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A1 8 Boiling Water With a Hair Dryer

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Abstract

We investigate if it would be possible to boil water from room temperature with a hair dryer, and the time taken to do this. We also explore the energy transfers associated with this. We conclude that it is possible to do this, taking a time of 240 seconds.

Introduction

There are many electronic devices that use heat as their primary useful energy output; such as electric heaters, electric blankets, convection heaters and heat pumps. In this paper, we investigate if it is possible to boil water with a hair dryer, and if so, how efficient this would be.

Conditions

To make the required calculations, some assumptions need to be made. The typical average power rating for a hair dryer is 1750 Watts [1], and we will also assume the hair dryer has an efficiency of 80%. It is difficult to determine an average efficiency for a hair dryer, as not many experiments have taken place to determine the efficiency of drying hair. Therefore we will assume an efficiency of 80%, as the hair dryer has been in existence as a portable device for around 100 years [2]. We are investigating the time taken for a hair dryer to heat up 1kg of water, which is contained in a perfectly conductive copper container, of weight 1 kg. This weight has been chosen as a copper pan has been found to have this weight, with a capacity of 1.8 L [3]. Finally, we assume the initial temperature of the water to be room temperature, at 300 K.

Heat Transfer

Hair dryers use convection, the circulation of air to transfer heat from the coil inside the hair dryer, using a fan to push the hot air out of the nozzle. Assuming the hair dryer is plugged into a mains socket, its input energy is electrical energy. Some of this energy is transferred to the thermal energy store of the coil, and some is used to power the motor which turns the blades of the fan pushing the air out.

For this experiment, we would place the hairdryer directly underneath the pan, with the end of the nozzle making contact with the pan to ensure as little heat as possible is lost to the surroundings.

Equations

To calculate the time needed to boil the water, we need to calculate the energy needed to bring the temperature of the water from 300 K to 373 K. To do this, we use the equation for specific heat capacity:

$$Q = mc\Delta T, \tag{1}$$

where Q is heat energy [J], m is mass [kg], c is specific heat capacity [J kg $^{-1}$ K $^{-1}$] (4200 J kg $^{-1}$ K $^{-1}$ for water) and ΔT is the change in tem-

perature [K]. So for 1 kg of water, the energy required to raise the temperature from 300 K to 373 K is 3.07×10^{5} J.

As we are using a copper container, it is necessary to also calculate the energy required to raise the temperature of it to 373 K. The specific heat capacity of copper is 386 J kg $^{-1}$ K $^{-1}$ [4]. Using equation (1) again, we can calculate the energy required to be 2.82×10^{5} J, for a mass of 1 kg. This gives a total energy of 3.35×10^{5} J.

In order to output this energy, the hairdryer would need to be operating for:

$$t = \frac{E}{P} = \frac{3.29 \times 10^{5} \text{ J}}{80\% \times 1750 \text{ W}} \approx 240 \text{ s} \qquad (2)$$

Where t is time [s], E is energy [J], P is power [W]. This assumes the hair dryer is operating at 100% efficiency, which is not the case. Taking the efficiency to be 80%, as stated in the conditions, the power output of the hair dryer would be 1400 W. This means that the time taken to boil water would now be 240 s.

Discussion

The typical time for a kettle to boil 1 litre of water is around 2-3 minutes [5]. This is comparable to the time calculated in this paper which is ≈ 4 minutes. The method used for boiling water in this paper assumes that the container is a perfect conductor, which in reality is not the case. We should also note that the efficiency chosen for the hair dryer is an arbitrary one, as there is not currently any easily available data on the efficiency of hair dryers. This value may in fact be lower than what was chosen here, as a lot of the energy is lost to sound and the heating of the device itself.

Conclusion

The value calculated does not take into account the energy dissipated out of the container due to heat, or the conductivity of the material used. Silver would be a better thermal conductor, but even with this there would be a large amount of energy lost. A hair dryer is not designed to boil water, but transport hot air to dry hair. It is recommended to use devices that are designed for the purpose of boiling water, such as kettles or microwaves.

References

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