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P5_8 Is Human Hair the Future?

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Abstract

The contents of this paper involve the study of human hair and its potential useful application in modern life with a focus on its thermal and tensile properties . It was found that the power generated by daily natural hair loss was $5.14 \times {}^{7}$ kW/h and that the force a single strand of hair could carry without snapping in ideal conditions was 5.47×10^{-3} N.

Introduction

Hair has existed in many shapes and forms throughout humanity's time and remains today as a form of both expression and individuality. Aside from being the second fastest growing tissue cell in the body making it readily reproducible, [1] human hair has an interesting composition consisting of 95 % keratin [2], a fibrous protein which heavily dictates the physical properties and possible functions of human hair. This paper looks at these qualities and discusses the utilisation of hair and its feasibility with regards to its power and tensile properties.

Power generation - Method

Hair is a renewable source with approximately 50-100 (averaged at 75) hairs said to fall off the human head everyday [3], by neglecting other sources of hair loss and assuming all humans have head hair, a total power generation value was derived using an average of these values. The assumption that no energy was lost and that the calorific value given by these hairs could be directly converted into a source of energy was also made. A distribution of hair lengths was taken from a general study obtaining percentages of people with various hair lengths, with a second distribution to differentiate between hair type lengths [4]. (e.g curly and straight hair) Each value was then multiplied by the population of the Earth, 7.753 billion [5], then multiplied by the average number of hairs each individual loses per day to obtain the total hair loss. This method was done to approximate hair length, however does not account for disparities in classification of hair (short hair was given an absolute value instead of a range) and is therefore simply a modeled average. The total mass of human head hair that falls daily was then estimated using the equation below.

$$m_t = H_t \mu \qquad (1)$$

where m_t represents the total mass of hair, H_t is the total daily hair loss in inches per day, and μ is the mass per unit length of hair. By assuming that one gram of hair has a yield of approximately one calorie [6] and no energy is lost, the total number of joules and therefore the total power produced by the hairs was determined.

$$j_d = C_d \times 4184 \qquad (2)$$

Where j_d is the joules per day, C_d is the calories given per day and 4184 is the calorie to joule conversion factor. This value was then converted to kilowatts per hour and compared to the power required in the average household.

Power generation - Results & Discussion

Total length of hair fall (km/day)	149,000
Mass of hair fall (kg/day)	295,000
Power (kW/h)	5.14×10^7

Table 1: shows the significant results obtained from the power generation calculations in the experiment.

As seen in Table 1, the power obtained from the worlds hair loss was found to be 5.14×10^7 kW/h. The total amount of energy required to power the average household is approximately 3,940 kW/h [7]. This means that approximately 13,045 homes could be powered. Although this number has no large significance it does show that if the resource was intentionally farmed perhaps a larger influx and therefore more meaningful amount of power could be produced.

Tensile Properties - Method

The tensile strength of hair is said to be 150-270 MPa [8], the maximum value was then used to determine the maximum force a strand of hair could withstand under ideal conditions.

$$\sigma = \frac{P}{A} \tag{3}$$

Equation that relates tensile strength σ, force required to break material P and cross sectional area A, with diameter of hair being taken as 25.4μm [9]. The force required to break each strand of hair was then calculated below.

Tensile Properties - Results & Discussion

The force a single strand of hair could lift without snapping was calculated to be 5.47×10^{-3} N. As seen above a single human hair could lift $\approx$ $5.47 \times 10^{-}3$ N. A human being that has a mass of 80 kg would require a force of approximately 785 N to be lifted upwards to oppose the effects of gravity. Assuming all hair strands have maximum tensile strength, 143,473 strands of hair would be required to lift a person, with the average human being having over 100,000 [9] hairs on their head. Individually, single hair strands lack the strength to be useful, however, when combined they are capable of lifting large weight and could be designed for practical uses, such as pulley systems. As hair is a renewable resource the potential for such systems does exist.

Conclusion

Large quantities of hair combined together could have potential uses under ideal conditions, however this neglects the fact that methods of collecting such large volumes of hair would be largely unfeasible. Separate research of carbon quantum dots using hair abundances proves to be a potential use allowing the stability of high efficiency solar panels to be increased however such methods are experimental and therefore meaning hair can currently not be used as a renewable source of energy or material.

References

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