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Investigate of Wear Behaviour and Mechanical Properties of Titanium Diboride Reinforced AMMC Composites

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ABSTRACT

Aluminium materials are more consumed in the construction and automotive sector for their less corrosion and good machinability. The tribological properties of aluminium can improve while adding reinforcement particles such as Titanium Boride, SiC, Al2O3, etc. This paper investigates the tribological and mechanical characteristics of the Al7075- TiB_2 composite to improve its strength and hardness. The TiB_2 is reinforced with various ratios like 6%, 12%, 15% for testing purposes. The boride powder was used to preheat up to 830°C with Al7075 for proper mixing. The mechanical properties (tensile and hardness) and metallurgical properties (Wear and Microstructural) are investigated through prepared samples. The composition of Al7075- TiB_2 can analyse with the help of the EDAX process.
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1. INTRODUCTION

In current industrial application, Aluminium has more consumed by the industries for easily available and good mechanical properties such as low wear and good strength. The strength of the aluminium based composite improves through adding of different reinforced materials such as Al_2O_3, SiC, TiC, TiB_2, ZrO_2, B_4C, etc. [6]. The Aluminium bases composite was prepared through different techniques such as Stir Casting, Infiltration, Sintering and Powder metallurgy [5]. Most of cases Stir casting is the primary solution for producing the AMMC composite for economical compactability, maximum yield and less damage. TiB_2 particles have preferred to enhance the thermal and mechanical properties of AMMC composite. Due to the preheating process, agglomeration can avoid while making composite [4]. Composites are prepared with carbide and boride, they can sustain in high thermal and wear conditions. Another option to reduce the wear rate in the composite is adding ceramic particles like Alumina, Silica, Zirconia [1]. Oxidative wear is the major problem in high thermal working conditions such as 800 ° C. The improper distribution of boride and oxide particles are the reason for oxidative wear. This can lead to affect the mechanical and metallurgical properties of composite materials. [2]. The preheating process helps avoid the damage of the composite like crack and porosity. The Preheating process mainly focuses on the removal of humidity and bubble formation while stirring process. [3]. The particulate injection is used to avoid agglomeration and particulate clusters. From previous literature, No characterization works and AA7075-TiB_2 adhesive wear studies were found. The AA7075-TiB_2 composite is prepared with TiB_2 reinforced particles with a different ratio like 6%, 12% and 15%. The quality of the prepared composite was proven by conducting the hardness, tensile and wear analysis. The combination is investigated through the Energy Dispersive X-Ray Analysis.

2. EXPERIMENTAL ANALYSIS

This research AA7075 alloy and TiB2 was selected for its wide application in automobile and various construction industries [4]. The ratio of TiB2 was identified from the existing study. The TiB2 particles are preheating at 530°C for excellence in mechanical properties.

Table 1. Chemical Constitutions of Al7075 Alloy

S.No	Constituents	Contribution
1	Aluminium	90.50
2	Silicon	0.04
3	Ferrous	0.2
4	Copper	1.7
5	Manganese	0.04

6	magnesium	2.41
7	Chromium	0.16
8	Zinc	5.22
9	Titanium	0.07
10	Ti+Zn	0.03

In the stir casting process matrix material, Al7075 was prepared as a small piece for easy melting [7]. The crucible furnace was used to melt the Al7075 at 880°C.

Figure 1. Titanium Boride

The boride reinforced particles are preheated to reduce the casting defects such as Crack, porosity and agglomeration and clustering. to 530° C, After that boride particles are mixed with matrix material gradually through the hopper setup. The stirring process was continued up to 10min to proper avoid the blowholes and porosity. [8].

Figure 2. Bottom Pouring Stir Casting

The prepared composite was needed to investigate mechanical and metallurgical properties[9]. Pin on Disk apparatus used to predict the wear rate of the AMMC then, Tensile and hardness test used to predict the strength of the AMMC. The surface quality and defects were investigated through the Microstructural investigation. [10].

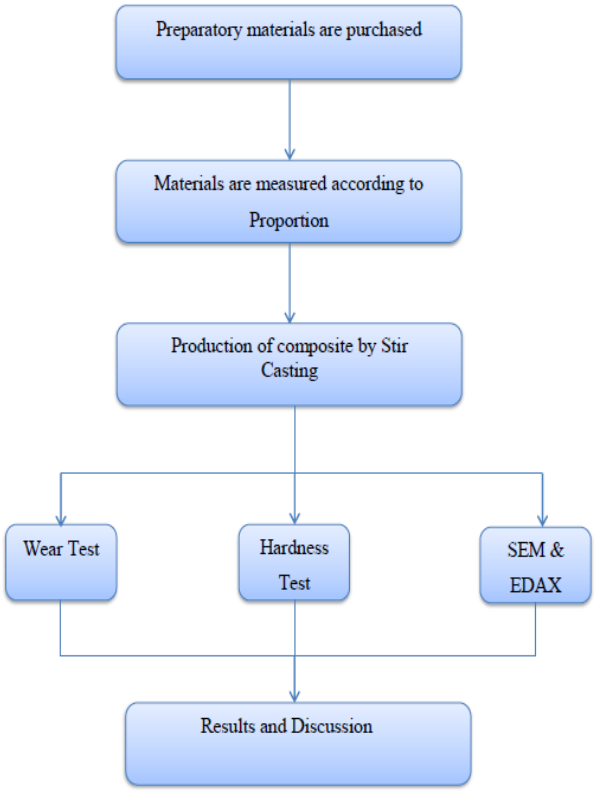


Figure 3. Processing Methodology

The grated paper used to polish the samples also remove the dust over the surface [11]. The polishing process is essential to Microstructural investigation while analysing the surface inspection.

Table 2. Composite Preparation with various percentage

Sample No	Materials	Aluminium (gms)	TiB2 (gms)
1	Al 7075 94% & TiB2 6%	122.73	8.22
2	Al 7075 88% & TiB2 12%	113.38	19.43
3	Al 7075 85% & TiB2 15%	107.03	31.65

The weight and density ranges are predicted through the Law of Mixture concept.

3. RESULTS AND DISCUSSION

3.1 EDAX Testing

The EDAX result shows the percentage of the material in composite material. In EDAX figure 4, 5, and 6 shows the contribution of matrix material Al7075 and reinforced particle TiB_2.

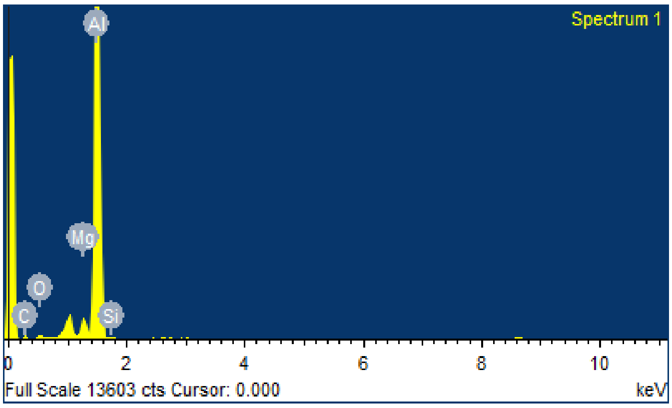


Figure 4. EDAX graph of AL% 7075 95 & TiB_2 6 %

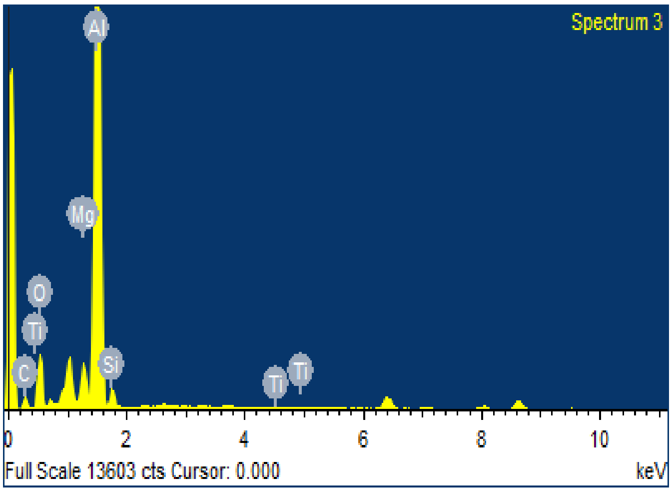


Figure 5. EDAX graph of AL7075 90% & TiB_2 12%

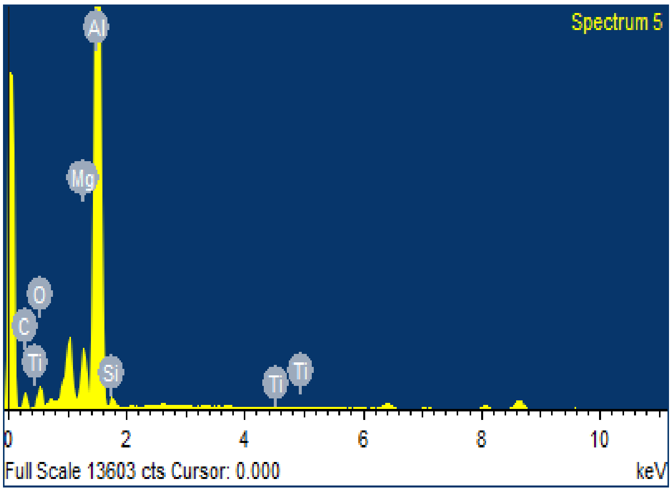


Figure 6. EDAX graph of AL7075 85% & TiB_2 15%

3.2 Tensile test Analysis

The composite piece yield was analysed by tensile inspection. The results indicate the ratio of the TiB2 particles is directly proportional to the strength of the material. The 15% TiB_2 produce the maximum tensile stress. increased in Al7075 composites, the tensile strength increases.

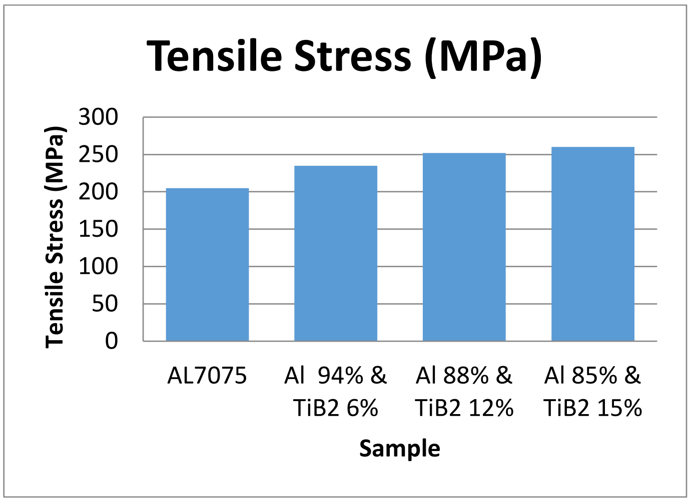


Figure 7. Tensile test report

Figure 7, indicate the tensile test report for the AL7075 and Al7075 with different ratio of TiB_2. The maximum tensile strength of 260 was achieved by the 15% TiB_2. The results show the boride particles have the efficiency to increase the tensile properties.

3.3 Effect of Hardness by TiB_2

In previous research most of the papers indicate the boride particle as a reinforecd medium, it plays a vital role to improve the mechanical properties [12]. Normally the stiffness and strength of the materials purely depend on the harness values [13]. In Al7075 has a low weight and average hardness value, but automotive and construction application the Al alloy should be in high hardness value [14]. Here the 6% TiB_2, 12% TiB_2, and 15% TiB_2 are mixed with Al7075 to improve the hardness. Fig 8 shows the Rockwell hardness values of the prepared samples.

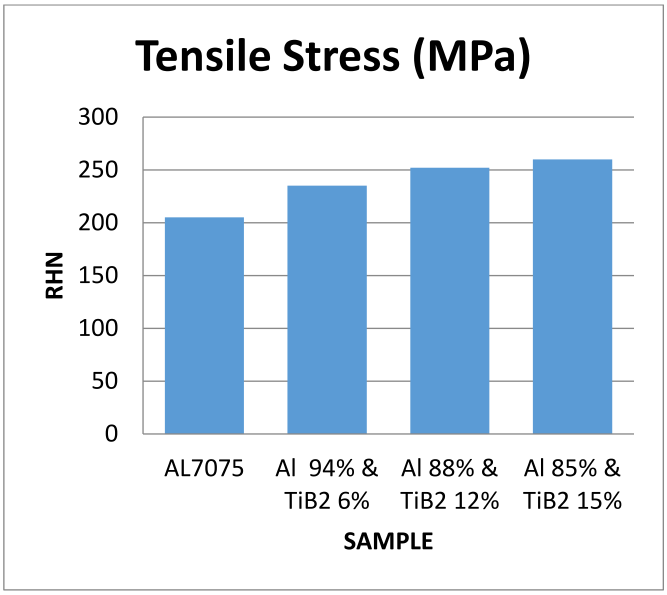


Figure 8. Hardness value report

Table 3. Hardness value for prepared samples

Sl.No	Sample	Applied Load (Kgf)	Rockwell Hardness Number					Mean Hardness value
			A	B	C	D	E	
1	AL7075	120	B68	B65	B67	B64	B67	B66
2	Al 7075 94% & TiB2 6%	120	B68	B66	B72	B70	B68	B69
3	Al 7075 88% & TiB2 12%	120	B71	B70	B74	B75	B72	B72
4	Al 7075 85% & TiB2 15%	120	B72	B72	B75	B71	B75	B73

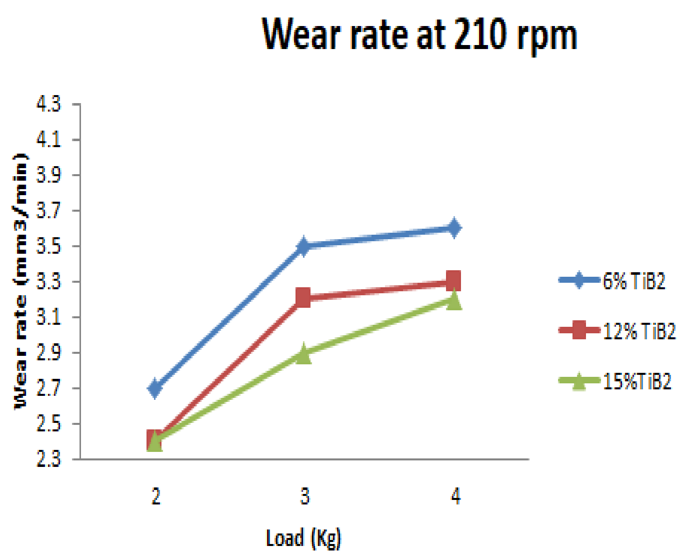
3.4 Effect reinforcement on wear properties

Table 4 indicate the wear rate for AMMC with various load and speed. The Pin on Disk apparatus set with 3 different speed and load conditions. (Speed- 210rpm, 320rpm and 410 rpm) (Load 2kd, 3kg and 4kg). These results indicate the effect of TiB_2 on AMMC wear rate. The amount of boride particles is decide the wear of composite materials. 15%TiB_2 AMMC produce good wear resistance and also withstand in high-speed 410rpm which is shown in table 4. Compare with 6%-TiB_2 the 15% TiB_2 has 15% higher wear resistance.

Table 4. Wear rate for prepared samples

SPEED (RPM)	LOAD (Kg)	WEAR RATE (mm^3/min)		
		6%	12%	15%
210	2	2.71	2.43	2.4
	3	3.51	3.22	2.89
	4	3.61	3.32	3.21
320	2	3.25	2.91	2.82
	3	3.70	3.31	3.12
	4	3.91	3.49	3.25
410	2	3.40	3.15	3.13
	3	3.82	3.47	3.31
	4	3.95	3.69	3.58

Figure 9 illustrates how the graph of wear rates does not correspond to the increase in TiB2 strengthening as a result of the various wearing processes that occur. The wear rate at different loads at 200 rpm demonstrates that the lower load produces less wear than the higher load. The amount of reinforcement between the counterfeit and the matrix affects the wear rate. The contact asperity between the hard face (disc) and the soft surface is responsible for the formation of the adhesive phenomena (pin). Adherence is a term used to describe how touch is deformed as a result of the effects of cold welding. It is known as adhesive wear that this process causes metal to be lost as asperities on the surface are removed by the sliding motion. Depending on the load function used, TiB2 particles have a constant sliding speed of 20 minutes, which is determined by the load function. In Figure 9, it can be seen that the effect of TiB2 on wear resistance is significant at low loads and that the friction coefficient decreases as the applied load increases to 4 kg. wear resistance, the resulting graph is not linear in nature.



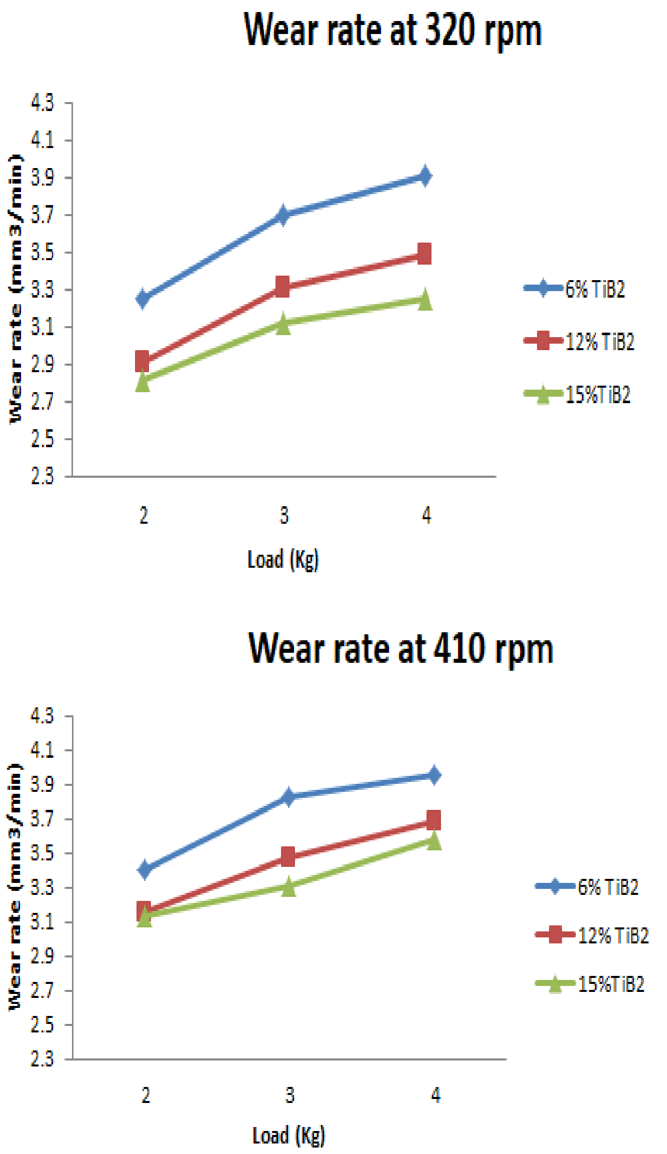


Figure 9. Wear rate load

In both cases, the TiB2 percentage was the same, with a significant increase in the applied load of 2 kg, but the resistance dropped to 3 kg. The proportion of particulate strengthening TiB2 in the wear study is important because of the significant changes in intensity that they experience. It is necessary to examine the worn surface and surface morphology of these specimens to better understand the nonlinear graphs that have been discovered in them.

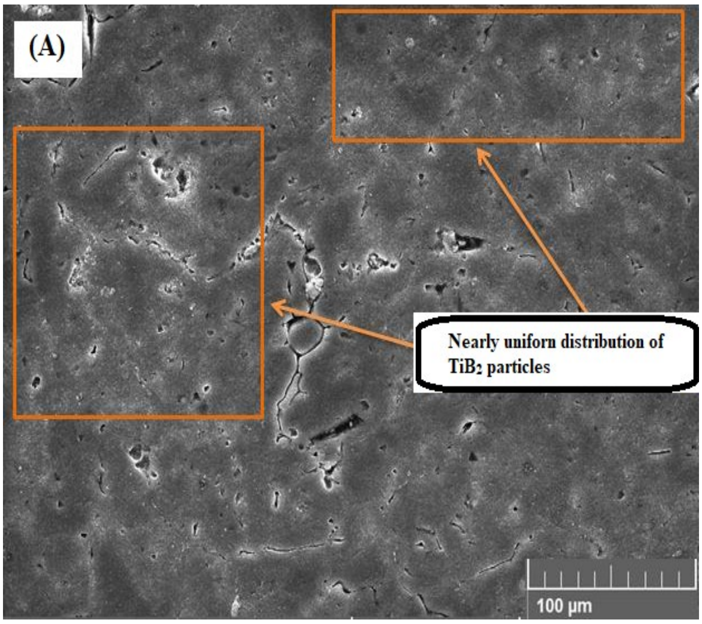


Figure 10. SEM image ofAl 7075 95% & TiB2 5%

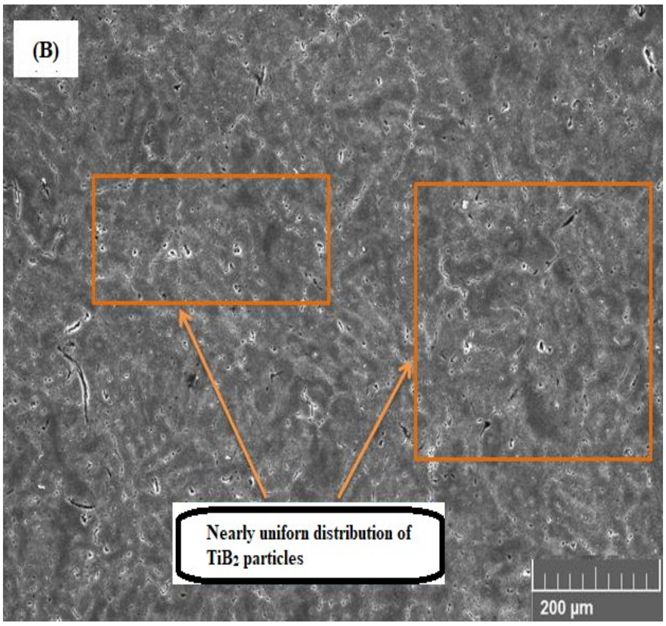


Figure 11. SEM image of Al 7075 90% & TiB2 10%

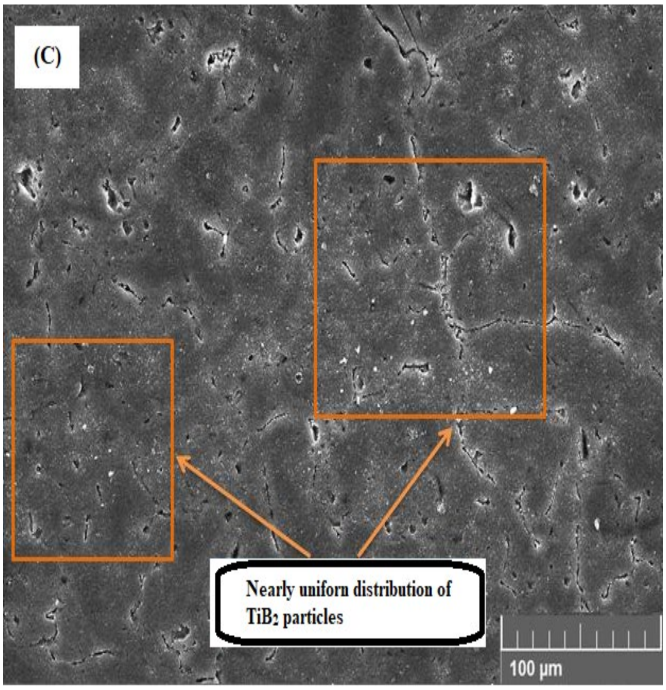


Figure 12. SEM image of Al 7075 85% & TiB2 15%

The SEM Analysis investigate the microstructural surface tribological properties. Images 10, 11, and 12 represent the agglomeration of TiB_2 particles in the Al7075 metal surface. Fig 12 shows the high percentage of TiB_2 deposited on the matrix materials surface. Some worn surface inspections were also done through the SEM analysis. The porosity was formed on sample 2 due to the stirring speed.

4. CONCLUSION

The Al7075- TiB_2 composite were made through the bottom stir casting process with various conditions. After that mechanical and tribological properties are investigated and the following points are discussed,

1. Preheating process effect is shown in the hardness range. Because preheating provide the proper bonding between the TiB_2 and Al7075.
2. While adding TiB_2 improve the tensile properties and also the strength of the AMMC.
3. The lowest wear rate occurs at the optimum speed of the Pin on Disk (210rpm).
4. The wear resistance shows 15%-TiB_2 particles influence maximum wear reduction in AMMC.
5. Microstructural analysis like porosity and worn surface inspection is also used to justify the surface quality of the composite.

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