Image I – Honey Coils

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Figure 1: Final Image of Liquid Rope Coil Effect observed with honey

Introduction

As an introduction to photography and flow visualization the subject of Honey exhibiting the Liquid Rope Coil Effect was chosen. This subject first brought to my attention from Destin Sandlin's youtube channel SmarterEveryDay with the title "Amazing Honey Coiling High Speed Video! - Smarter Every Day 53". This video, posted in 2012, shows the Honey coiling upon contact with a surface after falling[1]. Having observed this effect myself when using honey for baking, this video exposed me to the science of the natural phenonium involved in fluid flow. Now, several years later, my objective was to visualize this flow through my own camera.

Flow Physics

To create the Liquid Rope Coil Effect, honey was used. The choice of honey is foundational to the effect. The rope coil is a result of the viscous fluid falling on to a surface from an adequate height high enough to generate coils[3]. The height to achieve this coiling was not a barrier in this experiment as a height of roughly eight inches proved to be sufficient to generate coils. The coils form because the vertical falling fluid becomes subject to an axial compressive stress when it comes in contact with the surface. This axial stress causes the fluid to deform through buckling[5].

The buckling is due to the viscosity of the fluid[2]. Whereas water's kinematic viscosity is 1.0 cSt, honey's viscosity is 73.6 cSt[6].

There are four types of modes under which coiling can occur[2]. The inertia mode is when the height is very high, the radius becomes very small, and the coil frequency becomes very high. The viscous mode is when the height is very low and the large flow needs to move out of the way to allow the flow of more material. Coiling can be minimal as the flow moves out of the way. The gravitation mode is the one observed in this experiment. This happens when the height is moderate, as defined in the Eq. 01, the radius of the honey falling is decreased under gravity. This allows for consistent, stacking coils. The inertia-gravitational regime is where height is below inertia and above gravitational where coiling frequency variable and not as predictive as the other regimes.

The coiling frequency is defined through the following equations for the gravitational regime:

$$0.2 \leq \widehat{H} \leq 0.6 \qquad \text{Eq. 01}\ ^{5}$$

$$\widehat{H} = H * \left(\frac{g}{\nu^2}\right)^{1/3} \qquad \text{Eq. 02}\ ^{5}$$

$$\Omega_G = \left(\frac{gQ^3}{\nu a_1^8}\right)^{\frac{1}{4}} \qquad \text{Eq. 03}\ ^{4}$$

Where H is the height, g is gravitational acceleration, ν is the kinematic viscosity, Ω_G is the coiling frequency, Q is the volumetric flow rate, and a_1 is the radius of the flow above the coil.

Although the exact measurements of height and radius in this experiment were not measured due to the very involved photography process, rough estimates can be made of $H = 0.2m$ and $a_1 = 0.011m$. The volumetric flow rate cannot be calculated through the still images taken. Further photographic investigation with a high-speed camera would allow proper analysis of the coiling frequency.

Experimental Setup

To capture the image of this effect, several sources of lighting were used. To keep the illumination limited to the desired areas, experiment was done at night in a dark room. The main source of illumination was an Energizer Tac1000 flashlight supplying 1000 lumens. This flashlight was mounted to a chair 12 inches above the camera, illuminating the honey from the front and top. The second light source was a ring light just above and surrounding the honey. The combination of these light sources

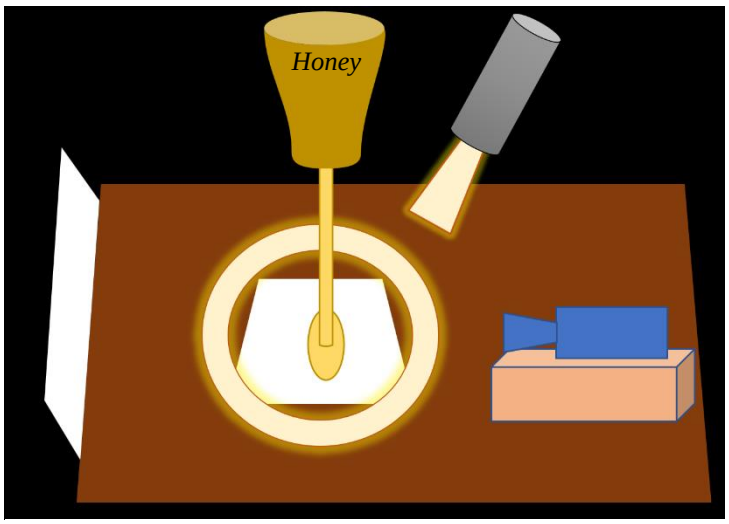

Figure 2: Diagram describing the experimental set up

Figure 3: Photo of the experimental set up

eliminated shadows in the font, viewable section of the honey. The bright intensity of light from the flashlight illuminated a small area around the honey, allowing for a dark background. The ring light allows the honey to be illuminated from all sides, making the golden glowing color of the honey greatly illuminated.

The far background behind the honey is a piece of white paper placed 18 inches behind the honey pour. This distance prevented the background from being illuminated by the high intensity of light. This allowed for a smooth, dark background. The foreground is another piece of white paper. The paper was placed so it draped down allowing the foreground color to be unbroken, with the edges of the paper outside of the boundaries of the image. The foreground paper was sandwiched between two binders. This allowed the ring light to be placed above the honey and make the focus of the image to be in a surrounded, bright confinement.

Photographic Techniques

The camera used for this image was a Nikon D3500 DSLR with a Nikon lens with the specifications of AF-P 18-55mm f/3.5-5.6G VR. The focal length was set to 55mm, the exposure was 1/1600, an aperture of f/6.3 and an ISO of 400. The original size was 6016x4016 pixels. The edited .jpg file is 1300x675 pixels in size, with some cropping along the top and bottom. The field of view was 4.4 inches wide at the focus plane.

Figure 4: The original, unedited photo

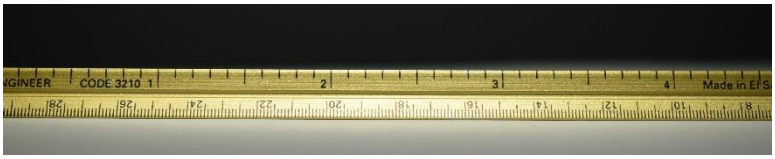

Figure 5: A ruler set at the location of the honey, describing the Field Of View

The camera was placed six inches from the subject, elevated by books to allow a perfectly framed image without manual intervention. Focusing was done prior to honey being poured by using a stand-in item, a pin, to ensure the correct focus plane.

Post-processing edits were made in the software Darktable, the image was cropped to remove background discontinuities and improve the sleek, clean look. The image was sharpened to make the edges of the honey look crisper. The RGB curve was altered to darken the background and brighten the foreground and honey. Retouching was also used to eliminate several bright glares on the honey in the stem and base.

Conclusion

This image successfully captured five beautiful coils above a golden pile of honey. The image is very simple, with just three general colors, is visually attractive. It supplies a great view of the Liquid Rope Coil Effect. The intent was thoroughly captured in this image beyond expectations. The only improvement would be in post processing. The image is rather dark, and the golden hue of the honey is somewhat muted. More editing could challenge these shortcomings, but I feel satisfied with the image and do not feel the need to address these minor defects.

Bibliography

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