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P4_03 Too Big to be Called a Sword

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Abstract

The impracticability and power of the "sword" wielded by the protagonist Guts, in the anime/manga: Berserk is highlighted through estimating its dimensions and the exerted power required for a horizontal swing. The mass of the weapon is estimated to be 123kg as a result of determining its dimensions, volume and density, with a power of 6400W required to swing it. The constant force exerted by the bicep to keep the sword held parallel to the ground with the elbow at the waist is found to be 44,000N.

Introduction

The world of Berserk is dark and horrible, full of demons, spirits and other powerful beings. The protagonist; Guts, proves to be very difficult to take down however, slashing man and monster alike cleanly in two with his massive sword, "Dragonslayer". Since Guts can wield this weapon easily in one or two hands, the questions are raised as to how effective this weapon would be in reality, how much power is required to swing it, or if it could even be lifted by an optimal candidate.

Theory

To estimate the mass of this weapon, the dimensions were obtained, this was done through comparing the weapons' height to Guts who is said to be 204cm tall [1]. Through this, lengths of 200cm including the hilt and 150cm for the blade alone were estimated. The width and thickness were also estimated this way using the blade's length as a reference, as these are not constant, an average over the two extremes were taken as 26cm wide and 4cm thick. Through modelling the sword as a cuboid, the volume was worked out to be 0.0156m^3. In addition to the volume, the density of the sword must be known in order to approximate it's mass. Since Guts states that his sword is made of steel and doesn't specify a type, a common density for steel [2] of 7,850kg/m^3 is used in this approximation. Through equation (1)

$$\rho = m/V, \tag{1}$$

and rearranging for m, the mass of the sword works out to approximately 123kg.

In the anime it is shown that Guts can swing his sword extremely quickly, covering a 180 degree arc in approximately 0.5 seconds.

By considering the sword as a thin uniform rod and integrating over the length of the blade, the moment of inertia is found to be 161.44kgm^2 through (2). After substituting dm for Mdr/L the upper and lower limit for r are 2m and 0.5m respectively.

$$I = \int_0^M r^2 dm \tag{2}$$

Where r is the distance from the hilt, dm is the change in mass, M is the total mass and L is the full length of the weapon.

The kinetic energy that the weapon carries is now calculated using (3)

$$K = 0.5 I \omega^2, \tag{3}$$

to be 3200J where ω is the angular velocity, which in this case is 2πrad/s. Using the assumption that all the energy transferred to the weapon is from the Guts' body, he must then exert a power of 6400W to swing the sword through an angle of 180 degrees in 0.5 seconds.

Finally, the force exerted by Guts' bicep to hold the sword at waist level, parallel to the ground using his elbow as a pivot point is considered [3]. To estimate the force required, the assumptions that his forearm is 0.2m long and his bicep is located 0.04m in front of the pivot point were used, with the mass distribution as shown in figure 1. The force required is estimated by equating the torque from the bicep to the torque provided by the sword, where $\tau = F * r$. As the forces acting downward are all perpendicular to the sword, F is just their weight W. The force that Guts' bicep must exert on the sword to keep it parallel to the ground is then found using (4)

$$F_{Bicep} = (W_{m1} r_1 + W_{m2} r_2 + W_{m3} r_3)/r_{Bicep}, \tag{4}$$

to be approximately 44,000N.

Conclusion

To show how unrealistic this weapon is, the results from previous calculations are compared to the results from a real two-handed weapon of length 1.6m, the Zweihander [4], with a mass of roughly 3kg. Using the same models, a power of 60W per swing is required and the force maintained by the bicep is 1130N, which are roughly 100, and 44 times smaller respectively.

Although a mass of 123kg can be lifted, extended periods of holding this up would require tremendous effort. Using the mass distribution as in figure 1, a force of 44000N is found, this may vary depending on what mass distribution used, but would still be of similar size. A force of this size applied on one muscle is equivalent to lifting roughly 4500kg, which is likely to result in damage to the arm and depending on circumstance, could remove the arm entirely. In conclusion, any person attempting to wield this sword would likely not inflict any damage on their opponent, but instead injure themselves far more effectively.

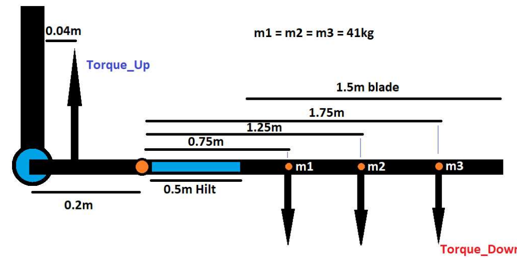

Figure 1: Model used to calculate the exerted force onto the sword, from the bicep.(Equation 4). The pivot point (elbow) being the centre of the blue circle on the left.

References

[1] https://characterprofile.fandom.com/wiki/Guts#Equipment [Accessed 20 October 2020]

[2] https://amesweb.info/Materials/Density_of_Steel.aspx [Accessed 10 October 2020]

[3] https://phys.libretexts.org/Bookshelves/College_Physics/Book%3A_College_Physics_(OpenStax)/09%3A_Statics_and_Torque/9.06%3A_Forces_and_Torques_in_Muscles_and_Joints) [Accessed 28 October 2020]

[4] https://military.wikia.org/wiki/Zweih%C3%A4nder [Accessed 13 October 2020]