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Damage effects of aluminum plate by reactive material projectile impact

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A B S T R A C T

This investigation describes and analyzes the damage effects of 2024-T3 aluminum plates normally impacted by cold isostatically pressed and sintered PTFE/Al/W reactive material projectiles. In the experiments, the reactive material projectiles impacted 3 mm thick aluminum plates at velocities in the range from 289 to 569 m/s and impacted 12 mm thick aluminum plates at velocities in the range from 500 to 956 m/s. The damage patterns and the corresponding penetration-induced deflagration behavior are presented and analyzed. In addition, combining theoretical considerations with experimental results, the effect of impact velocity on the extent of petal bulge and the penetration hole sizes is analyzed. Moreover, by comparing the calculated results with the experimental data, the influences of chemical energy released from the reactive materials during penetration on the extent of petal bulge and the penetration hole sizes are investigated and discussed. As the results show, the damage of aluminum plates by reactive material projectile impact not only varies with the kinetic energy, but is also significantly influenced by the chemical energy released in the penetration process.

1. Introduction

Reactive materials are a class of novel energetic composite materials, significantly different from traditional energetic materials, such as explosives and propellants. These new materials are formulated to initiate and release chemical energy under highly dynamic loads. Therefore, when subject to impacts which produce high strain rate plastic deformation, reactive material projectiles provide the energy required to drive a self-sustaining reaction, releasing a large amount of chemical energy in the penetration process. This dramatically enhances the lethality to targets by means of the combined effects of kinetic and chemical energy [1–3].

The unique chemical response of reactive materials during penetration is significantly influenced by projectile/ target impact conditions, resulting in damage effects and mechanisms that are difficult to understand well. Therefore, several studies have been performed to investigate the impact-induced initiation and damage effects [4–9]. Mock et al. conducted impact experiments to explore the influences of particle size and impact velocity on the time after impact for initiation. They obtained an empirical relationship between impact pressure and the time after impact for initiation [4]. Ames et al. used a vented chamber to investigate the energy release characteristics of reactive material projectiles in ballistic impact experiments. They determined a correlation between the pressure in the chamber and the chemical energy released [5,7]. It is shown that the impact-induced initiation characteristics and the chemical response during penetration are significantly influenced by impact velocity, target thickness and so forth. However, under different impact conditions, the influence of chemical energy released from reactive materials during penetration on damage is less well understood. And the differences between damage produced by reactive projectiles and by steel projectiles remain little researched. In this investigation, ballistic impact experiments were conducted to explore the damage of thin and thick aluminum plates caused by reactive material projectile impact. The influence of chemical energy released during penetration on damage is also discussed.

2. Experimental setup

2.1. Preparation of reactive material projectiles

Reactive material projectiles were prepared by isostatically pressing powder mixtures (11.3% PTFE, 7.5% Al and 81.2% W, by weight) encapsulated in a rigid cylindrical mandrel with a moving piston and then sintering the pressed specimens at a temperature of 380 °C in a vacuum oven. The initial powders were approximately spherical with the following average sizes: 100 nm PTFE powder, 44 μm Al and 44 μm W. And the pressed and sintered sample had a high density of approximately 7.8 g/cm^3. The prepared reactive material projectiles were about 10 mm high and 10 mm in diameter. The preparation process of the reactive material projectiles is described in Fig. 1.

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