Chapter 35
Study of Mechanical Properties and EMI Shielding Behaviour of Al6061 Hybrid Metal Matrix Composites

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ABSTRACT

In the present technological environment, the aerospace industry needs cutting-edge materials not only to meet the requirements such as lower weight and higher values of strength and stiffness, but also to protect against electromagnetic interference. In this article, an attempt has been made to prepare Al6061 hybrid metal matrix composites reinforced with varying percentages of SiC, Al_2O_3, and fly ash particulates through a stir-casting route. As per ASTM standards, various tests have been conducted to know the density, tensile strength, yield strength, and hardness. Simultaneously, all the prepared composites are tested for electromagnetic interference (EMI) shielding effectiveness (SE) under the X band frequency with the help of a vector network analyzer. In order to identify the composite possessing good mechanical properties, as well as shielding effectiveness, a TOPSIS methodology has been employed in this work. The present study reveals that the proposed hybrid composite contains 5% of each reinforcement material which shows better mechanical properties as well as good shielding effectiveness.

DOI: 10.4018/978-1-7998-5357-2.ch035

INTRODUCTION

The enhancement of the performance of aircrafts is the insistent need of the aerospace industry which is constantly driving the development of high-performance structural materials. For more than five decades composite materials have achieved good track record and received significant traction in the aerospace industry. The aluminum metal matrix composites (AMMCs) are the first generation metal matrix composites which are used to make aerospace components such as wing slat tracks, bulkheads, doors, landing gear parts, wheels, vertical tails etc. are manufactured by using aluminum metal matrix composites (Moona et al, 2018). Now a days these first generation AMMCs are replaced with hybrid aluminum metal matrix composites called as second generation or new generation MMCs to meet the advanced engineering applications (Srinivasan et al., 2017). Though the development of hybrid aluminum metal matrix composites is at the research stage, they are anticipated to have substantial structural applications in aerospace industry (Muley et al., 2015). Specifically, the Al6061-based hybrid metal matrix composites (HAMMCs) are better substitutes for conventional aluminum alloys because of their increased strength, hardness, and strength to weight ratio and their better wear resistance. The characteristics of HAMMCs are primarily depending on the type and the amount of reinforcement materials. HAMMCs can usually be reinforced with various oxides, carbides, nitrides, and borides. Selvam et al. (2013) fabricated an Al6061 composite reinforced with SiC particulates and fly ash using modified stir-casting. They observed that there is an improvement in mechanical properties, such as hardness and tensile strength with the increase in weight percentage of SiC particulates with a constant weight percentage of fly ash. Lokesh and Mallikarjun (2015) prepared HAMMC with silicon carbide (SiC) and graphite through liquid metallurgy route and studied the influence of hybrid reinforcement on mechanical properties and finally concluded that their proposed HAMMCs were promising engineering materials in the mechanical aspects of composites. Pitchayyapillai et al. (2016) made an attempt to develop an HAMMC reinforced with alumina (Al_2O_3) and molybdenum disulphide (MoS_2) using a stir-casting method. They noticed that the mechanical properties of the composite increase with an increase in weight fraction of alumina particles and the increase in weight fraction of molybdenum disulphide leads to decrease in mechanical properties such as tensile strength and hardness. They suggested the optimum parameters for achieving good mechanical properties. Quader et al. (2017) prepared HAMMC reinforced with Al_2O_3 and red mud through campo casting. Their experimental study reveals that the tensile strength and young's modulus values increased gradually as the reinforcement content in the composite increased from 2.5% to 10% by weight fraction. Reddy et al. (2018) carried an experimental investigation to explore the mechanical characterization of HAMMC reinforced with SiC and boron carbide (B_4C). They found that the HAMMC, 96% Al6061 reinforced with 2% of each reinforcement material has higher tensile, flexural strength and hardness compared to that with less than 2% of each reinforcement material. James et al. (2018) prepared HAMMC comprises 90% of Al6061 reinforced with 5% of zirconium dioxide (ZrO_2) and 5% of Al_2O_3. They noticed a considerable improvement over parent alloy in terms of tensile strength and hardness.

Despite many benefits offered by the aerospace composite materials, some components are susceptible to various damages. Some of the damages are caused by electromagnetic interference (EMI) due to lightning strikes. In view of preventing from the damages, material researchers have been striving to explore materials which provide shielding against EMI because the present-day aircrafts are using digital fly-by-wire systems. The fly-by-wire system refers to the use of digital control systems instead of analogue control systems employed in older aircrafts. The modern aircrafts are equipped with cockpit automation, digital navigation systems, on-board digital equipment etc. The EMI is a phenomenon