Journal of Physics Special Topics
An undergraduate physics journal

A2_6 Pokémon: Let's Analyse, Darmanitan!

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December 6, 2018

Abstract

In this paper, the feasibility of the statement made in the "Pokédex" about the Pokémon "Darmanitan" that it can "destroy a dump truck with one punch" is explored. It was found that it would require ∼22,500 Darmanitans to produce the 4.94×10^{10} J of energy needed to vaporise the dump truck entirely, although the connotations of the word "destroy" are still up for debate.

Introduction

Many Pokémon enthusiasts may have speculated about the feasibility and implications of real-life Pokémon, if they were to exist. Moreover, Nintendo have begun to explore the incorporation of Pokémon into more lifelike scenarios with the release of "Pokémon GO" and more recently, "Pokémon Let's Go, Pikachu and Eevee".

Within the Pokémon universe, the so-called "Pokédex" records information about Pokémon and also provides a compelling piece of information that defines them. The following is an example about the Pokémon "Darmanitan":

Darmanitan: "Its internal fire burns at 2,500° F, making enough power that it can destroy a dump truck with one punch." - (Pokédex entry from Pokémon Black Edition [1].)

This paper outlines the physical analysis of the feasibility of this statement.

Theory

To quantify Darmanitan being able to destroy a dump truck, it is assumed that the main source of destructive power would come from its high internal temperature, and that the truck would be completely vaporised.

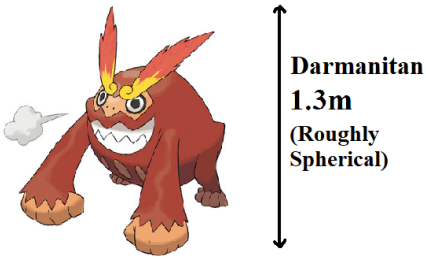

Figure 1: Darmanitan, along with its height [1].

Firstly, 2500° F equates to ∼1640 K, and Darmanitan and the truck are assumed to be black bodies. The power that Darmanitan can produce is assumed to be as a result of its internal fire, and can be calculated using the following power law:

$$P = \epsilon \sigma A T^4 \tag{1}$$

where P is the power produced, ϵ is the emissivity, σ is the Stefan-Boltzmann constant, A is the effective surface area of the body and T is the temperature. To find the effective surface area, Darmanitan is assumed to be a sphere with radius (1.3 m / 2) = 0.65 m. It is assumed that Darmanitan can channel the energy radiated spherically from the internal fire into a di-

rected attack, which will have an effective energy output if powered only by the internal fire.

Now the amount of energy required to completely vaporise a dump truck can be found. This consists of the total energy required for the temperature change, plus the energy needed to vaporise the constituent materials of the truck, which is assumed to have a mass of 6,530 kg [2] and constitute of 100% iron.

To calculate the energy required, the following relations can be used:

$$Q = mc\Delta T \tag{2}$$

$$E = mL \tag{3}$$

Here, Q is the heat energy required to change the temperature of the truck by (ΔT), m is the truck's total mass, c is the specific heat capacity of the truck, E is the energy required for a given phase change of matter and L is the latent heat associated with the given phase change.

Vaporising the truck requires the iron to undergo two phase changes, solid to liquid (fusion) and liquid to gas (vaporisation). For iron, the latent heats associated with these phase changes are 2.47 $\times$ 10^5 Jkg^{-1} and 6.09 $\times$ 10^6 Jkg^{-1} respectively [3]. The specific heat capacity of iron is 450 $Jkg^{-1}K^{-1}$ [3].

For the energy required to heat the iron to a point where it will be vaporised, a value for its boiling point is required. This is taken to be 3020^o K [4] and the truck's starting temperature is assumed to be 293 K (room temperature).

The total energy required to vaporise the truck consists of the summed total of these energies. This value can then be compared to the power output of a Darmanitan as the attack is assumed to take place over a period of 1 s (hence, $P = E$). Thus, the total energy can be found by summing equations 2 and 3 for fusion and vaporisation.

$$E_{Total} = m(c\Delta T + L_{Fus} + L_{Vap}) \tag{4}$$

Results

The surface area of Darmanitan was found to be 5.31 m^2. Substituting this into equation (1) along with known constants $\epsilon = 1$ for a black body and $\sigma = 5.67 \times 10^{-8}$ $Wm^{-2}K^{-4}$ gives a total power output of 2.18 x 10^6 W, and hence an energy output of 2.18 x 10^6 J.

Substituting the values for the latent heat of fusion and vaporisation for iron, the specific heat capacity of iron and the boiling point of iron (outlined in the theory section) into equation 4 gives a total energy requirement of 4.94 $\times$ 10^{10} J for vaporising a dump truck.

When comparing this to the power and hence energy output of Darmanitan, it can be seen that it would require ~22,500 Darmanitans attacking simultaneously in order to completely vaporise the truck, assuming that all of their attacking power is a result of their internal fires.

Conclusion

It has been shown that if the internal fire of temperature ~1640^o K is the only energy source of an attacking Darmanitan, it does not appear to produce anywhere close to the amount of energy required to vaporise a dump truck. However, this calculation was performed based upon a series of assumptions, including that the energy produced would be channelled uniformly towards the dump truck and entirely as heat.

In reality, some heat would be lost due the radiation of heat in other directions, and some additional energy would likely be produced due to Darmanitan's anatomy (e.g. muscles). Furthermore, the attack is described as a "punch", although "destroying" a truck as a result of a physical punch is more difficult to quantify.

References

[1] https://pokemondb.net/pokedex/darmanitan [Accessed 27 November 2018]

[2] http://www.877joebark.com/delivery_guidelines/about_our_dump_trucks [Accessed 27 November 2018]

[3] https://www.engineeringtoolbox.com/ [Accessed 28 November 2018]

[4] http://www.chemicalelements.com/elements/fe.html [Accessed 28 November 2018]