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P2 1 Dragon Punch: Science of the Shoryuken

Corban C. B. Gardiner, Joel E. Grout, Oliver J. T. Brough, Tom E. Halliday

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

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Abstract

We investigate the speed at which the character Ken Masters, from Street Fighter, must perform his Shoryuken move in order for flames to ignite on his fist. It was found that he would need to punch upward at Mach 1.96, or 672 ms^{-1}. Furthermore, he would experience around 13200 g's and would need to consume 100 servings of spaghetti bolognese (Ken's favourite meal) for the energy required to perform the move.

Introduction

The video game franchise Street Fighter started in 1987 with the release of the first game simply titled 'Street Fighter' [1]. This first entry of the series only features two students of a fictional martial-art called 'Ansatsuken'; Ryu and Ken Masters. Both perform the same moves, however the focus of this article is their signature uppercut move; the 'Shoryuken' [1]. Later games add visual flairs to Ken's Shoryuken by showing flames igniting while the uppercut is performed. We present a discussion on the dynamics required in order to perform an uppercut, in which flames appear on the user's fist, assuming their body is able to withstand the conditions.

Theory

For us to investigate this topic, we must first look into how flames can form due to motion. The most prominent example of this phenomenon would be spacecraft re-entry into the atmosphere, where the surface of the spacecraft is heated through atmospheric drag and, at higher velocities, compression of the air in its path. The compression of the air in the path of the spacecraft is called adiabatic compression, which is where compression of a volume of ideal gas causes an increase in temperature [2]. For this to occur in an open environment, with air at 20 °C, the object must be travelling above the speed of sound (Mach 1). When adiabatic compression occurs, due to the large increase in temperature caused, other sources of heating are assumed to be negligible. The temperature change in an ideal gas, under these conditions, can be modelled as:

$$\frac{T_1}{T_0} = \frac{[2\gamma M^2 - (\gamma - 1)][M^2(\gamma - 1) + 2]}{(\gamma + 1)^2 M^2}, \quad (1)$$

Where T_1(K) is the final temperature, T_0(K) is the initial temperature, γ is the specific heat ratio, and M is the Mach number [3].

Visible flames forming under these conditions are dependent on the material causing the compression, specifically the auto-ignition point of that material. The auto-ignition is the temperature at which a material will spontaneously combust, without the presence of an ignition source

[4].

Results

During the Shoryuken, Ken's sparring gloves are the only part of his fist to catch fire. Therefore we can use the auto-ignition point for leather, which is 485 K [5], rather than the auto-ignition point of his fingers, which is much higher at just over 2000 K [6]. Taking final temperature, T_1, as 485 K ,the specific heat ratio of air, γ, as 1.4 and ambient temperature, T_0, as 293 K, we used equation 1 to derive a fourth-order polynomial for M. The solutions of which produce a value for M to be ± 1.96 and $\pm 0.43i$. As the velocity is a real value in the positive direction, the only acceptable solution to the polynomial is for the object to be travelling at Mach 1.96, taking the speed of sound to be 343 ms^{-1}, the velocity required to produce flames would be 672 ms^{-1} to 3 significant figures.

As Ken's Shoryuken travels directly upwards, we used equations for kinetic energy and gravitational potential energy to calculate the total energy by summing the values together, as seen below.

$$E = \frac{1}{2}mv^2 - mgh, \tag{2}$$

As Ken's Shoryuken travels around double his height, we took h=1.75 m and m=83 kg [1]. This gave a total energy of 18800000 J, to 3 significant figures, required to perform the move, using g=-9.81 ms^{-2}.

Using $v^2 = u^2 + 2ah$ to find a, where Ken is travelling from rest, equating to just over 129000 ms^{-2}. Meaning Ken would be undergoing just under 13200 g's of force.

Conclusion

The total energy required for the Shoryuken was around 18.8 MJ, which is around 4500 kcal. This equates to the calorific content of 15 servings of Ken's favourite meal, spaghetti bolognese (assuming 300 kcal per serving [7]). As only 15% of the calorific content of consumed food contributes to mechanical effort [8], Ken would have to eat 100 servings of spaghetti bolognese in order to perform a Shoryuken just once.

As Ken would have to travel at Mach 1.96 and experience 13200 g's in order to ignite his sparring glove during the uppercut, it would be completely impossible for any human to replicate, mainly due to human muscles not being able to output the 18.8 MJ of energy required. Despite this, even if Ken was able to perform this move he would most certainly not be able to withstand the g-forces acting upon his body. However in a world where apparent superhumans use the power of yoga to stretch for miles or fly using just their legs as propellers, this move does not appear out of the ordinary.

References

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