Team Second

MCEN 4151

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with Cameron Misegadis

The video described in this report was the second team assignment in the University of Colorado's Flow Visualization class. The purpose of the team projects are to allow you to develop a more challenging experimental setup from which to capture fluid flow phenomenon. The phenomenon intended to be captured in this video was that of the Leidenfrost effect, specifically that of self-propelled Leidenfrost droplets. For this project, I was determined to also make it my first attempt at a video submission as the Leidenfrost effect is only fully realized when viewed in video format.

To create this video, first a proper self-propelled Leidenfrost droplet platform had to be created. To do this, we took a solid ¼" slab of brass and machined it incorporate ratcheting ridges at $30°$ as seen in figure 1.

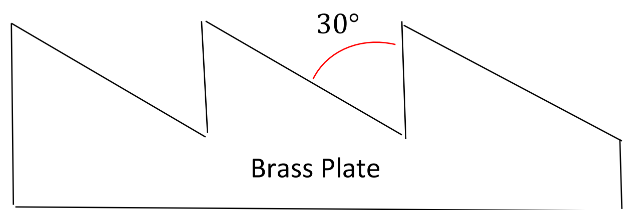

Figure 1: Depiction of the shape the brass plate was cut into.

Once the brass plate had been machined, it was placed on a hot plate and allowed to heat up. After the optimal temperature was reached (approximately $460°C$), water was dropped onto the plate from a syringe approximately 2 cm above the plate. These drops where repetitively dropped at a rate of approximately 2 $drops/sec$.

The Leidenfrost effect is a fluid phenomenon where liquid droplets comes in contact with a surface of temperature far exceeding that of the liquids boiling point. This contact produces a vapor jacket around the droplet essentially insulating it from the heated surface. This is because the vapor essentially suspends the droplet above the surface preventing it to come into any further contact.[1] A Leidenfrost droplet is self-propelled by this vapor jacket actually deforming and compressing when it reaches a sharp corner as seen in figure 2. The horizontal force of this interaction is

$$F = 0.5A_{eff}h|dP/dx|\cos\theta$$

Equation 1

where A_{eff} is the total area in which the force acts, h is the thickness of the vapor layer, P is the Poiseuille vapor pressure, and θ is the angle of the incline that was machined in the plate. [2]

[1] http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Leidenfrost_effect.html
[2] Linke, H., B. Alemán, L. Melling, M. Taormina, M. Francis, C. Dow-Hygelund, V. Narayanan, R. Taylor, and A. Stout. "Self-Propelled Leidenfrost Droplets." *Physical Review Letters* 96.15 (2006): n. pag. Print.

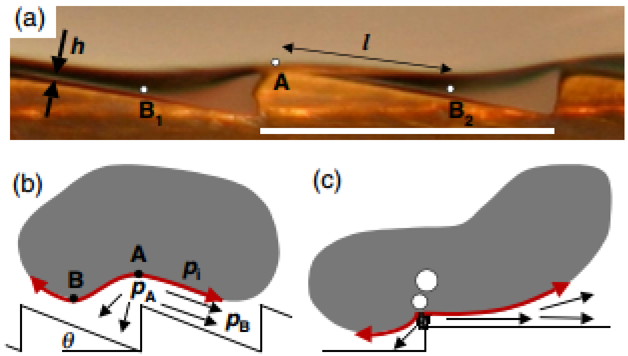

Figure 2: Depiction of self-propelled Leidenfrost droplet geometry.[3]

In order to clearly visualize the Leidenfrost droplets, we used a black background and lit the droplets with two 2000W halogen lamps. The camera was placed on a tripod and manually focused in and out while filming to achieve the desired effect of seeing different times in the cycle at different intervals. Multiple videos where shot with the intention of snipping together multiple shots, however, after reviewing the material, I decided I rather enjoyed just a single particular video captured in one shot.

The video was taken using a Canon EOS Rebel T2 with the stock 35 mm plane shutter SLR EF lens. I originally shot the video at 60 fps in hopes of slowing it down during post processing. I used VideoPad Video Editor as it was a free software I could download at home. I was able to slow down the video by 50%, add introduction and ending screens, turn the entire production black and white and overlay music in my final cut of the video. Music was obtained free online source intended for public use. The composer is Johnny Ripper and the title of the song is “I Am You With George”.

This video captured exactly what I set out to capture when staring the project. I had always been fascinated by self-propelled Leidenfrost droplets after seeing a similar video where a maze was created to make the droplets run an actual course. In the future, I would very much like to build a Rube Goldberg style contraption in which self-propelled Leidenfrost droplets are utilized.

[3] Linke, H., B. Alemán, L. Melling, M. Taormina, M. Francis, C. Dow-Hygelund, V. Narayanan, R. Taylor, and A. Stout. "Self-Propelled Leidenfrost Droplets." *Physical Review Letters* 96.15 (2006): n. pag. Print.