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Finite Element Simulation of Impact on Metal Plate

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Abstract

This paper studies the impact of bullet with aluminum alloy plate fixed on all sides. Simulations were carried out to study effect of bullet impact angle and thickness of aluminium alloy plates. These simulations were performed using Finite Element Method implemented through Ansys Workbench. The target plate was struck at 0°, 15°, 30° and 45° obliquely and the impact velocity was 830 m/s in all tests. The results showed a critical oblique angle, which comes out to be 45°, at which the penetration process changes from perforation to ricochet. The other simulation was done to determine the thickness of the plate at which the penetration process changes from perforation to embedment. Simulation was done for plate thickness of 2 mm, 6 mm, 10 mm, 15 mm, 20 mm and 30 mm. It was observed that for thickness of 18 mm and above, complete penetration does not occur.

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Keywords: Plate; impact; bullet; finite element simulation.

1. Introduction

Combat soldiers operate in a diverse range of operational environments and injury threats. The need for study of protection against small arms and light weapons is very important both from a civilian and a military point of view. Most of the ballistic studies consider only normal impact where the angle between velocity vector of projectile and normal vector of target plane is zero. But in most cases impacts are at some angle. In this research work, the effect of bullet impact on aluminium alloy plate in different conditions is studied. Two simulation were done by impacting 7.62 x63 mm NATO Ball (with a soft lead core) bullet with the velocity of 830 m/s on aluminium alloy plate of thickness 6mm and 500 mm x 500 mm cross section. First targets were struck at 0º, 15º, 30º, 45º and 60º obliquity, and critical angle is determined. In second simulation target were struck with varying thickness of 2 mm, 6 mm, 10

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mm, 15 mm, 20 mm and 30 mm. It was seen that bullet penetrated the plates of thickness less than 15 mm and angle 45°, above that it does not penetrate.

Borvik et al. [1] has studied impact on 20 mm thick aluminum plate with NATO ball and APM2. The studies were conducted experimentally and numerically. Further the impact velocity was 830 m/s. The initial and residual velocities were measured using laser based optical devices. It was shown that at critical angles was less than 600 for which perforation was changed to embedment. The same author has also studied resistance of five different high strength steel plates to small arm projective impact [2]. Multilayer insulation were also studied by White et al. [3] against hypervelocity bullet impact. Iqbal et al. [4] has characterized mild steel at various stress and strain rate. Material properties have been used to perform numerical ballistic simulation of 12 and 16 mm thick target against API projectiles. The same author has also studied effect of projectile nose shape, impact velocity and target thickness on different types of plates [5], [6]. Manes et al. [7] has studied experimentally and numerically the effect of low velocity impact on sandwich panels. It is shown that such structures very critical to low velocity impact. The same author has also studied impact of small calibre bullets with aluminium plate.

2. **Simulation** of **7.62** mm **soft core bullet impact on plate at different angles**

In this simulation a 7.62 mm soft core bullet assigned with velocity 835 m/s is impacted on aluminium. The material model used for bullet and plate is available in standard AUTODYN material library. Fixed boundary condition is applied on the edges of the plate. Initial velocity of 835 m/s is given to the bullet in z-direction. Results were obtained for plate at different angle of 0°, 15°, 30°, 45° and 60°.

Table 1. Meshing statistics for different geometries.

Geometry	Nodes	Elements
Bullet	1787	8315
Plate	3439	3366
Total	5226	11681

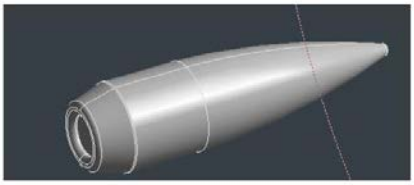
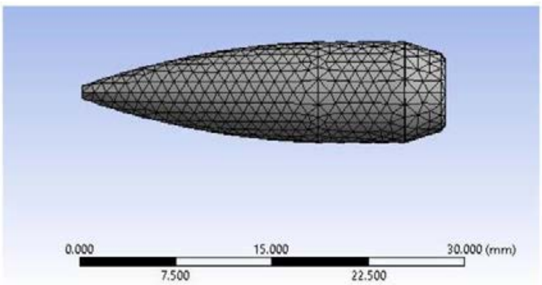
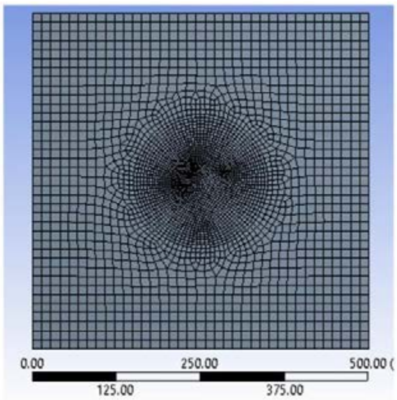


Fig. 1. (a) CAD model of bullet.





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