Journal of Physics Special Topics

P2_1 Using High Velocity Rounds to Slow Aerial Descent

M. McHugh, A. West, J. Blake, R. Hall

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH.

October 20, 2011

Abstract

The 2010 film "The A-Team" features a scene where a M1 Abrams tank is falling and the primary armament is fired in an attempt to slow the rate of descent after losing two of three parachutes. In order to change the tank's momentum enough to return the impact velocity to typical levels, the main armament would have to fire 11 consecutive rounds (with negligible reload times) before impact. This best case scenario shows that this method to slow the tank is unfeasible.

Introduction

In the film "The A-Team" a tank, which has been forced to air drop, comes under attack and loses two of the three parachutes attached. The crew, in an attempt to reduce the impact velocity, aim the primary gun down and fire repeatedly, using the recoil to slow themselves (as well as guide them) to safety. The aim of this paper is to test the viability of using the main gun, firing typical rounds, to slow the tank.

Analysis

The tank used is a M1 Abrams main battle tank. This tank is not designed for aerial drops, and these manoeuvres are usually conducted only metres from the ground compared to the high altitude situation in the film. A tank that has been air dropped typically has an impact velocity, V_i, of 8.86ms^{-1} (28fts^{-1}) [1].

First, the total area of all three parachutes, required for a safe landing, must be calculated. Assuming the system has reached terminal velocity, the area of the parachutes and the tank was found via the following equation (1)[2],

$$V_t = \sqrt{\frac{2\,m\,g}{\rho\,A\,C_d}}\ , \qquad (1)$$

where V_t is terminal velocity, m is mass, ρ is the density of air, A is the cross sectional area, and C_d is the coefficient of drag.

Rearranging we find, A

$$A = \frac{2\,m\,g}{\rho\,V_i^{\,2}\,C_d}\ . \qquad (2)$$

The required impact velocity has been substituted in for V_i. The average mass of an M1 Abrams tank is 61.3 tons [3], ρ is 1.25 Kgm^{-3} [4] and C_d is assumed to be 1, a estimate for a flat square shape. The total area of the system is calculated ≈ 12250m^2.

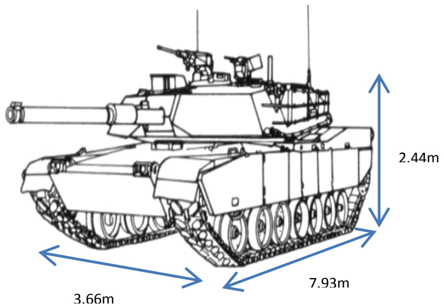

Figure 1: *An illustration of an M1 Abrams tank with labelled dimensions [3]. The profile of the tank is taken as a rectangle.*

To find the area of the three parachutes only, the area of the underside of the tank was subtracted. With respect to *Figure 1*, the area of the tank's underside was found as 29.0m^2. Using this value, the total area of all three parachutes was determined as 12228m^2.

As stated earlier, two of the three parachutes were lost in the attack. The tank shifts and now points nose downwards, with a new area of $8.9m^2$. To estimate the area of the new system, comprising of just one parachute and the tank area, the total parachute area was dived by 3 and added to the new area of the tank. The resultant area of the new system was $4084m^2$.

As a consequence of the decreased surface area the terminal velocity of the system will increase. Using equation (1) the increased velocity, V_a, of the system was evaluated as $15.34ms^{-1}$.

For the tank to hit at the ground at desired impact velocity V_i, the system must decrease in momentum, which in turn requires a force. The change in momentum, Δp, is given by equation (3)[5],

$$\Delta p = m\Delta V = m(V_a - V_i)\,. \qquad (3)$$

The magnitude of the force required to change the momentum of the tank was found via equation (4),

$$\frac{\Delta P}{\Delta t} = F_n \qquad (4)$$

where F_n is the force required and Δt is the impulse time. It is estimated that for the main gun of the tank the impulse time would be 0.5s. From *equations (3)* and *(4)* the force required would be 789000N.

As previously stated, the opposing force needed to slow the tank is due to ammunition recoil. Assuming that the recoil force is not damped, Newton's 2^{nd} and 3^{rd} *Laws* were applied to find the recoil force. Current anti-tank ammunition is 24.2kg [6].

The acceleration of the ammunition was found using,

$$a = \frac{v - u}{\Delta t} \qquad (5)$$

where Δt, once again, is the impulse time and u and v are the initial and exit velocities of the rounds respectively. The average value of v is $1560ms^{-1}$[2] and u was assumed to be zero. Using *equations (4), (5)* and *Newton's 2^{nd} law*, the recoil force was calculated to be ≈75500N.

By doing a simple ratio of the force needed against the force supplied by the recoil, the number of rounds needed to be fired consecutively to decrease the tanks velocity was calculated;

$$\frac{789000}{75500} = 10.45 \qquad (6)$$

which means approximately 11 rounds would need to be fired. However, these rounds would need to be fired one after the other to negate accelerating back to $15.30ms^{-1}$.

Conclusion

In the film "The A-Team", it is unclear how many rounds are fired, but it is less than 11, accompanied with long reload times. The most important point to consider is that the recoil is dampened in a modern tank. This would reduce the force even further. In conclusion, it is unfeasible to fire the main armament of a M1 tank to slow its descent enough after losing a considerable amount of drag from the parachutes.

Further work could be undertaken to find if the impact velocity of $15.34ms^{-1}$ (≈34mph) would be survivable, compared to the typical $8.86ms^{-1}$ (≈20mph) impact velocity.

References

[1] http://tinyurl.com/d76xdnz (Accessed: 21/11/2011)
[2]P. A. Tipler, *Physics for Scientists and Engineers* (New York, 1999), 4th Ed. p. 136
[3] http://www.inetres.com/gp/military/cv/tank/M1.html (Accessed: 21/11/2011)
[4] http://hypertextbook.com/facts/2000/RachelChu.shtml (Accessed: 21/11/2011)
[5] P. A. Tipler, *Physics for Scientists and Engineers* (New York, 1999), 4th Ed. p. 227
[6] http://www.fas.org/man/dod-101/sys/land/m830a1.htm (Accessed: 21/11/2011)