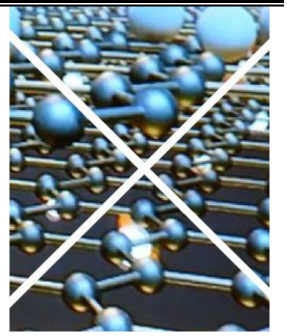
TIJMET, Vol. 003 (2020) 10-15

The International Journal of

Materials and Engineering Technology

ISSN: 2667-4033
TIJMET ID: 200301002 (6 pages)
Type of the Paper: Article
Received 03.03.2020 Revised: 01.04.2020 Accepted: 03.03.2020 Published (Online): 06.04.2020
Journal homepage: http://dergipark.gov.tr/tijmet



INVESTIGATION OF THE BULLET IMPACT ENERGY PERFORMANCE ACCORDING TO VARIABLE TIP GEOMETRY

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Abstract

Penetration is the most critical concept in ballistic studies. Penetration is defined as the ability to penetrate the target. Bullet tip geometry and velocity are the most important factors in terms of the penetration. There are many limitations in increasing the velocity of the bullet. Therefore, projectile geometry can be studied in this field. So, in this study, six different tip geometry of bullet are investigated in terms of the ballistic impact performance. Numerical simulations are performed in ANSYS program, which is the finite element program. Explicit dynamics toolbox is used to perform the numerical study. Six different tip geometry of bullet was modeled in 3D modeling program. The geometries are transferred to the ANSYS workbench program. Initial velocity is accepted as 300 m/s for all conditions. Within this study, the impact energy performance of six different bullet tip geometry was obtained. In addition, stress and deformation results on the target were also compared.

Keyword: Bullet, Impact performance, Nose geometry, Numerical analyses.

1.Introduction

Penetration is the most critical concept in ballistic studies. Bullet tip geometry and velocity are the most important factors in terms of the penetration. So, some studies were reviewed about the bullet tip. Wen et al. [1-2] formulated analytical equation to figure penetration quantity using different bullets' tip shapes o puncturing target material. Jordan has made ballistic investigations and studied residual velocity of bullets impacting on target plate and viewed that the energy absorbed on the target material changes in different types of the bullets [3]. Jeng et al. [4] estimated the ballistic limit based upon law of conservation of energy for GFRP (Glass fiber reinforced plastics). Ballistic limit, damage evolution, penetration mechanism was analyzed by Ulven. Four particular bullets were used in his study; hemispherical, conical, flat tip, fragment simulating [5]. Muslim Ansari studied experimental and finite element analyses of penetration of target plate, different projectile nose shapes. Also, result of experiment and series of analysis were compared in his study [6]. Muslim Ansari et al. concerned numerical an experimental of perforation of laminated composite. The effect of inclined impact on the ballistic rendition of target plate has been investigated by datate four impact angels is conducted with gas gun [7]. Nilakantal et all. the effect of projectile of different shapes, diameters and lengths on velocity in ballistic test [8] and it showed that was affected impact resistance. Eser SÖZEN at al. [9] presented that another factor affecting ballistic resistance as well as tip geometry of the bullets is the weight and dimensions of the projectile. The values obtained from the model and experimental data were compared in order to verify the model which provides the calculation of the distribution of pressure and bullet velocity in the barrel by Halil ISIK [10].

At the end of the literature review, it was obtained that bullet tip shape is important parameter in terms of the penetration. So, bullet impact energy performance according to variable tip geometry was investigated.

2. Materials and Methods

There are many limitations in increasing the velocity of the bullet. Therefore, projectile geometry can be studied in this field. So, in this study, six different tip geometry of bullet are investigated in terms of the ballistic impact performance. The geometries of the pellets were created by using SOLIDWORKS program as shown in Figure 1.

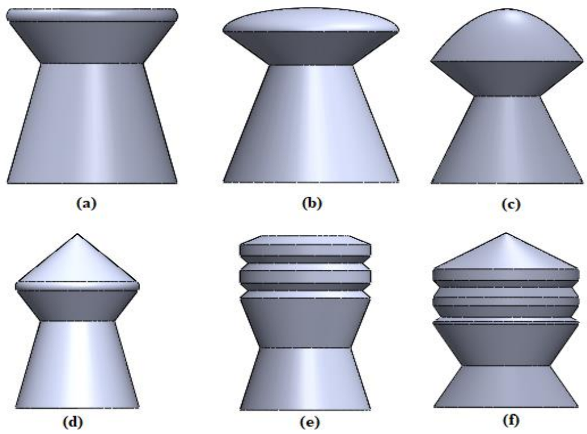

Figure 1. Pellets tip shape.

Pellets materials were assigned as lead material and target material were assigned as structural steel. In the analyses, initial velocity was accepted as 300 m/s for all pellets. Mesh independency was performed to validate the obtained mesh structure as shown in Figure2. After mesh accuracy operation, it was determined that the 18000-element number is suitable for these analyses.

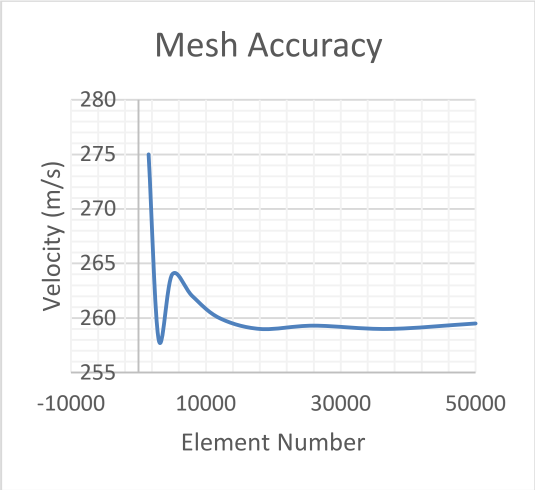

Figure 2. Mesh İndependency

Mesh view was shown as Figure 3 after validation process for the pellet (a).

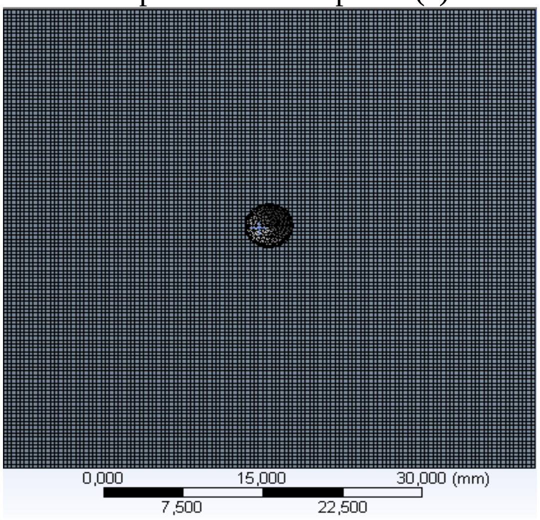

Figure 3. Sample mesh view for pellet (a)

ANSYS workbench explicit dynamic toolbox was used to perform the proposed study as shown in Figure 4. Pellet was accepted as rigid and plate was accepted as deformable.

Pellet velocity was accepted as 300 m/s for each pellet as shown in Figure 5.

Support type, which is fixed support, was applied to the model as shown in Figure 6.

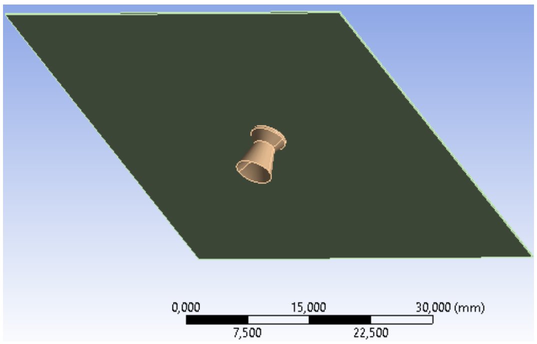

Figure 4. Ansys workbench analysis model

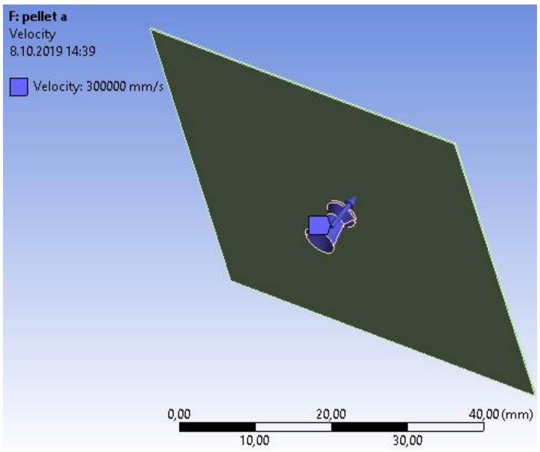

Figure 5. Pellet velocity

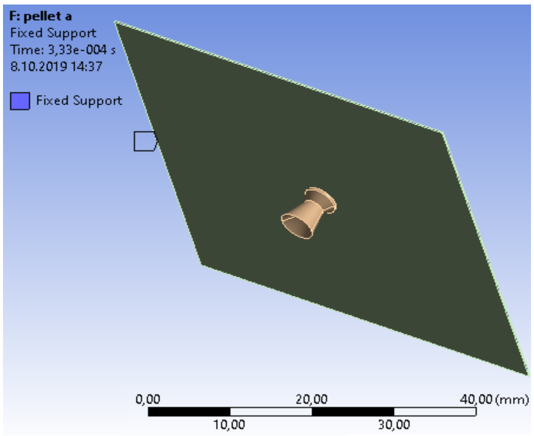

Figure 6. Fixed support view

When the analysis was performed for the pellet (a) with 300 m/s initial velocity, exit velocity was obtained as maximum 259,7 m/s as shown in Figure 7.

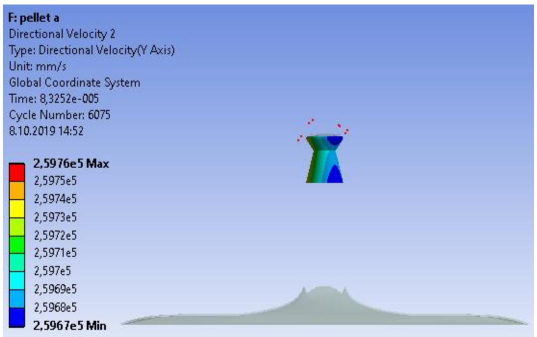

Figure 7. Exit velocity of the pellet (a)

Exit velocity of the pellet (b) was found as 261,66 m/s after the analysis as shown in Figure 8.

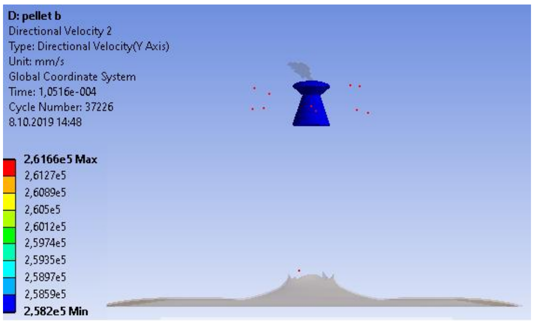

Figure 8. Exit velocity of the pellet (b)

Exit velocity of the pellet (c) was found as 278,81 m/s after the analysis as shown in Figure 9.

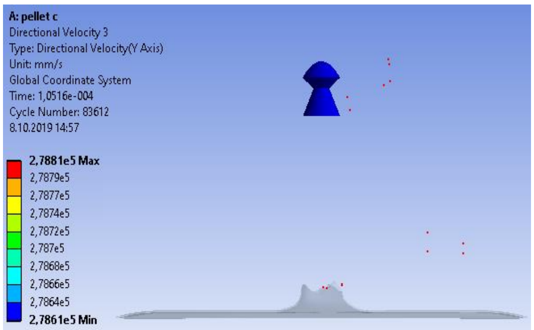

Figure 9. Exit velocity of the pellet (c)

Exit velocity of the pellet (d) was found as 285,21 m/s after the analysis as shown in Figure 10.

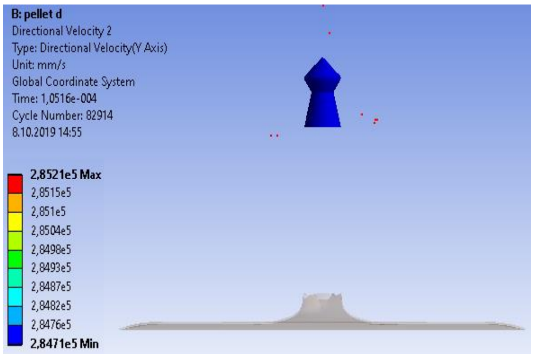

Figure 10. Exit velocity of the pellet (d)

Exit velocity of the pellet (e) was found as 274,73 m/s after the analysis as shown in Figure 11.

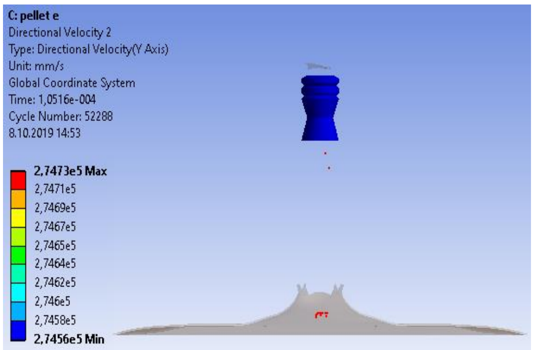

Figure 11. Exit velocity of the pellet (e)

Exit velocity of the pellet (f) was found as 277,75 m/s after the analysis as shown in Figure 12.

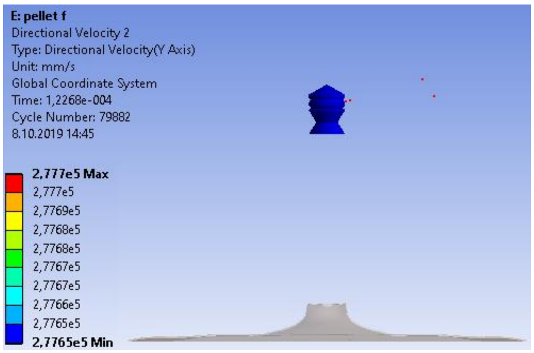

Figure 12. Exit velocity of the pellet (f)

At the end of the analyses, exit velocities of the pellets were determined according to the applied initial velocity.

3. Results and Discussion

Penetration concept is important in many ballistic studies. Penetration is defined as the ability to penetrate the target. Bullet tip geometry and velocity are the most important factors in terms of the penetration. Exit velocity of the different tip shape pellets were given in Table 1.

Impact energy was calculated according to the initial velocity $V_i = 300\ m/s$ by using energy equation (1).

$$E = \frac{1}{2}m({V_i}^2 - {V_e}^2) \qquad (1)$$

Table 1. Exit velocity of the pellet

Pellet Type	V_e (m/s)
Pellet (a)	259,76
Pellet (b)	261,66
Pellet (c)	278,81
Pellet (d)	285,21
Pellet (e)	274,73
Pellet (f)	277,7

Calculated energy was shown in Table 2.

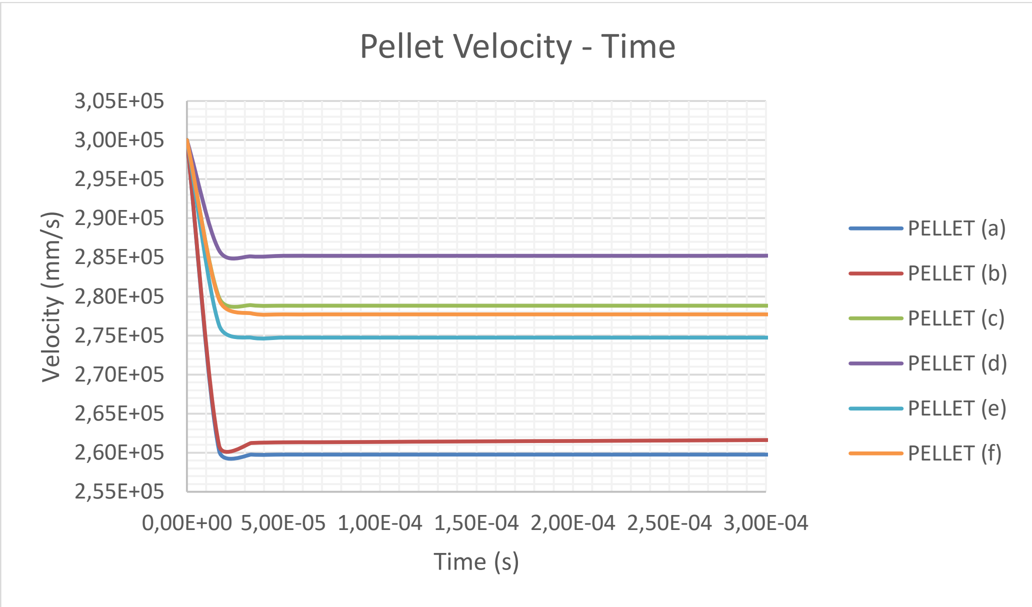

Figure 13. Comparison of the exit velocity according to tip shapes

When the Figure 13 was investigated, it was clearly seen that sharpen tip geometry (pellet (d)) has lowest velocity decrease due to geometrical properties. Maximum velocity decrease was found in Pellet (a) due to flat tip shape.

Table 2. Calculated energy according to the tip geometry

Pellet Type	V_i (m/s)	V_e(m/s)	Weight (gr)	Energy (J)
Pellet (a)	300	259,76	0,46	5,180691
Pellet (b)	300	261,66	0,38	4,091468
Pellet (c)	300	278,81	0,41	2,514322
Pellet (d)	300	285,21	0,57	2,466748
Pellet (e)	300	274,73	0,79	5,736754
Pellet (f)	300	277,7	0,64	4,122467

When the weight of the pellet was taken into account, maximum energy absorption was found in pellet (e) due to weight of the pellet. When the stress and deformation results were investigated, there is no meaningful result due to high velocity impact process.

4. Conclusions

Bullet tip geometry and velocity are the most important factors in terms of the penetration. In this study, six different tip geometry of bullet are investigated in terms of the ballistic impact performance. The effect of the shape of the projectile on penetration was examined and the projectiles were considered rigid. Pellet (d) has minimum velocity decrease due to geometrical properties. So, pellet (d) needs minimum energy to penetrate the plate in terms of the ballistic impact performance.

Funding
This study was supported by Scientific Research Project Center of Gaziantep University (No: HUBF.YLT.19.03).

Acknowledgments
We would like to express my deepest appreciation to organizing committee of TICMET19 in the selection of my study which was presented in the conference organized on 10-12 October, 2019 in Gaziantep University.

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