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Study on Mechanical and Wear Behaviour of AA7075/TaC/Si3N4/Ti Hybrid Metal Matrix Composites

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ABSTRACT

This research article focuses on the development of AA7075 alloy reinforced with different wt% of Tantalum Carbide (TaC), Silicon Nitride (Si3N4), and Titanium (Ti) particulates using stir casting. Mechanical characteristics like tensile, compression, and microhardness of the developed composites were analysed. High temperature tribological properties of the hybrid MMCs were studied for various input control factors like sliding speed, load, and temperature. Design analysis has been executed by Taguchi orthogonal array and ANOVA (analysis of variance). The incorporated reinforcements exhibited improved wear resistance at ambient temperature along with elevated temperatures. Monolithic dissemination of reinforcements in the prepared composites magnifies the mechanical and tribological characteristics for composites compared to matrix material. From the optimization technique, it was witnessed that wear rate and frictional coefficient are afflicted by temperature go after load and sliding speed. The optimal amalgamation of control parameters of distinct tribo-responses has been detected.

KEYWORDS

AA7075, Metal Matrix Composite, Stir Casting, Wear

1. INTRODUCTION

In today's modern scientific world, development and characterization of new material is a never-ending process for the production of new products and technology. Therefore, the field of material science has witnessed the development of composite material to satisfy the above demand in military, automobile and marine sectors. Aluminium based MMCs has raised its demand in various kind of engineering and medical applications because of its enticing properties for instance lightweight, high strength, high corrosion resistance characteristics, high wear resistance properties, young's modulus, withstanding elevated temperatures, excellent castability, good thermal stability and high toughness (Al-Salihi et al., 2019). Now a day's engine block material is substituted by aluminium alloy instead of cast iron with a view to reduce the load of the vehicle and make it greater fuel-efficacious (Pariyar et al., 2021). Since 1943, aluminium 7075 series alloy is extensively utilized as a structural material

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in the aeronautic industry due to its appealing property. It has been used for numerous applications for instance gears, shafts, aircraft fittings and defence applications (Jayendra et al., 2020). Chinmayee Kar et.al (Kar & Surekha, 2021) experimentally investigated AA7075 based AMC reinforced with titanium carbide (TiC) and red mud of size 25 and 2 microns using liquid stir casting technique. It was noticed that, the strength of the heat treated specimens were seen to be approximately double than that of the as-cast specimens due to the grain refinement during thermal treatment. TiC and red mud build a robust interfacial bonding among the matrix and reinforcement material. Further, the processing temperatures of the MMC were responsible for the formation of unstable exothermic products at the interface of the alloy and reinforcement also helps in enhancing the strength of the MMC. Also, due to plastic deformation brittle fracture was formed resulting in increase in hardness at the cost of the composite. The author also compared similar research works and found that fly ash particulates reinforced hybrid AMC improves the mechanical characteristics of the AMCs, which acts as a barrier to the dislocations. Nithin Raj et.al (Faisal & Prabagaran, 2018) evaluated the tribological behaviour of LM13/12wt%Si_3N_4/3wt%Gr hybrid composite under exalted temperature (150°C). The results reveal that both at room and high temperature, wear rate shows an upward trend due to the stress-provoked which fractures the Si_3N_4 particulates in the matrix. COF increases owing to the hardening of layer, thermal softening and also the lubrication outcome made by chemical revulsions. N.Ramadoss et.al (Ramadoss et al., 2020) characterized B_4C (1μm) and BN (10μm) reinforced Al7075 hybrid composite utilizing stir casting technique. Microstructural analysis shows the homogeneous distribution of reinforcements in the base matrix and the formation of Al_3BC, AlB_{12}, AlN as interfacial reactions. It was noticed that mechanical properties such as tensile, hardness and compressive properties of the developed composite enhanced due to interfacial bonding between matrix and reinforcements, grain size and strain gradient strengthening effect of composites. Corrosion resistance found to be improved, during precipitation hardening it forms intermetallic phase Al_2Cu and this acts as an obstacle for dislocation. T.Pratheep Reddy et.al (Pratheep Reddy et al., 2020) analysed aluminium 7075 hybrid MMC reinforced with B_4C and fly-ash particles having particle mesh size of 150 μm using liquid metallurgy stir casting technique. It was noticed from results that the mechanical and tribological attributes are enhanced by reinforcements with aluminum metal matrix alloy. Resistance to plastic deformation and uniform dispersion of reinforcements enhances the microhardness and rigidity of the composite material. Other mechanical characteristics such as tensile, percentage of elongation and impact analysis reveal that the developed hybrid MMC improved due to the presence of hard ceramic particulates. White patches along with abrasive and abrasion wear were observed on the surface of the wear samples which in turn improves the wear behaviour of the composite particularly for structural applications such as turbines. J.Pradeep Kumar et.al (Mir & Anand, 2018) reviewed AMMC material reinforced with TaC, Si_3N_4 and Ti. The author concluded that TaC is an extremely high temperature ceramic refractory material mostly used for high-temperature applications. Since the combinations Al-TaC, the proposed composite material can have eminent material, mechanical and thermal properties for extremely high-temperature applications. Also, Si_3N_4 and Ti was used as ceramic particulates in aluminium metal matrix composite due to its excellent tribological properties, good creep and fatigue properties at low and high temperature applications.

The proposed AA7075 based MMC has unique features like high strength, low density and weight, due to the presence of aluminium as a matrix material. Also the composite material has the ability to withstand both extreme low and high temperatures particularly for components used in military, defence and automobile applications. The developed composite material has very less chance for ductile to brittle transition at low and high temperatures. In the current article, a novel MMCs comprises of AA7075 as base matrix and TaC/Si_3N_4/Ti as reinforcements has been fabricated using low-cost conventional liquid metallurgy stir casting technique. The reinforced materials were added with different wt% and the prepared composite was exposed to several mechanical and tribological tests at room and elevated temperatures. The intention of this attempt is to dispute the asset mechanical characteristics of AA7075/TaC/Si_3N_4/Ti with prosperous tribological features of the composite at

Tensile Fracture in Laser Welding Joints of Al-Cu-Li-Mg-X Alloy Bearing Gaseous Porosity