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P3 1 Energy of the Empire

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Abstract

This paper explores the blaster Princess Leia uses in 'Star Wars: Episode IV - A New Hope' during the rescue scene aboard the Death Star. We analyse the energy required to vaporise the grate based on its size and material. We assume the grate is composed of steel and explore thermodynamic principles and material properties to estimate the energy delivered by Leia's blaster, which is calculated to be 10.36 GJ.

Introduction

Inspired by the blasters' central role in Star Wars, we set out to explore the science behind their impressive feats. Specifically, in 'A New Hope', during Princess Leia's rescue aboard the Death Star, where she destroys a metal grate with one blaster shot, raises questions about the weapon's energy output.

Theory

The metal grate is estimated at half Han Solo's height (6'1", 1.85 m [1]), making it about 3'. The grate appears to be completely destroyed, with no debris left behind. We assume, for this investigation, that it was vaporised. Assuming the grate was made of steel, the closest comparable alternative would be an A36 mild steel Cattle grid depicted in figure 1 [2].

Method

The steel cattle grid we use as a substitute consists of bars measuring 390 mm deep, 76.1 mm wide, with a 130 mm gap between the bars [3]. The grate, with a length of 914.4 mm, includes three connecting bars spaced every 875 mm. One horizontal connecting bar is centrally positioned, shown in figure 2.

Figure 1: A36 mild steel cattle grid.

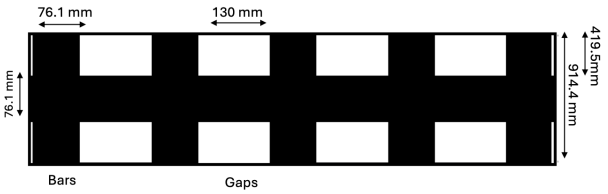

Figure 2: Diagram depicting the spacing of the bars. Not to scale.

The volume of one bar is 0.0271 m^3 (76.1mm $\times$ 390 mm $\times$ 914.4 mm). Subtracting the area occupied by the vertical bars from the horizontal connecting bar gives a remaining volume of 0.0156 m^3. A36 mild steel has a density of 7900

kgm^{-3} [4], giving each vertical bar a mass of 214.4kg. Therefore, the total mass of the five vertical bars is 1072 kg. Adding the horizontal bar, which weighs 125.5 kg, brings the overall mass of the steel to 1197.2 kg.

Results

The mass of vaporised steel (kg) was determined using the vaporisation temperature of A36 mild steel, calculated at 3155.9 K based on its mean vaporisation temperatures and elemental composition [5]. Assuming the initial temperature of the grate was 293 K (20°C), $\Delta T = 2862.9$ K, with c = 470 $Jkg^{-1}K^{-1}$. The following is used:

$$Q = mc\Delta T \tag{1}$$

The energy needed to vaporise the steel grate is 1.61 GJ. However, to completely vaporise the steel grate, it is essential to account for the latent heat of vaporisation. Given by:

$$Q = mL_v \tag{2}$$

The latent heat of vaporisation, calculated by averaging the latent heats of all elements comprising the steel alloy is 6350.3 $kJkg^{-1}$ [5]. Using this value and the previously determined mass, the energy required to overcome this approximates to 6.81 MJ.

Additionally, the sublimation enthalpy of iron - comprising over 99% of the alloy - adds to the energy required. With an enthalpy of 7439.7 kJ/kg [6], this contributes 8.91 GJ to the energy requirement. Summing the calculated energies, the total energy needed to vaporise the steel grate is 10.36 GJ.

To find the power required for the laser to mimic this in a real life scenario, the power equation is used:

$$P = \frac{W}{t} \tag{3}$$

Where W is energy of the blaster bolt, and t is assumed to be the average trigger pull duration for a standard handgun $\sim$ 0.06 seconds [7]. Using this information, the required laser power is calculated to be 172.2 GW.

Conclusion

This study analyses the feasibility of vaporising a steel grate using the energy from a blaster bolt in A New Hope. An estimated 10.36 GJ is needed, requiring a laser power of 172.2 GW for a trigger pull of 0.06 seconds. While lasers in this power range exist, they produce pulses in the ps range [8], much shorter than the duration needed for a Star Wars blaster bolt.

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