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P6_7 A Shocking Destiny Awaits

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Abstract

This paper outlines the calculated values for specific heat capacity to allow the ability "Chaos Reach", from Destiny 2, to be used by a Guardian, along with the total amount of Vex Goblins that can be vaporised from the use of this ability. The calculations were based from properties witnessed from 'true' lightning, the pain threshold temperature of a human, and the composition of the Goblins. It was found that the specific heat capacity of the Guardian is $3.40 \times 10^{14} \text{Jkg}^{-1} \text{K}^{-1}$, and the number of Goblins that can be vaporised by this ability is 14.9×10^7 .

Introduction

Destiny 2 is an open world, first person shooter game, in which the characters (known as Guardians) acquire special abilities to aid them in their battles. One of these abilities is called "Chaos Reach" - an ability that summons a massive surge of lightning to be cast through the Guardian, which lasts for 4 seconds in total [1]. The source used for Chaos Reach states that targets explode upon impact, but for the purpose of this paper, targets are said to vaporise instead. One enemy of the Guardians are known as the "Vex", in which their main appearance comes in the form of a "Goblin". These Goblins are androids of human size and stature.

This hypothetical scenario of Chaos Reach can use the energetic properties seen in 'true' lightning, due to the similarity of a single bolt of lightning to this ability. This game depicts Guardians as perfect electrical insulators but no consideration has been made for the heat energy involved with the use of Chaos Reach, therefore making this the area of interest of this paper.

This scenario also involves a much larger bolt of lightning than what is witnessed in reality, so therefore the assumption made was that the properties of this bolt would just scale up by a factor of the size difference between a 'true' lightning bolt and this hypothetical bolt. This difference will be represented numerically through the analysis.

Theory

Since the properties of lightning can be used for Chaos Reach, the voltage and current of a typical lightning bolt are used within the calculations. These values are found to be 100MV and 100kA [2] respectively. A typical lightning bolt also has a radius of 1 inch (0.0254m) [3], however, Chaos reach has a radius of 2.4m so therefore these lightning bolt values are multiplied by 94.5 (the difference in radius), to account for the size increase. This increase is due to the following relationship:

$$V = IR \quad (1)$$

Where V is the voltage, I is the current and R is the resistance. In this case, resistance is constant so therefore an increase in voltage would therefore increase the current also. This constant resistance can be proven by the following equation:

$$R = \frac{\rho l}{A} \quad (2)$$

Where R is the resistance, ρ is the resistivity, l is the length and A is the area. Due to the fact that ρ is a constant, and that the ratio of l/A is also constant, this causes the resistance in this scenario to remain constant.

Now using these amended voltage and current values, the power of Chaos Reach can be calculated by

using the following equation:

$$P = IV \quad (3)$$

Using an I value of $9450 \times 10^3 A$ and a V value of $9450 \times 10^6 V$ gives an overall power value of $8.93 \times 10^{16} W$.

The total energy of Chaos Reach can then be calculated by using:

$$E = Pt \quad (4)$$

Where E is the energy and t is the time period Chaos reach lasts for. The use of P solved from equation 2, and a time period of 4 seconds stated previously, gives an energy value of $3.57 \times 10^{17} J$.

This energy can be used to calculate two separate properties, one for the Guardian and the other for Chaos Reach itself. These are the specific heat capacity of the Guardian and the total mass of Vex Goblins that can be vaporised by this ability.

To calculate the specific heat capacity of the Guardian, the following equation is used:

$$c = \frac{E}{m\Delta T} \quad (5)$$

Where c is the specific heat capacity, E is the energy, m is the mass of the Guardian and ΔT is the change in temperature of the Guardian.

The mass of the Guardian can be assumed to be the mass of an average human ($m = 75kg$) and the change in temperature of the Guardian can be found from the difference between the average ambient skin temperature and the pain threshold temperature of the human body in a neutral environment. These have been found to be $307K$ [4] and $321K$ [5] respectively. This created a ΔT value of $14K$. The overall specific heat capacity of the Guardian comes out to be $3.40 \times 10^{14} Jkg^{-1}K^{-1}$.

The amount of material that can be vaporised by this energy can be found by using:

$$M = \frac{E}{l} \quad (6)$$

Where M is the mass of the material, E is the energy and l is the latent heat of vaporisation for the material.

The Vex Goblins are said to be made of hammered brass [6] (a copper and zinc alloy), and the latent heat of vaporisation can be found from the ratio of the composition. This composition is found to be a 13:7 copper to zinc ratio [7], in which the latent heat of vaporisation has been calculated to be $3740kJ/kg$.

This was solved by multiplying the latent heat of vaporisation of both components by their respective ratios, and finally adding them together [8]. Dividing the energy by this latent heat of vaporisation gives a mass value of $9.55 \times 10^{10} kg$.

The mass of a single target (Goblin) is required to solve for the total amount of Vex Goblins that are vaporised by this ability. This mass can be worked out by multiplying the density of brass with the volume of an average human, solved directly from the mass stated previously using the following relationship ($1kg \sim 1000cm^3$). The density of this brass alloy is $8530kg/m^3$ [9], and the volume is $0.075m^3$. Multiplying these values together gives a mass value of $640kg$ for a single Vex Goblin.

Finally, by dividing the total mass (solved by Eq. (5)) by the mass of a single target, a value for the overall amount of Goblins that will be vaporised is given. Through calculation, this value comes to be 14.9×10^7 .

Conclusion

The specific heat capacity calculated in this paper is several orders of magnitude larger than any other heat capacity seen by any material presently known. This value does come from the assumption that the lightning coming from Chaos Reach is purely thermal but, if this scenario were to occur in reality, the energy would be in the form of electrical, light and thermal energy. The slight energy change would reduce the specific heat capacity and the amount of mass able to be vaporised by this ability.

References

- [1] <https://bit.ly/3pTJbJh> [Accessed 29/11/21]
- [2] <https://bit.ly/31ztMoN> [Accessed 29/11/21]
- [3] <https://bit.ly/3y4y0FR> [Accessed 29/11/21]
- [4] <https://bit.ly/3rJag4c> [Accessed 29/11/21]
- [5] <https://bit.ly/3pACM5x> [Accessed 30/11/21]
- [6] <https://bit.ly/3owewlr> [Accessed 30/11/21]
- [7] <https://bit.ly/3IuuwWA> [Accessed 30/11/21]
- [8] <https://bit.ly/3EDNe2k> [Accessed 30/11/21]
- [9] <https://bit.ly/3owo8Na> [Accessed 30/11/21]