Demonstrating the effects of bullet expansion in a fluid target

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Abstract

The effect of bullet expansion when traversing water is simulated using a simple hydrodynamic ballistics model. In this study bullets were modeled as having a drag coefficient of 0.25, and on entering the air-water interface the drag coefficient was increased to 1 and the bullet diameter expanded to 1.5 times its original diameter. Results for 45ACP and 9mm are presented and compared to non-expanding bullets and each other.

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Bullets commonly fired from handguns are often designed to expand in a reliable fashion for use in circumstances where over penetration of a target is not desirable. Such bullets are realized by manufacture from deformable materials, or if harder metal jacketed bullets are employed then a soft metal, hollow, or a fracturable point are incorporated in the bullet nose. On entry into a different medium from air, these bullets tend to deform and undergo rapid deceleration.

There are numerous amateur ballistics experiments that can be readily found as video clips on the internet that demonstrate the effect of hollow point bullets impacting water targets. Complete calculations of terminal ballistic performance of bullets are very complex, however, the major characteristics of bullets impacting water targets can be demonstrated with a reduced set of equations. This letter presents the results of numerical simulations of bullets traversing an air-water interface varying only the aerodynamic drag coefficient and the bullet diameter to affect penetration.

A hydrodynamic, ballistic model after that of McCoy (1989), has been constructed that includes a point model and the effect of aerodynamic drag on the bullet traveling through a fluid medium. The bullet is simulated entering the water target at normal incidence for both non-expanding and expanding bullets. When expanding bullets cross the air-water interface, the bullet diameter is increased by a factor of 1.5 and its drag coefficient is increased to 1. The physical model is shown in figure 1.

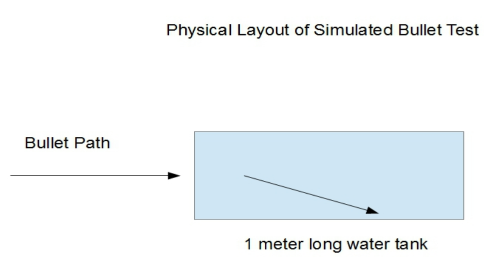

Figure 1: Physical layout of simulation environment.

The first simulations are for non-expanding 45ACP and 9mm bullets, as defined in Table 1. These were fired into the 1m water tank. The simulations showed that both bullets penetrate the 1 meter water tank and exit back into air with considerable, though reduced velocity. The trajectory and velocity profiles for these two bullets are shown in figure 2, with 9mm shown as the red trace and 45ACP in blue.

Table 1: Simulation parameters for bullets

Caliber	Mass (grains)	Initial Velocity (fps)
9mm	115	1200
45ACP	230	850

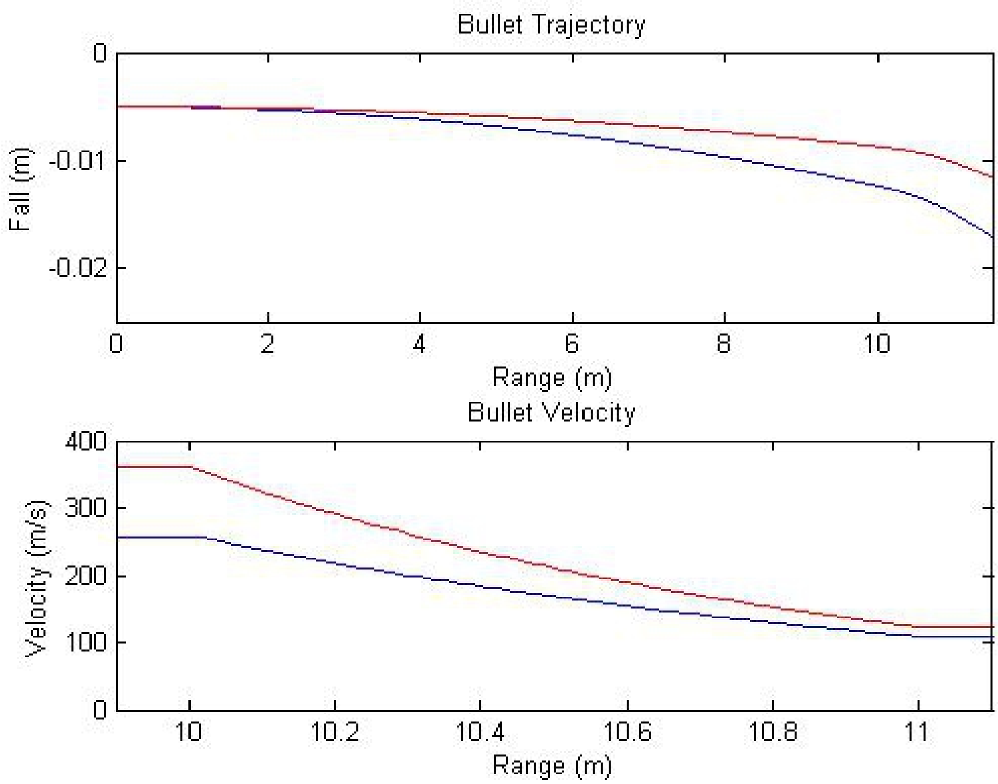

Figure 2: Non expanding bullet passage through the water tank. 45ACP is shown in blue with the 9mm shown as a red trace. The water tank begins at 10m.

A second set of simulations using expanding bullets was used to demonstrate the effect of changing the shape of the bullet as changing the bullet diameter and its drag coefficient. In this case, both of the bullets remained in the 1 meter water tank. Figure 3 shows the trajectory and velocity profiles for the expanding bullets.

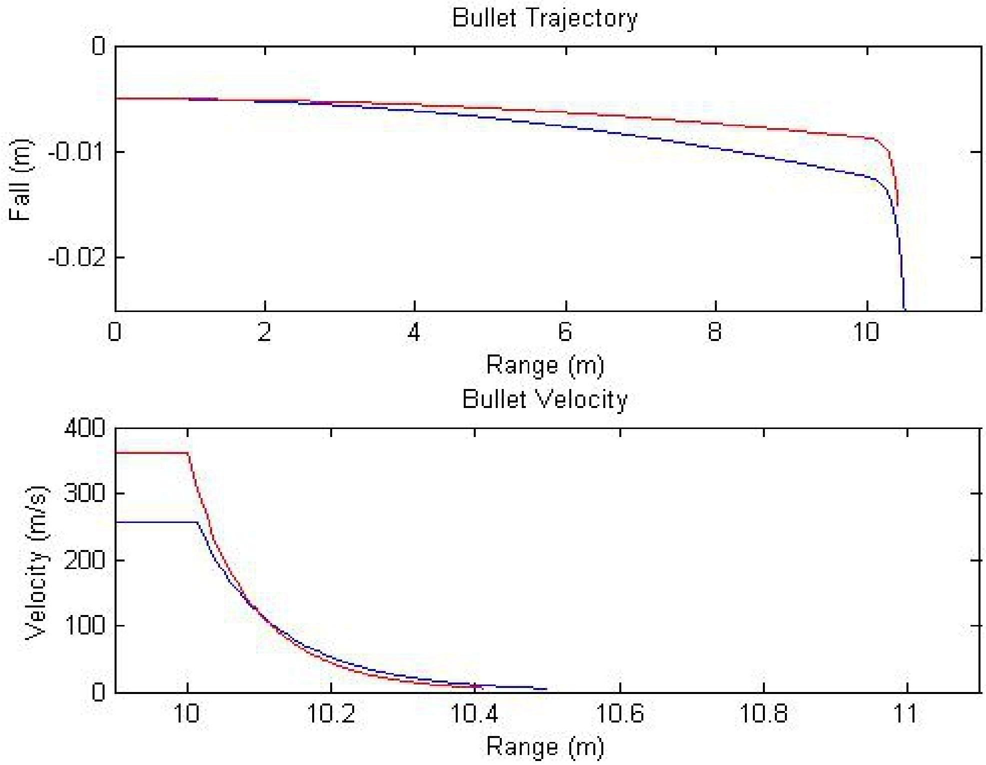

Figure 3: Expanding bullet entry into water tank.45ACP is the blue trace and 9mm is the red trace. The interface is located at 10m.

This letter has demonstrated that the major features of expanding bullets that limit penetration when fired into a water tank can be demonstrated by changing the drag coefficient and the bullet diameter. The 45ACP penetrates further into the water tank, approximately half a meter, while the higher velocity but lighter weight 9mm bullet penetrates about a two fifths of a meter.

Author Biography

Scott W. Teare is Professor of Electrical Engineering at New Mexico Institute of Mining and Technology in Socorro, NM. He has co-authored over 100 technical and scientific works, with 1 patent awarded and two currently under review.

References

1. McCoy, Robert L., ***Modern Exterior Ballistics, The Launch and Flight Dynamics of Symmetric Projectiles***, Schiffer Military History, 1999.