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P1_5 Overcooked

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Abstract

In this paper, the non-relativistic acceleration experienced by an oven is calculated, in the situation whereby it is being opened with the contained gas at the Plank temperature, one of the theoretical values for the highest possible temperature of matter. In the situation where the contained gas is ideal across all temperatures and the oven has a mass of 100kg, the instantaneous acceleration of the oven as the door is opened, was calculated to be $4.9 * 10^{32} ms^{-2}$.

Introduction

It has long been known that there exists a lower-bound for the available temperatures that matter can exist at, which is known as absolute zero, however there also exists theoretical upper temperature limit known as the plank temperature, at which the gravitational forces between the particles increase so much due to their velocity, that they overpower the fundamental forces of the material. So what if we managed to heat up an ideal gas in a perfectly insulated and sealed oven up to this temperature (assuming the oven can withstand the contained temperatures structurally), and at which point the door of the oven (covering one side of the cube) were to disintegrate instantaneously into an ideal gas, detaching from the remainder of the oven, releasing the contained gas, and such accelerating the oven which will be placed on a friction-less surface. This paper covers, under this circumstance, what would be the instantaneous acceleration of the oven as the door detaches. Relativistic effects are not accounted for, but would be present as the oven accelerates.

Method and Results

The oven being considered in the following calculations will have an internal volume of $1m^3$, taking the internal shape of a perfect cube with edge dimensions of $1m$. The initial temperature of the atmosphere that the oven will be closed in, and such the temperature of the air in the oven will be $293.15K$ or about 22^oC. The initial pressure in the oven before heating will be one atmosphere (approximated at $101325Pa$), therefore the pressure in the sealed oven after heating up to the Plank temperature ($1.41 * 10^{32}K$ [1]) has completed, can be found using the ideal gas law, to be $4.9 * 10^{34}Pa$. The relation used for this calculation was:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \quad (1) \quad [2]$$

where P_1 is the initial pressure in the oven before heating, P_2 is the pressure in the sealed oven after heating, T_1 is the initial temperature of the gas in the oven before heating, an finally T_2 is the temperature that the gas in the oven will be heated to (the Plank Temperature). Once the door has been disintegrated, all of the gas in the oven will be exerting a pressure on the gas in the atmosphere (and also unevenly on the oven walls), by a process which is assumed to be totally efficient, and as such, due to the now open side of the oven having an internal area of $1m^2$, the magnitude of the force exerted on the oven will be the of the same magnitude as that of the pressure, however in Newtons rather than Pascals, an as such having a value of $4.9 * 10^{34}N$. For a $100Kg$ oven [3], this would result in an instantaneous acceleration of $4.9 * 10^{32}ms^{-2}$ (calculated using Newton's second law) on the oven assuming that there is no external forces present on the oven at that time.

Conclusion

In conclusion, it was found that the instantaneous acceleration of the oven due to the force of the oven being 'opened' and the gas being released (with the pressure in the oven exerting an uneven force across the oven walls) was $4.9 * 10^{32}ms^{-2}$ given the stated assumptions and conditions mentioned above. This is extremely high and would result in light speed being achieved very quickly, however, reaching the plank temperature would be physically impossible, partly due to needing a method to reach this temperature (needing a very high energy input and something already at the Plank temperature), needing some way to keep a vessel held together at such high pressures and temperatures, and needing some way to seal the vessel throughout the heating process. Therefore, even though this may not be possible to practically carry out, it does demonstrate the practicality in the uses of contained, pressurised gas for propulsion, as when gas is released from a system, a force has been shown to be imparted on the body releasing it, (given the gas is being accelerated upon release). In the case of the oven, the higher the temperature (and so pressure inside due to the fixed volume of the oven) of the gas inside it, the higher the acceleration will be due to resulting forces imparted by the gas, however, even with low temperature gas, if the gas has a high energy density (such as by being compressed as is done on man-made satellites and spacecraft), propulsion would be more than feasible.

References

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[2] `http://www.passmyexams.co.uk/GCSE/physics/pressure-temperature-relationship-of//-gas-pressure-law.html` [Accessed 10/12/2020]

[3] `https://littleupgrades.com/how-much-oven-weigh/#:~:text=A20standard%20oven%20range%20weighs,ovens%2C%20weigh%20about%202520pounds` [Accessed 10/12/2020]