Journal of Physics Special Topics
An undergraduate physics journal

A4_1 Hammer Down!

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October 31, 2023

Abstract
In this paper, we investigate the properties of Reinhardt's Rocket Hammer from the video game Overwatch. We model the hammer with three V2 rocket engines powering the swing instead, and find the thrust force and thus velocity the hammer would be travelling at by the ends of one swing. We find the total thrust $T_{total} = 959.7$ kN, and the hammer velocity $v_{hammer} = 1161$ m s^{-1}

Introduction

Reinhardt Wilhelm is a playable character in the video game Overwatch, and wields a weapon aptly called a Rocket Hammer. As the name entails, this is a large hammer powered by three rocket engines located on the rear of the hammer head. In the game most characters can withstand at least 3 hits from the hammer before being eliminated, but if we were to model the hammer using both known and measured values, how much force would a single swing impart and what effects would this have?

Reinhardt's Dimensions

Reinhardt's height is given as 2.23 m [1]. Using pixel measurements of the in-game model, we found his arm length to be 1.17 m, the length of the hammer as 2.45 m and the grip length (the length of the hammer minus the pommel at the end) to be 1.79 m. Adding the grip length to Reinhardt's arm length gives us a swing radius of 2.96 m. Assuming a 180 degree arc, we found the total path length of a single swing to be 9.230 m. The whole swing occurs over a span of 0.96 s [5]. We also found that the nozzle diameter of each the rockets on the hammer was 0.180 m using this method.

Choosing Rockets

To understand the effects of the rockets on the head of the hammer, we decided to model them using the properties of the German V2 rocket. We do this because Reinhardt is both a German character, and has a knack for 'precision German engineering', so using the most famous German rocket appears to be the most apt. It should be noted that we have chosen to neglect the effect that scaling down the rockets would have on some of the properties, as this would be both beyond the scope of this paper and would require more space than can be afforded for the structure of this article.

Modelling the Hammer

We took the mass flow rate of a V2 rocket to be 130 kg s^{-1} [2], and the specific impulse I_{sp} to be 239 s [3]. Using this, we can thus find the exit velocity v_e as 2343 m s^{-1} using Equation 1 below, where g is taken as the acceleration due to gravity.

$$I_{sp} = \frac{v_e}{g} \tag{1}$$

We then used the the rocket thrust equation [4] to obtain the thrust of one of the rockets in the hammer.

$$T = \dot{m}v_e + (p_e - p_0)A_e \tag{2}$$

with $\dot{m}$ as the mass flow rate, p_e and p_0 as the exit and free stream pressure respectively, v_e as the exit velocity, and A_e as the exhaust area.

p_0 can be calculated using:

$$p_0 = \frac{1}{2}\rho v_e \tag{3}$$

With ρ being the fuel density which we took as the density of ethanol as this was the fuel source for V2 rockets, a value stated at 789 kg m^{-3} [3]. We were also able to calculate the area of the exhaust from the pixel measurements taken prior. After obtaining all the necessary parameters, we were able to calculate the thrust using Equation 2, and since thrust is additive we took $3T = T_{total}$.

To calculate the acceleration of the hammer, we can write the equation for Newton's second law in the form:

$$T_{total} = m_{hammer}a \tag{4}$$

where T_{total} is the combined thrust of three rockets, m_{hammer} is the mass of the hammer taken as 400 kg [5], and a is the hammer's acceleration.

We can the rearrange Equation 4 to obtain the hammer acceleration, and then substitute this into Equation 5 to obtain a value for velocity.

Next, we were able to use Equation 5 below to calculate velocity

$$v_{hammer}t = s + \frac{1}{2}at^2 \tag{5}$$

To calculate the velocity, we rearranged for v_{hammer}, substituted in 9.230 m for the displacement, s, used the acceleration above for a, and 0.96 s (our total swing time) for t.

Numerical Results

Our results yielded a value for the thrust of one rocket as 319.9 kN, meaning $T_{total} = 3T$ is calculated to be 959.7 kN. Using this, we obtained a value for the acceleration of the hammer, a, to be 2399 m s^{-2} which allowed us to find $v_{hammer} = 1161$ m s^{-1}, or just under 2600 mph. Very clearly, an object of this mass moving at supersonic speeds would very easily obliterate any living creature in a single swing - a far cry from the 3 swings it takes in the game. Additionally, the shock wave from the hammer (which is travelling above Mach 2) would cause minor damage to nearby structures as well as rupturing the eardrums of both the wielder and victim of the hammer (although we imagine that would be the least of their concerns).

Conclusion

Reinhardt's hammer is an impressively deadly weapon which would be practically unusable in reality, but if it were to be, the user, target, and surrounding area would all suffer from it's capabilities.

References

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