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Short Communication

Ballistic impact performance of an armor material consisting of alumina and dual phase steel layers

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ABSTRACT

Utilization of a ceramic front layer provides an improvement in the ballistic efficiency of monolithic metallic materials. In the current paper, the ballistic behavior of laminated composite having alumina front and dual phase steel backing layers was studied using 7.62 mm armor piercing (AP) projectiles under normal impact. The variables used were martensite content of the backing layer and the areal density of the composite. Experimental results showed that utilization of a 6 mm thick alumina front layer which was bonded to dual phase steel enhanced the ballistic resistance of the dual phase steel remarkably.

1. Introduction

A significant enhancement in the ballistic protection can be achieved when a hard ceramic layer is used in front of a metallic armor material. The material formed by this way is called laminated composite which has a significant potential in reducing the weight of armor due to their multifunctional components: a hard front layer and a tough backing layer. In this type of material, ceramic materials have been used in the front layer to fracture the projectile whereas, metallic or composite materials have been considered to be used as the backing layer to absorb the remaining energy of the projectile and support the broken ceramic particles [1–6]. It is evident that the material properties, thicknesses and combinations of the layers are very important parameters affecting the performance of the laminated composite as an armor material [1–6]. For this reason, in order to make a good selection for the laminate materials, an optimization is required with respect to these parameters. In earlier studies [1–4], the cone crack formation in the ceramic front layer was mentioned as the main damage mechanism for the laminated composite armors. It is one of the main reasons for the high ballistic performance of the laminated composites since it acts as a stress distributor from a low surface to high surface area through its geometrical shape. Hetherington [4] made an optimization for alumina/aluminum laminated composite and determined the optimum thickness ratio of two layers when keeping the areal density constant. In another study, Sadanandan and Hetherington [5] worked on the ballistic performance of alumina/aluminum and alumina/steel armors using oblique impact by 7.62 mm AP (armor piercing) and ball ammunition. They stated that the ballistic resistance of the composites increased with obliquity between the target and the projectile [5]. Furthermore, alumina/AA 6061-T651 laminated composites were impact tested using different layer thicknesses at 100–300 m/s [6]. It was found that utilizing thick layer laminates allowed less penetration than thin layer laminates [6]. Zaera et al. [7] studied on the effect of adhesive thickness on the ballistic performance of alumina/aluminum laminated composite. They reported that when the thickness of adhesive layer increased the area affected by plastic deformation on the metallic plate increased. Sherman and Brandon [8] examined the ballistic failure mechanisms for the semi-infinite supported alumina tiles either by using drop weight test or armor piercing tests with 7.62 mm projectile. The main damage mechanisms for both tests were the formation of radial cracks from bottom to top of alumina tiles and the cone structure [8]. Moreover, the ballistic performance of different ceramic materials was tested using depth of penetration tests with 12.7 mm projectiles at the projectile velocities of 750, 850 and 910 m/s [9]. It was concluded that silicon carbide exhibited better performance than alumina and boron carbide. Moreover, Sherman and Ben-Shushan [10] obtained that the impact damage on ceramic tiles reduced significantly when ceramic tiles were confined. In recent studies [11–13], the effect of the mechanical properties of metallic backing layer and layer thicknesses on the alumina/aluminum 2024 alloy and alumina/4340 steel was investigated. It was reported that the aluminum alloy in T6 condition and the 4340 steel with the hardness between 40 and 50 HRC provided the best protection against 7.62 mm AP projectile.

In ceramic/metal laminated composites, the front ceramic layer is broken into several pieces by brittle fracture upon impact and

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