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A4_1 A Dish of Im-peck-able Taste

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Abstract

In this paper we aim to investigate the practicalities of being able to cook using sound waves. By assuming a spherical speaker surrounding a chicken of mass $1.50kg$ and a range of volumes ($0dB - 150dB$), the time taken to cook the chicken was found within the range 1.4×10^{10}–1.4×10^{-5} years. Additionally, by using this method it would cost 1.77p in order to cook the chicken. As a comparison, an average $2.5kW$ oven would take 1hr and 20 minutes to cook the chicken, costing 48p. Overall, despite the cheaper cost, cooking with sound would be impractical.

Introduction

The law of conservation of energy states that the total energy of an isolated system is constant over time, and in this paper we use this law to examine a scenario in which the energy produced from sound is converted into heat energy and used to uniformly cook a chicken. In this scenario, the chicken is cooked using a spherical speaker that perfectly encloses it.

Firstly, we assume that this conversion is 100% efficient and that there is no dissipation of energy, to obtain the shortest possible time to cook a chicken using these methods. Secondly, we assume that there is no heat loss. This is because the amount of energy contained in sound is small, and the rate of cooling would likely exceed the rate of heating.

Theory

In order to find the amount of heat, Q, that is required to raise the temperature of a mass, m, from a temperature T_i to a final temperature of T_f, we can use the equation:

$$Q = mc\Delta T = mc(T_f - T_i) \qquad (1)$$

Where c is the specific heat capacity of the object. For this scenario, we can take the initial temperature of the chicken to be $4°C$, as this is the recommended fridge temperature [1]. The temperature at which a chicken is cooked is $74°C$, and thus this is the value used for the final temperature [2]. The specific heat capacity of non-frozen chicken is 4.34 $kJ/(kg \cdot K)$ [3] and we can take the average mass of a chicken to be $1.5kg$.

We can also know that the power provided by any given sound measured in Decibels by converting it to Watts using the equation:

$$L_N = 10 \log_{10}(N/N_{ref}) \qquad (2)$$

[4] where L_N is the sound power level in units of Decibels (dB), N is the sound power in units of Watts (W) and N_{ref} is the reference sound power in units of Watts (W). For $0dB$, $N_{ref} = 10^{-12}W$.

Rearranging Eq. (2) for N, and subbing in the value for N_{ref},

$$N = 10^{\frac{L_N - 120}{10}} \qquad (3)$$

Since $Q = Power \times time$, by substituting in values from Eq.(1) and (3) we can find the time it would take to heat an object using a given sound.

Results

A plot was made to analyse how the time to cook the chicken changes over a range of volumes.

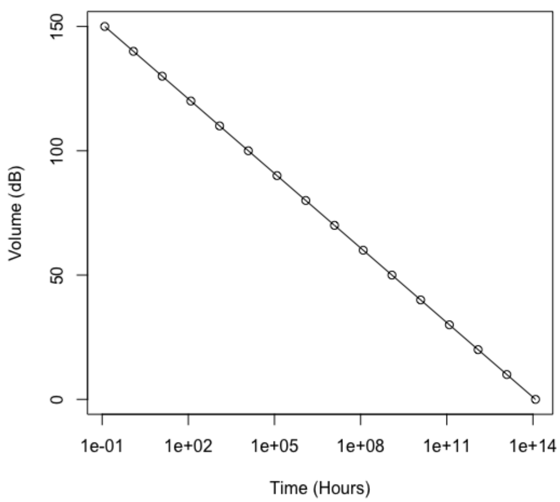

Figure 1: Plot displaying a linear relationship between the volume used to cook the chicken and the time taken until it is fully cooked

It can be seen in Figure (1) that when time in hours is plotted on a logarithmic scale, it has a linear relationship with the volume in Decibels, as the decibel scale is logarithmic in nature.

Heavy duty home speakers often operate in the range of $90dB$. For this volume, our calculations show that it would take $\sim$ 14 years in order to cook the chicken. This value is impractical and to reduce the cooking time, a higher volume should be chosen. At $120dB$ the volume is equivalent to that of a rock concert, and time for cooking would be reduced to $\sim$ 123 hours. By increasing the volume to $150dB$, which is that of a turbofan engine at take off, the chicken will be cooked within a time of $\sim$ 7.5 minutes.

Discussion and Conclusion

Using an average electric oven with an expected power of $2.5kW$, we expect a chicken to cook for around 1 hour and 20 minutes. [5] This would cost 48p at current prices of 14.4p per kWh [6]. Using the method given in this paper, running a home theatre speaker for 14 years to cook a chicken would cost 1.7p at the same kWh value.

However, the cost calculation is vastly reduced due the assumptions made in this paper. In the real world, energy would be lost in the form of heat. Cooking time would therefore increase along with the cost of the process.

Further to the cost calculations, spherical speakers do not exist in the real world, so you would have to consider the heat gradient, leading to uneven cooking when using flat speakers.

Overall, this shows that while cooking with sound would be a novel idea, that may help save some money, the time scales required along with the assumptions needed make it completely impractical for any real purposes.

References

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