lattice material. Similar examples were seen by a couple of investigates [7-8].

4.5 Ductility test result (% Elongation) of Al2024 alloy and its Composites

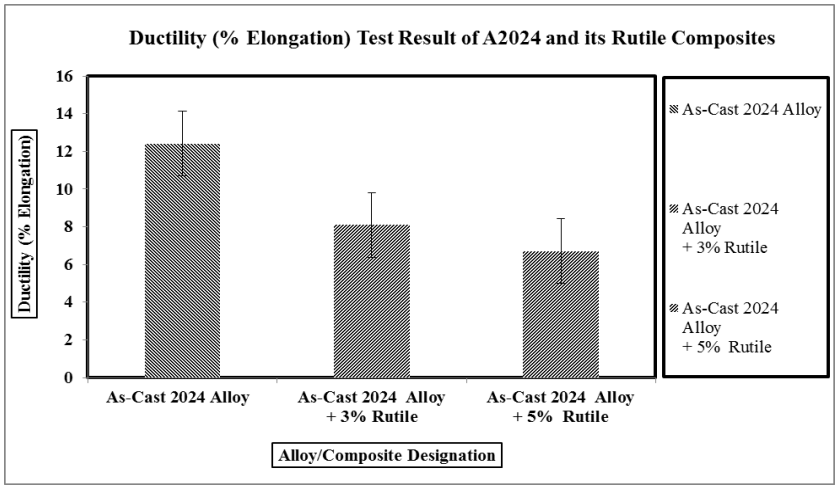

Figure 6: Ductility test result (% Elongation) of Al2024 alloy and its Composites

Figure 6: it is shows that the Ductility in (% Elongation) reduces with the increasing Rutile content in the metal. As balance to the as-cast alloy (Al2024), and the addition of 3% Rutile shows that the decrease in ductility by 4.3 (34.67%). In contrast, 5% Rutile addition shows a decrease in ductility by 5.7 (45.96%) respectively. The decrease in Ductility (% Elongation) in threw composites might be ascribed because of the expansion of hard reinforcement (Rutile) in the material grid.

4.6: Fractography Test Results

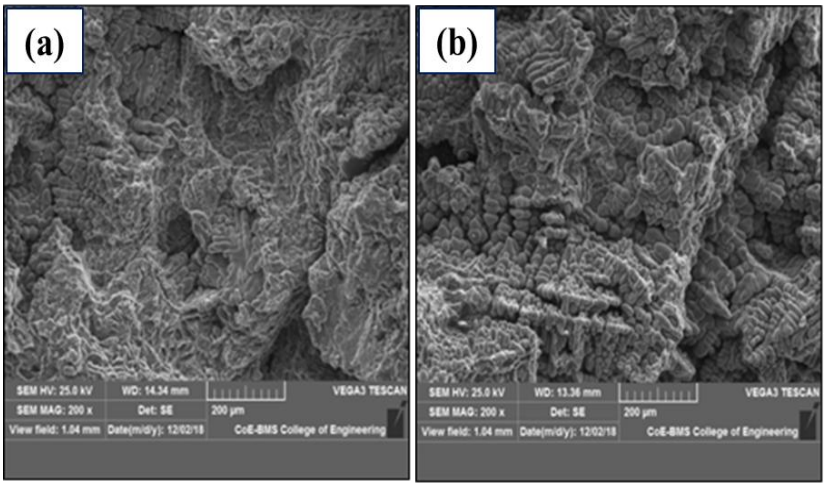

Figure 7: Fractography of A2024 and its Rutile composites where (a): As-cast 2024 alloy (b) As-cast 2024 +5% Rutile

Figure 7: shows the Fractography of A2024 and it's the rutile composites where (a): As-cast 2024 alloy and (b) as-cast 2024 + 5 % Rutile at low and high magnification. The Fig 6 (a) we can observe many dimples which indicate dimple fracture. The Fig 6 (b) we can observe the combination of dimples and voids which indicate dimple fracture indicating a brittle fracture.

4.7 Wear behaviour of Al2024 grid alloy and its Rutile composites.

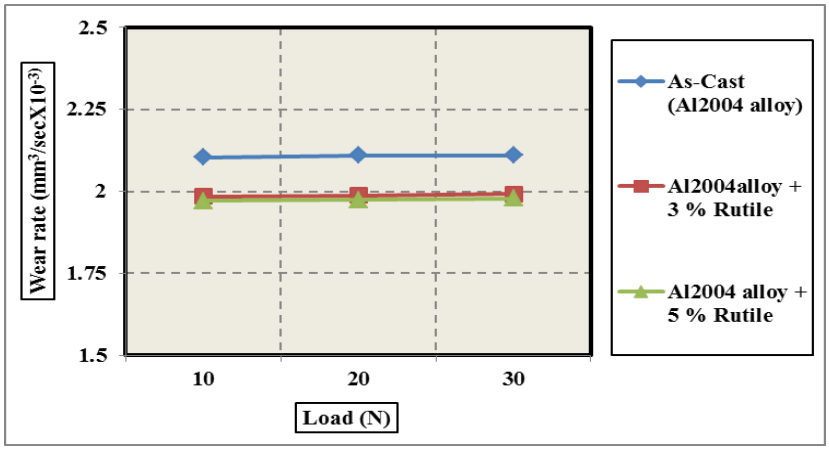

Figure 8: Wear Rate vs Load of Al2024 grid alloy and rutile composites

Figure 8: shows the plot of wear rate of composite Verses Load of Al2004 grid alloy and its composites (Varying rutile percentage 3% and 5%) respectively. It is shown from the above figure that the composite had good resistance wear balance to the as-cast. The wear rate decreases and it might be credit to the increasing in the hardness which is earn sufficient to the constant sequence and bonding of the rutile in the composites. Typical mechanism of wear composites is in this section, as the load goes on increases both tend to increase with an increase in rutile percentage. Similar trends were observed by several researchers [8-9].

4.8 Wear Surface Morphology of Al2004 grid and its rutile composites

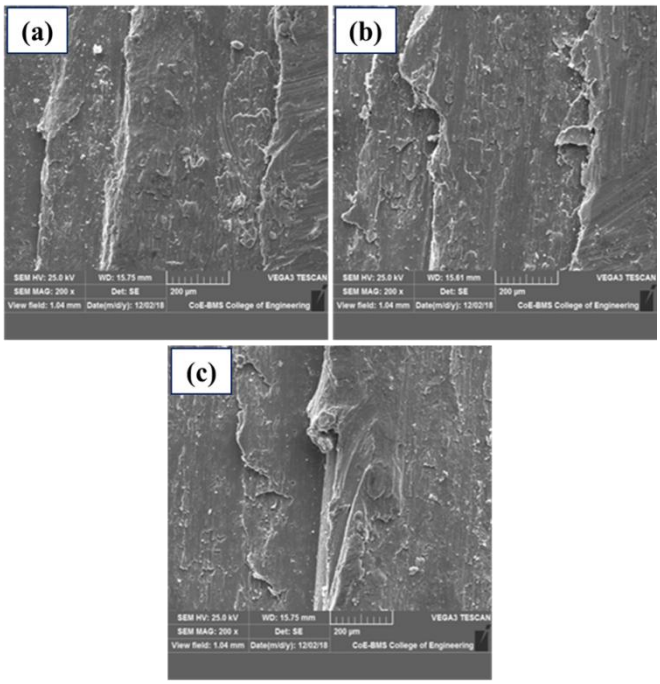

Figure 9: Wear Surface Morphology of Al2024 grid alloy and its rutile composites. Where (a) Al2024 grid alloy at a load of 30N (b) Al2024 grid alloy+3% rutile at load of 30N (c) Al2024 grid alloy+ 5% rutile at a load of 30N

Figure 9: shows the Wear Surface Morphology of Al2024 alloy and its rutile composites. Where (a) Al2024 grid alloy at a load of 30N (b) Al2024 grid alloy+3% rutile at a load of 30N (c) Al2024 grid alloy+5% rutile at a load of 30N.From the Fig 7 (a-c) we can see grid alloy at untreated condition, wear phenomenon occurring here involved the brim formation and material removal took place by plastic deformation due to high load of 30N.

V. CONCLUSION

The conclusions are given taken from the current study:

The tests are led to assess the mechanical properties of a Rutile (TiO2) fortified Al2024 composites of an different weight level of a support, it was discovered that

(i) The Optical Micrographs of polished specimens, the following was observed:

- The distribution of reinforcement particles (Rutile) is found to be uniform.
- The Rutile particles are not trapped in the grain boundaries.
- A significant number of the Rutile particles are arranged inside the grid itself which shows that it has been wetted better due to the extension of Mg as a wetting specialist.
- The Rutile Particles has caused good wetting with the grid which is very favorable in the improvements of the mechanical properties.

(ii) Rutile particles as a reinforcement helped in increasing the hardness (BHN) of Al2024 from 80.5(BHN) as per the following:

- 3% Rutile– 85.4(HV 0.05) (9.53% increase)
- 5% Rutile– 90.4 (HV 0.05) (6.35% increase)

(iii) Rutile particles as a reinforcement helped in increasing the UTS (MPa) of Al2024 from 140.8(MPa) as per the following:

- 3% Rutile– 147.2(MPa)(4.54% increase)
- 5% Rutile– 151.1(MPa)(7.31% increase)

(iv) Rutile particles as a reinforcement helped in increasing the YS (MPa) of Al2024

From 96.8(MPa) as per the following:

- 3% Rutile– 107.2(MPa) (10.4% increase)
- 5% Rutile– 111.6(MPa) (15.28% increase)

(v) Rutile particles as reinforcements reduced % Elongation of Al2024 from 12.4 % as per the following:

- 3% Rutile– 8.1 % (34.67% decrease)
- 5% Rutile– 6.7 % (45.96% decrease)

(vi)Wear surface morphology of Al2024 alloy shows rough surface with more grooves and ridges compared to wear surface morphology ofAl2024-Rutile composites.

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