International Journal of Surface Engineering and Interdisciplinary Materials Science
Volume 10 • Issue 1

# Role of Reinforcement Particle Size and Its Dispersion on Room Temperature Dry Sliding Wear of AA7075/TiB2 Composites

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## ABSTRACT

Aluminum alloy-based metal matrix composites (AMCs) are widely accepted material in the aerospace, automotive, military, and defence applications due to their light weight and high strength. For tribological applications, high-performance wear-resistant materials like AMCs are the candidate materials. In this investigation, AA7075-based composites with different size $TiB_2$ particles were fabricated using in-situ and ultrasound casting techniques (UST). The AMCs were tested using pin-on-disc tribo tester, and the effects of different sized $TiB_2$ particles on wear resistance of AA7075/$TiB_2$ composites have been investigated. The wear resistance of AA7075/$TiB_2$ composite fabricated using UST is found to significantly improve when compared to base alloy and also in-situ composite due to refinement in the particle size, reduced the agglomeration, and improved the distribution of $TiB_2$ particles. The test results also revealed the existence of a mixture of mechanically mixed Al–Zn–Fe intermetallic alloy and oxides of these elements.

## KEYWORDS

Agglomeration, Aluminium Matrix Composites, In-Situ, Sliding Wear, Tribological Properties, Ultrasound

## 1. INTRODUCTION

Low density and high performance of aluminium matrix composites (AMCs) make it a potential candidate for automobile, aerospace, and other manufacturing industries. The current state of the art of AMC manufacturing consists of in-situ synthesis, which holds many advantages over other techniques such as stir casting, powder metallurgy, and spray forming. In-situ synthesis of AMCs is advantageous for the generation of fine thermally stable reinforcement particles and process flexibility (Pramod, et al. 2015; Chakraborty et al., 2012). Recently, an ultrasound-assisted in-situ casting technique (UST) has been developed for the synthesis of AMCs, which can refine the particle size down to submicron and nano regime and also enhance the uniform dispersion of reinforcement

DOI: 10.4018/IJSEIMS.2022010102

particles. A wield of UST towards the in-situ composite synthesis is beneficial for tailoring the size and distribution of reinforcement particles and thus enhance the mechanical properties of AMCs (Meti et al., 2017). Recent studies including the works by the current author's reports that the ultrasonic-assisted composite fabrication can synthesize a good quality Al/$TiB_2$ composite with $TiB_2$ particles of micron, submicron and nanometer in size with enhanced mechanical properties (Siddhalingeshwar et al., 2009; 2011a, 2011b; 2013, Patil et al., 2020; Banapurmath et al., 2020).

Along with the microstructural and mechanical properties, the tribological characteristics of AMCs are also a significant design element. The tribological behavior of AMCs dramatically depends on the size and volume fraction of reinforcement particles. A better understanding of the mechanism of wear and the parameters affecting the wear can give the insight to design a new material with improved wear resistance. The dry sliding wear of composite materials involves complex processes like mechanical, chemical, and thermal interactions between the two sliding surfaces. Delamination is one of the primary phenomena that causes a drastic alteration in the dry sliding wear rate. Literature summarizes that the size, volume fraction, and dispersion of reinforcement particles can affect the delamination phenomena. Hence, the studies on dry sliding wear of composites, delamination pattern, and the role of parameters like reinforcement particle size, the fraction of particles, and its dispersion are of great significance for the design of a wear-resistant composite. The tribological behavior of AMCs reinforced with a various fraction of both ex-situ and in-situ reinforcements such as SiC, TiC, $B_4C$, $TiB_2$, graphite, and fly ash are available in the literature. The studies on the influence of particle size and dispersion of particles on the wear performance of submicron and nano-size particle reinforced composites are minimal.

Mandal *et al.* (2007) reported that the incorporation of in-situ synthesized $TiB_2$ particles (1-2 μm of average size) enhanced wear resistance by 2-3 times for both Al-4Cu and A356 alloy matrices. Tee *et al.* (2000) analysed the wear performance of Al 1100/$TiB_2$ and Al-4.5Cu/$TiB_2$ composites by varying the fraction of $TiB_2$ particles and found that the addition of micron-sized $TiB_2$ particles of about 10 vol. % enhanced the wear resistance up to 18 times, and further increase in reinforcement content to 15 vol. % resulted in a marginal increase in wear resistance than the monolith alloy. Tee *et al.* (2000) also found that the dry sliding wear of Al/$TiB_2$ composites results in ragged edge formation of $TiB_2$ particles rather than fracture. Studies by Sharma *et al.* (2018), Kumar *et al.* (2008) and Adebisi *et al.* (2016) reported that the particle size reduction can enhance the wear performance of AMCs. Sahin and Kamil (2004) found that the mode of wear varies with the reinforcement particle size, and it plays a significant role in displacement, and damage of soft matrix materials, which is investigated by the reinforcement particles upon the sliding, may vary with the size of reinforcement particles. Though a series of studies are reported on the wear performance of Al/$TiB_2$ composites, there are no reports about the role of $TiB_2$ particle size especially in the submicron and nano range on the wear behavior and governing wear mechanism involved in dry sliding wear of Al/$TiB_2$ composites processed through UST. Hence, in this investigation, the study of the effect of fine (sub-micron) and coarse (micron) $TiB_2$ particles on the wear behavior of AA7075/$TiB_2$ composite processed through ultrasound-assisted in-situ casting technique. The effect of particle size on the operating wear mechanism is also discussed in detail.

## 2. EXPERIMENTAL DETAILS

Aluminum AA7075 alloy melted in a graphite crucible at 800 $^0$C. $K_2TiF_6$ and $KBF_4$ salts are mixed in a stoichiometric ratio to obtain $TiB_2$ particles by aluminothermic reaction with molten aluminum. The preheated salt mixture (at 150 $^0$C for 1 hour) was added to the AA7075 melt and stirred at regular intervals of 10 minutes. The melt was kept at 800 $^0$C for 60 minutes to complete the reaction. After the in-situ reaction, the slag and dross formed removed, and the composite melt cast to 100x100x10 mm mild steel mold preheated to 300 $^0$C. A separate set of casting made for 5 and 7.5% of $TiB_2$

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