On the Needs of Enhancement of Energy Absorption at Various Oblique Angle under High Speed Impact

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ABSTRACT

This study proposed to enhanced the capability of energy absorption on fixed target plate at different oblique angle under high speed impact. The bullet impact on the fixed target plate quite severe at the normal and oblique angle of impact. Thus, the presence of extra mechanism such damper was vital to deal with this severe impact. The high speed impact on 6.0 mm thick high strength steel with polyurethane as damper were simulated using specific dynamic software under Johnson-Cook model and Mooney-Rivlin model for bullet of 7.62 x 63 mm APM2 and damper. The different angle, which are range between 0° up to 60° obliquity from Y-axis and the impact velocity was 830m/s in all test. Result showed that the energy absorbed by the plate was proportional with the increment of angle from 0° to 45° which is 871.66J, 965.07J and 1704.5J when using the damper. At 45°, the energy absorb was the highest and at 60° the energy absorbs decrease to 1217.7J. In conclusion, this study provides an initial idea on how to reduce the bullet impact and determination of better angle for high energy absorption during the impact.

Keywords: Bullet impact, Damper, Energy absorption, Fixed target, Oblique angle.

INTRODUCTION

Bullet impact is commonly associated with defensive armour, which is used to protect human life. National defence sectors, such as the military and police are likely to use this defensive armour in their own organisations to protect their member's lives. The bullet impact, on the other hand, is more closely associated with the armoured vehicle that was used in war to protect the waggon occupants from bullet penetration. Normally vehicle armoured was covered by energy absorb material known as spall liner. Most armoured vehicles' spall liners were currently fixed in a vertical position. Previous study in bullet impact, this position is less effective and requires more research into bullet impact before it can be used in a modified armoured vehicle (Senthil et al. 2017).

Past study by Faidzi et al. (2021) in metal sandwich panel under high velocity impact state sandwich panel has good energy absorption, high bending stiffness and good potential to be explore. The arrangement of the sandwich plate plays significant role in order to maximize the energy absorb produced by the ballistic impact. In the recent review by Duan et al. (2022) in the effect of bullet impact at oblique angle state that velocity drop during perforation is essentially unaffected by an oblique angle of roughly 30°. The velocity loss was significant at the highest oblique angles, and the critical oblique angle for impact was in between 45° to 60°. None of the bullets were able to perforate the target plate at higher oblique angles. The penetrating behaviour of a projectile is influenced by a number of factors such as mass, shape, and structural integrity (Vickers et al. 2016). Type of the projectile response in ballistic impact are breakup, ricochet, broch, penetration and perforation. This study contributes in the selection of the parameter and understanding in the effect of the bullet impact on the oblique plate and the effectiveness of rubber in ballistic impact.

In this study, the fixed target plate with damper was subjected the bullet impact were simulated using specific dynamic software. The target plate was arranged by four types of oblique angle, which are 0°, 30°, 45° and 60°. The data of energy absorption at this different angle were recorded and compared in order to determining the effective angle for better energy absorption.

RESULTS AND DISCUSSION

From the simulation of bullet impact with obliquity of 0°, 30°, 45° and 60°, the result show in decreasing of the velocity of the bullet from 0° to 45° which is from 606.51 m/s to 50.71m/s. In 60° angle the velocity of the bullet was increase from 50.71 m/s to 511.78 m/s. Table 1 showed the data from the simulation of energy absorption by the metal plate. At 0° angle, the total energy absorb by metal plate was 871.66J and increase until the angle was 45° which is the energy absorption was 1704.5J. At 60° angle, total energy absorption was reduced to 1217.7J.

Fig. 1 showed the significant reduction of bullet velocity up to 50.71 m/s at the 45° angle. Fig. 2 showed the highest energy absorption was at 45° angle up to 95% from the 0° angle. From both figures, it can be said that the trend shows the increment of oblique angle would have potential to reduce the bullet velocity and increased the energy absorption of the metal target plate.

Table 1. Velocity of bullet and metal plate total energy absorption

Plate angle from y-axis	Bullet velocity (m/s)	Metal plate total energy absorption (J)
0°	606.51	871.66
30°	573.49	965.07
45°	50.71	1704.5
60°	511.78	1217.7

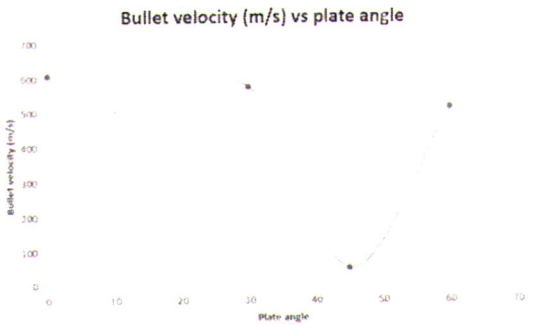

Fig. 1 Bullet velocity at various oblique angle

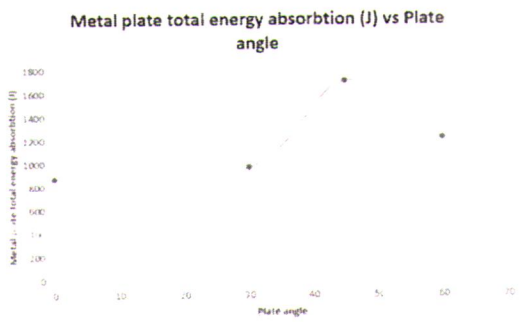

Fig. 2 Metal plate total energy absorption at various oblique angle

Fig. 3 showed the effect of bullet impact on metal plate after 10 m/s at various different angles from Y-axis. At 0° and 30° the effect of the bullet impact is penetration and at 60° the effect is ricochet. At the turning point which 45° the bullet was stop by the metal plate. In addition, the bullet velocity is the lowest and the bullet impact effect is rebound or stuck on the plate. After an angle of 45° from Y-axis the bullet velocity will increase again and the bullet impact effect changes to ricochet. At this angle the bullet velocity increases because the bullet does not stop at the plate but there is a change in the direction of the bullet. At an angle of 60° from the y-axis, the total energy absorption decreases from when the angle is at 45° from the y-axis. This is because the energy on the bullet is not completely transferred to the plate but changes the direction of the bullet.

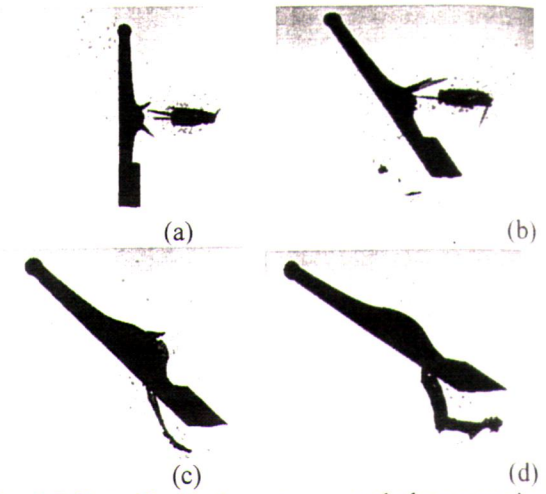

Fig. 3 Effect of bullet impact on metal plate at various angle of (a) 0°, (b) 30°, (c) 45° and (d) 60° from Y-axis.

CONCLUSION

Total energy absorption by metal plate and velocity of the bullet influenced greatly by the oblique angle and damper. It was found that 45° angle is a critical angle which has potential to receive better total energy absorption compared to other angles. It can be said that the 45° angle started to change the effect of the impact from perforation to ricochet. In 60° angle, the velocity was significantly increase due to the angle change the direction of the bullet and less energy absorption. From this study, it can conclude that increasing the obliquity of angle will increase total energy absorption by the plate.

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