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ScienceDirect
Defence Technology 11 (2015) 10−17
www.elsevier.com/locate/dt

Enhancement of wear and ballistic resistance of armour grade AA7075 aluminium alloy using friction stir processing

Abstract

Industrial applications of aluminium and its alloys are restricted because of their poor tribological properties. Thermal spraying, laser surfacing, electron beam welding are the most widely used techniques to alter the surface morphology of base metal. Preliminary studies reveal that the coating and layering of aluminium alloys with ceramic particles enhance the ballistic resistance. Furthermore, among aluminium alloys, 7075 aluminium alloy exhibits high strength which can be compared to that of steels and has profound applications in the designing of lightweight fortification structures and integrated protection systems. Having limitations such as poor bond integrity, formation of detrimental phases and interfacial reaction between reinforcement and substrate using fusion route to deposit hard particles paves the way to adopt friction stir processing for fabricating surface composites using different sizes of boron carbide particles as reinforcement on armour grade 7075 aluminium alloy as matrix in the present investigation. Wear and ballistic tests were carried out to assess the performance of friction stir processed AA7075 alloy. Significant improvement in wear resistance of friction stir processed surface composites is attributed to the change in wear mechanism from abrasion to adhesion. It has also been observed that the surface metal matrix composites have shown better ballistic resistance compared to the substrate AA7075 alloy. Addition of solid lubricant MoS_2 has reduced the depth of penetration of the projectile to half that of base metal AA7075 alloy. For the first time, the friction stir processing technique was successfully used to improve the wear and ballistic resistances of armour grade high strength AA7075 alloy.

Keywords: Armour grade aluminium alloy; Friction stir processing; Boron carbide; Molybdenum disulphide; Wear; Ballistic resistance

1. Introduction

Steel is globally accepted as primarily used material for the construction of military and non-military vehicles. It is attributed to the features associated with steel, such as high energy absorbing properties, high strength, greater notch toughness and high hardness [1−3]. Selection of suitable armour materials for defence applications is very crucial with respect to increasing mobility of the systems as well as maintaining safety. Therefore, determining the material with the lowest possible areal density that resists the predefined threat successfully is required in armour design studies. A number of various material systems can be considered in this perspective, especially substituting the steels with light metal and alloys [4]. The aluminium and its alloys have profound application in the design due to their of lightweight fortification structures and integrated protection system low density, high specific strength, high specific energy absorption capability, good corrosion resistance, good thermal conductivity, less sensitivity to adiabatic shear banding and thermoplastic