Falling Honey

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Introduction

The initial project for the Flow Visualization course was to "get our feet wet" and capture a clear image that displays an interesting fluid flow. A phenomenon that has caught scientist's attention for many years is the way that very viscous fluids, such as honey, fall in coils, just as a rope would fall from directly above. These sorts of fluids act almost non-Newtonian, and because of that, they buckle as they fall in order to create the coils. I chose to display this phenomenon in my image. Room-temperature honey was dropped from directly vertical so that the coiling could be captured and observed.

About the Flow

The honey was held at different heights in order to determine which height captured the best coils. The height that the honey falls from is directly correlated to the coiling frequency[1]. After a few tries, the best result was found from a height of three inches. At higher heights the coils were too small, and lower heights did not leave enough space for the image to be captured without covering the camera in honey. The honey was poured from the original bear-shaped container so that the opening that it fell through was uniform. The diameter of the opening was ¼ inch. The diameter of the honey remained relatively unchanged as it fell because the bottle of honey was not held very high above the pile, therefore, it was also ¼". It was poured onto a flat paper surface. Because no horizontal forces were acting on the fluid, it fell straight down until it hit the surface. Once there was a small amount of honey on the surface, it began to coil on top of itself. Once the honey left the cap of the container, it remained uniform throughout the fall. The bottle was not squeezed so that the velocity of the honey leaving the bottle remained constant. Research has shown that the coiling of the honey is also dependent on the diameter of the stream falling. The diameter used in this photo, ¼", was relatively wide and because of that the image was easier to capture. A smaller diameter would have allowed for more coils to pile on each other before falling, but it would have fallen too quickly to capture clearly in an image using this camera. Because the honey fell from a relatively low

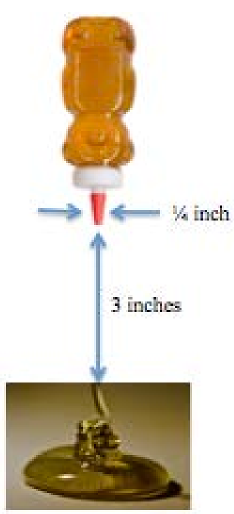

Figure 1: Schematic of how the honey was poured.

height, gravitational forces only affected it. Inertial forces would also affect honey falling from much higher[3]. The relative viscosity of the honey used (at room temperature) was 10,000 cps. Water has a viscosity of about 1cps at room temperature. The viscous forces, and the "stickiness" of the honey are what caused it to buckle on itself and form the coils. This is what is called the "liquid rope-coil effect" because honey, along with several other fluids, coil just as a rope would when falling directly vertical[3]. Studies published in the 1960's called it a "buckling instability that requires a longitudinal compressive stress, like the buckling of an elastic column under a load" [2]. The flow of the falling honey was laminar, with a Reynolds Number less than 2000.

Visual Technique

It was very important to make the background of the picture have as few distractions as possible. In order to do this, I used one piece of white construction paper. Part of the paper was taped down to the kitchen countertop and the other to the wall. There was no crease in the paper between the two surfaces so that there would be no line in the background of the picture. This gave the appearance that I desired for the background. The honey was not altered for the final picture. It was left at room temperature and was not diluted. The lighting used was also important so that the honey could be seen clearly. The fluorescent ceiling lighting was left on in the room. The ceiling lights were four and a half feet above the counter were the honey was. An additional light was used to make the honey even brighter. A led bike light was shown at a 45-degree angle about a foot away from the honey. The camera flash was not used.

Photographic Technique

The camera used to take the photo was a Sony Alpha Series DSLR. The photo was taken at ISO 200 and an aperture of f5.6. The shutter speed was 1/80th. The distance between the lens and the honey was 5 inches. Several distances were tried, but this distance provided the clearest photo of the coils. The aspect ratio, 16:9, of the camera remained unchanged throughout each photo taken. The MacBook photo editor was used to change the aspects of the original photo. The contrast was changed so that the photo was darkened significantly. The darkening showed the definitive lines between each coil, which could not be seen in the lighter image. Changing the contrast also eliminated the shadows from behind the honey in the photo. The shadows were from the surroundings in the kitchen underneath those lights. The original and final photos are shown below in Figure 2 and Figure 3.

Figure 2: Raw Photo

Figure 3: Final Photo

Conclusion

I believe that the image captured the physics of the falling honey very well. It shows the four coils on top of each other. This image, in comparison to others taken, showed the most amount of coils on top of each other. As more coils formed, the honey became too heavy and would fall to the pile below. Before this photo was taken, several coils had formed already, creating the honey pile below the coils. I would have liked to show more of the coils with less honey beneath. That would have allowed for a closer picture of the coils, and less distractions from the honey below. The effects used on the picture after it was taken darkened it significantly. The spot light made the center of the picture lighter, but the edges very dark. I would have liked to take the photo closer to the honey so that the dark edges could be removed and without adding blur when cropped. However, changing the contrast of the photo made the coils very clear. In the future, I believe the same experiment could be performed using honey that has been slightly cooled. It may slow the effects and give more time for an image. This could also be achieved using a high-speed camera.

Works Cited

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[2] Ribe, N. M., H. E. Huppert, M. A. Hallworth, M. Habibi, and Daniel Bonn. "Multiple Coexisting States of Liquid Rope Coiling." *J. Fluid Mech. Journal of Fluid Mechanics* 555 (2006): 275. Web.

[3] Ribe, N. M., M. Habibi, and Daniel Bonn. "Stability of Liquid Rope Coiling." *Physics of Fluids Phys. Fluids* 18.8 (2006): 084102. 7 Feb. 2007. Web.