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A5_4 #Bingate: The Great British Controversy

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Abstract

This paper investigates the time taken for ice-cream to fully melt when taken out of the freezer and placed in $18°C$ heat, based on the episode of GBBO where a contestant's Baked Alaska was removed from the freezer during the challenge. We found that the total time required for complete melting was just over $1.0hr$, at $67.04minutes$, concluding that in order for the Baked Alaska to have completely melted, it was never fully frozen in the first place.

Introduction

On 24th August 2014, perhaps the most controversial episode of TV aired. Series 5, episode 4 of the Great British Bake Off (GBBO) saw Iain eliminated after failing to present anything for the Baked Alaska showstopper challenge. Due to several freezers being broken, bakers were pushed for space to freeze their ice-cream desserts and Diana had taken Iain's dessert out of the freezer to make space for her own. As a result, the ice-cream was almost completely melted and Iain refused to present a pool of dessert to the judges, opting to put it in the bin instead. The incident was subsequently dubbed 'Bingate' by fans and the media alike. In this paper we investigate claims by producers and presenters of GBBO that the dessert was only out of the freezer for $40s$ [1], by determining the true amount of time it would take for ice-cream to fully melt.

Theory

In the episode, Iain uses a spring-form, loose-bottomed cake tin to hold his Baked Alaska. Assuming the dessert is purely ice-cream and ignoring the other constituents (Iain never added the meringue to his), using measurements taken of our own similar tin, the dimensions are $23cm$ diameter, $7.5cm$ height and $0.5cm$ thickness.

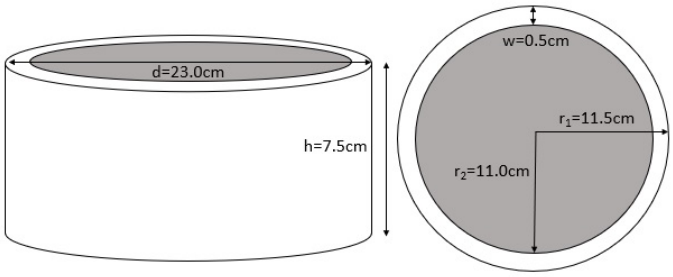

Figure 1: The left shows a schematic of our cake tin, and the right shows the top view, with measurements of the inner and outer radii of the two cylinders

Thus, we can say we have a cylindrical volume of ice-cream, equal to the volume of the 'inner' cylinder of the tin (fig. 1).

$$V = \pi r^2 h = \pi r_2^2 h \tag{1}$$

where r_2 is the inner radius of the cylinder, equal to $11cm$. The volume is then used to calculate the mass of ice-cream, using a density of

$917kgm^{-3}$ [2]. We can calculate the power transferred to the tin during heating by the air temperature. We then assume this is the total power applied to the ice-cream in the tin, heating it and causing melting. Using the law of thermal conduction:

$$P = \frac{dQ}{dt} = -kA\frac{dT}{dr} \tag{2}$$

where k is thermal conductivity $(W(mK)^{-1})$, A is surface area of the cake tin, and $\frac{dT}{dr}$ is the temperature gradient across the cake tin. By substituting in the formula for the surface area of the tin and integrating the following:

$$\int_{r_1}^{r_2} \frac{dr}{r} = \frac{-k(2\pi h)}{P} \int_{T_1}^{T_2} dT \tag{3}$$

We can then rearrange for the power, P, and the equation becomes:

$$P = (T_2 - T_1)\frac{-k2\pi h}{\ln \frac{r_2}{r_1}} \tag{4}$$

The following equation is used to calculate the energy required to completely melt the ice-cream:

$$Q = m_{ic}L_{f(ic)} \tag{5}$$

where m_{ic} is the mass of ice-cream and $L_{f(ic)}$ is the latent heat of ice-cream. Finally, to calculate the time it would take to melt the ice-cream, we can use:

$$Q = Pt \therefore t = \frac{Q}{P} \tag{6}$$

All values used are assuming vanilla ice-cream, rather than the more complicated sesame ice-cream used by Iain.

Results

We calculated the volume of ice-cream to be 2.85 x $10^{-3}m^3$, and therefore the mass of ice-cream to be $2.61kg$. The thermal conductivity of anodized aluminium (cake tin material) is given as $0.530W(mK)^{-1}$ [3].

Using Eq.(4) and substituting in for $k = 0.530W(mK)^{-1}$, $T_2 = 18°C$ [4] (the series was filmed in April 2014 near Reading, this episode was filmed on the hottest day that month), $T_1 = -5.6°C$ [5] (freezing T for vanilla ice-cream), and our values for r_1, r_2 and h, the power transferred to the cake tin is $P = 132.60W$, or $132.60Js^{-1}$.

Calculating Q using $m_{ic} = 2.61kg$ and $L_{f(ic)} = 204kJkg^{-1}$ [5], we get Q equal to $533.33kJ$ when using Eq.(5). Substituting in our values for P and Q, the time needed to melt the ice-cream completely was found to be $67.04mins$.

Conclusion

From these calculations, it can be seen that for the ice-cream to have fully melted, it would have had to have been out of the freezer for just over $1.0hr$. Thus we can assume Iain would have noticed the ice-cream being out in that time and that in reality, the ice-cream was likely not fully frozen when it came out of the freezer.

References

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