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P4_7 Rail of a Time

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Abstract

Within this paper, we discuss whether the Halo 4 railgun is a device that is producible with modern-day technology. It is discovered that the current required to launch the projectile at 345 ms^{-1} is 216.8 kA. This is not possible as a high power would have to be produced in a handheld weapon, meaning a real-life Halo railgun is not achievable. This is understandable as the game portrays weapons from the year 2557 that use advanced technology we do not currently have access to.

Background

A simple railgun is constructed of two parallel bars connected to a power source. A free to move bar is perpendicularly laid across them, completing the circuit and allowing current flow. The resulting magnetic field generates a force and thus acts upon the bar, propelling it out of the chamber at a high velocity.

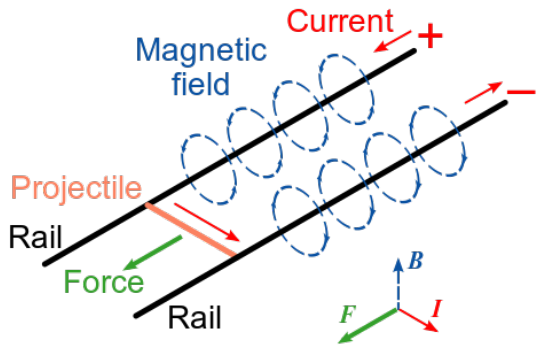

Figure 1: The schematic diagram of a railgun and the direction the projectile is fired with vector directions of current, magnetic field and force [1]. The figure also represents how the railgun is modelled.

For a simple model, the assumption is made that the rails are thin, finitely long and cylindrical to allow for calculation of the magnetic field produced. With these assumptions, the basic design of a railgun can be matched to fit the specifications of the Halo 4 railgun [2]. The rails are given a maximum radius and separation based on the portrayed weapon, then the required current can be found. The round used in Halo 4 is a ferric-tungsten round which has also been assumed to be 20% iron and 80% tungsten, this allowed for an estimation of the mass.

Method and Equations

We first had to calculate the force on the projectile in the barrel.

$$B = \frac{\mu_0 I}{4\pi\rho} \tag{1}$$

Eq. (1) describes the magnetic field (B) produced by a thin, finite wire and can be used in our model. μ_0 is the permeability of free space, I represents the current flow and ρ is the distance from the wire to a desired point [3].

$$F = IBdl \tag{2}$$

After obtaining the field strength, Eq. (2) shows that it is possible to calculate the force on the projectile by multiplying the field with the magnitude of current, I, and the length of the connecting bar (dl) [4]. The resulting magnetic field of both bars can be calculated using:

$$B = \frac{\mu_0 I}{4\pi(R + w - \rho)} + \frac{\mu_0 I}{4\pi(R + \rho)} \tag{3}$$

where R is the radius of the rail and w is the spacing between the rails. If Eq. (2) and Eq. (3) are combined and then integrated over the space between the bars, the force on the projectile can be calculated with the use of Eq. (4).

$$F = \frac{\mu_0 I^2}{2\pi} \ln\left(\frac{R + w}{R}\right) \tag{4}$$

Using the equations of motion where acceleration is constant, the relationship between current flow and resulting velocity of the projectile can be obtained:

$$V = I\sqrt{\frac{\mu_0 S}{M\pi} \ln\left(\frac{R + w}{R}\right)} \tag{5}$$

where S is the barrel length, M represents the mass of the projectile and V represents the velocity.

Results

After reviewing the specifications of the Halo 4 railgun, it was estimated that the barrel is 2/3 the total length of the weapon and 1/3 of the height. This led to a separation (w) of 0.213 m [2]. However, since the width of the weapon is 0.074 m, the maximum radius (R) for the rails is 0.037 m. The round propelled is made up of diameter, 0.016 m and length, 0.065 m. When the ratio of materials in the alloy are considered, the total mass can be calculated using the densities [5]. It was found that the mass (M) of the projectile was 0.223 kg.

Within Halo 4 the velocity of the round is extremely high. In order to fire a projectile at the speed of sound, 345 ms^{-1}, Eq. (5) states that 216.8 kA of current would have to flow through the weapon.

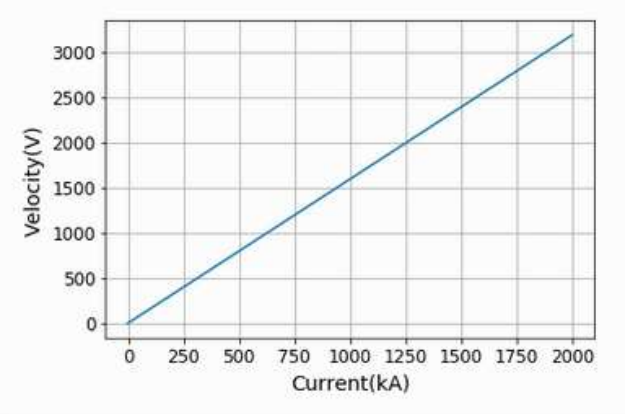

Figure 2: The linear relationship between current and resulting velocity of projectile due to Eq. (5)

Conclusion

The Halo 4 rail gun's specifications limit the maximum size of wires that can be used. The extremely high currents needed for operating the gun are not possible within the size constraints of the weapon. The gun is carried and therefore needs a portable power supply. With current technology, no power source would meet the needs of this weapon whilst keeping its mobility. This means that we can state that the weapon is not feasible in reality at this current time. More advanced technology would be required.

References

[1] `https://bit.ly/3DOgjrj` [Accessed 31 October 2021]

[2] `https://bit.ly/3FZQDZN` [Accessed 31 October 2021]

[3] `https://bit.ly/3nKxdBK` [Accessed 31 October 2021]

[4] `https://bit.ly/3DOihrD` [Accessed 31 October 2021]

[5] `https://bit.ly/3FMDKlk` [Accessed 31 October 2021]