Journal of Physics Special Topics
An undergraduate physics journal

A1_1 Undercooked in Overcooked?

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October 28, 2020

Abstract

In this paper we determine the temperature of an oven in the video game Overcooked 2 by considering the thermal energy required to start an oven fire in 24 s. Then, using this oven temperature of 860 °C we investigated whether it was possible to properly cook a chicken in the 12 s cooking period set out in the game. We found the temperature at the centre of the chicken to be 760 °C which is significantly higher than the temperature of a properly cooked chicken, 75 °C.

Introduction

In the video game Overcooked 2, you and your friends are tasked to prepare food dishes to feed the unruly resurrected slices of bread called "The Unbread" [1]. In this paper we will be using the recorded times of cooking and setting fire to a chicken dish in the oven to determine the temperature of the Overcooked 2 ovens and verifying whether the chicken would be properly cooked in this time.

How hot is the oven?

In Overcooked 2, it takes 12 s for a chicken to be cooked in a preheated oven and another 12 s before a fire starts. The primary cause of oven fires is due to the ignition of grease, so we assume the oil in the baking tray catches fire and not the chicken.

Additionally, we assume that the chicken is roasted in canola oil and that the oil and chicken both start at a room temperature of $T_0 = 24\,°\text{C}$. Canola oil will spontaneously burst into flames at its autoignition temperature, 424 °C, and a chicken is cooked when it reaches a temperature of 75 °C [2, 3]. Using the relationship between heat transfer, Q_{tot}, and temperature change, ΔT, we can calculate the total thermal energy required for these processes to occur with 20 mL of oil and a medium chicken to give

$$\begin{aligned} Q_{tot} &= (m_{oil} c_{oil} \Delta T_{oil}) + (m_{ch} c_{ch} \Delta T_{ch}) \\ &= 151\,\text{kJ} \end{aligned} \tag{1}$$

where m_{oil}, m_{ch}, c_{oil} and c_{ch} are the masses and specific heat capacities of the oil and chicken respectively, with corresponding values of 0.018 kg, 1.5 kg, $2208\,\text{J}\,\text{K}^{-1}\,\text{kg}^{-1}$ and $1770\,\text{J}\,\text{K}^{-1}\,\text{kg}^{-1}$ [4, 5, 6].

Next, the average power from the oven, P, is found by dividing the total thermal energy by the time taken for a fire to start, t_f to give

$$P = \frac{Q_{tot}}{t_f} = 6.3\,\text{kJ}\,\text{s}^{-1}. \tag{2}$$

Finally, for an electric oven with a cylindrical Nichrome heating element of surface area $A = 0.027\pi\,\text{m}^2$, and emissivity $\epsilon = 0.79$, we can use the Stefan-Boltzmann Law to determine the temperature of the oven, T_1, as [7]

$$T_1 = \sqrt[4]{\frac{P}{\epsilon \sigma A}} = 860\,°\text{C}. \tag{3}$$

Will the chicken be cooked?

Using the oven temperature we can now verify whether a spherical chicken of density $1070\,\mathrm{kg\,m^{-3}}$ will be properly cooked in the recorded 12 s [8]. To calculate the temperature of the centre of the chicken we use an equation describing the temperature propagation in a sphere of constant density, as derived from the one dimensional law of diffusion [9]

$$T(0,t) = T_1 + 2(T_1 - T_0) \cdot \sum_{n=1}^{\infty} (-1)^n \exp\left(-Dt\left(\frac{n\pi}{a}\right)^2\right), \quad (4)$$

where t is the time in the oven, D is the thermal diffusivity of the chicken and a is the radius of the spherical chicken, assumed here to be 0.15 m. Evaluating the equation for thermal diffusivity

$$D = \frac{\kappa}{C} \quad (5)$$

where κ is the thermal conductivity and C is the heat capacity per unit volume, which have corresponding values of $0.41\,\mathrm{W\,m^{-1}\,K^{-1}}$ and $1800\,\mathrm{J\,kg^{-1}\,K^{-1}}$ respectively, gives us a value of $D = 2.2 \times 10^{-7}\,\mathrm{m^2\,s^{-1}}$ [10]. Substituting these values into Eq. 4 we find that the temperature at the centre of the chicken is $\sim 760\,^{\circ}\mathrm{C}$.

Conclusion

The results of this paper show that the oven in Overcooked 2 must be at least 860 °C to cause the autoignition of canola oil in 24 s.

Subsequently, we confirmed that the chicken would be fully cooked in the recorded time of 12 s as the internal temperature of 760 °C is much hotter than the 75 °C that defines a properly cooked chicken. However, as a chicken is $\sim 75\%$ water and water boils at 100 °C, it is extremely likely that the chicken is burnt to a crisp completely.

Notably, in Overcooked 2 it takes the same time to cook any food in the oven as it does to cook a chicken. Therefore, as foods possess a range of densities, specific heats and thermal diffusivity values, the thermal energy required to cook a dish and thus the minimum temperature of the oven may vary with different foods.

Furthermore, we must note that values of density, specific heat and thermal diffusivity change slightly as a function of temperature, but in this paper we treated them as constants for simplicity.

In conclusion, video games are not governed by the laws of physics, so it is entirely possible that the oven is magic and will cook any food evenly and perfectly in the recorded time.

References

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