Flow Visualization – Get Wet Project

Colored Wax

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Introduction

The purpose of this project was to produce a stunning image that that illustrates a fluid phenomenon. I was interested in working with colored wax because of the stunning colors and because I wanted to explore the interesting motion and interactions of fluid wax. I initially worked with wax and water. I was playing with the extremely quick cooling time and buoyancy of liquid wax as it falls onto water. The in interaction was interesting but not visually appealing. I then experimented with flows of different colored wax flowing together. The viscosity and surface tension helped to reduce color mixing and keep distinct boundaries between colors. This made for a visually beautiful interaction. The shearing forces acting on the wax produced interesting interactions. Finally the fact that waxes changes state at room temperature allowed for almost lava flow like characteristics to be captured. My goal with this image was to capture the interesting interaction of the different colored flows of wax as they change state form liquid to solid.

Setup and Physics

For this experiment a flat 12 by 5 inch peace of clear acrylic was used to create a ramp. The ramp was set at about 30 degrees off the table The ramp was placed on a white table with two white walls to create a clean background. A desk lamp was placed at the end of the ramp to provide a bright light source for a clear image. The light was 10 inches above the subject. The collared wax sticks were held 3 inches above the ramp with a metal beam and tape. A heat gun was used to melt the wax and create the flows of wax. . The ramp was lifted a half inch of the table after the flow began to cool and puddle at the end of the ramp. This was done to give depth to the image and highlight the lava like flow during phase change. The setup is shown below.

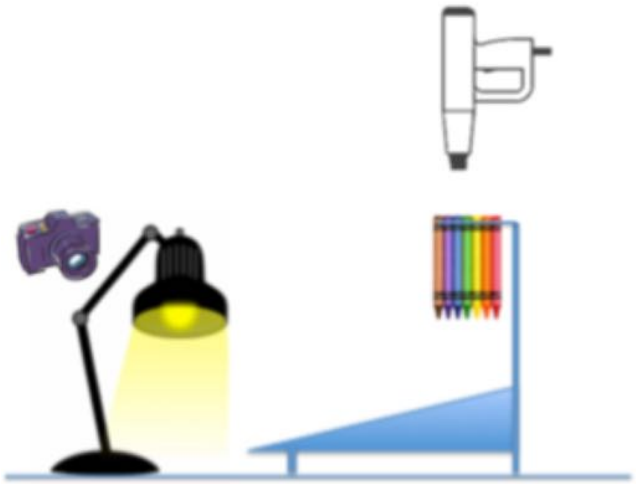

Image 1 - Setup

The size of the wax object in the final image is about 1.5 inches long and an inch tall. The final image shows wax at a state between liquid and solid. The exterior has cooled and started to harden while the interior is still molten. At this point the flow is slow and viscous. The paraffin wax melts between 120 and 147 degrees Fahrenheit. (Crayola Crayons, 2016) The exact melting temperature varies do to the different color wax. At 105 degrees Fahrenheit the paraffin wax begins to deform. In this experiment several forces are acting upon the wax. First gravity is pulling the liquid wax down the ramp. Each stream of fluid is experiencing a shear force from both the ramp and during its interaction with other streams of wax. The internal viscosity and surface tensions are holding the individual streams together. As the searing forces pull at each other between streams of wax they begin to mix. Due to the high viscosity distinct boundary lines exists between colors. The Reynolds number for this fluid is defined by several variables.

$$R_e = \frac{UD}{\nu}$$

First the kinematic velocity must be found υ. The equation can be seen below; were μ is the dynamic velocity and ρ is the density. The density for paraffin wax increases as the temperature decreases. (INOUYE, 1934) The density of paraffin wax as a solid is $0.920\,\frac{g}{cm^3}$ at 75 degrees Ferinhight and liquid at $0.795\,\frac{g}{cm^3}$ at 147 degrees Ferinhight. (N. Ukrainczyk, 2009) Due to the molten nature of the subject I chose $0.850\,\frac{g}{cm^3}$ for ρ. The dynamic velocity for paraffin wax is $6.89Mpa * s$.

$$\upsilon = \frac{\mu}{\rho} = (6.89Mpa * s)/\,(0.850\,\frac{g}{cm^3})$$

This means that the kinematic velocity υ equals $8.10\,\frac{mm^2}{s}$. The velocity was chosen do to distance traveled during the exposure.

$$R_e = \frac{UD}{\nu} = \frac{0.01(\frac{m}{s}) * 0.0127(m)}{8.1e^{-6}(\frac{m}{s^2})}$$

The Reynolds Number is 9.6 this makes senses for a viscose liquid that is in the process of phase change.

Visualization Technique

To visualize the interactions between the wax streams, bright colors were used. The colors were chosen to be astatically appealing. The contrast in the various colors helps to clearly highlight the shearing interactions between the different streams. The pour white background helps to focus the image and reflect light. The lighting is done from above with a bright desk lamp as stated above. The overhead fluorescent bulbs also provided light to the image. Because of the cooling wax exterior there were some interesting bright points witch helped to reveal the molten quality of the object. The slightly offset lights provide a shadow witch gave the image more depth and helping the viewer to orient the object.

Photography Technique

The field of view of the image is about 2 inches wide and 1.5 inches long. The object was about five inches from the end of the lens. The focal length was 55mm. The lens I was using is called The Cannon EF-S 18-55mm f/3.5-5.6 IS II. The camera I used is a DSLR Canon EOS Rebel T3. The original raw image was 2,848 pixels high and 4,272 pixels wide. The final image after cropping and editing was 2,206 pixels high and 3,944 pixels wide. The IOS setting was IOS100. This made for a clear image but caused the image to need to be brightened in post editing. The aperture was set at F5.6 with a shutter speed of 1/125. After taking the photo I made some slight adjustments using GIMP photo editor. I cropped the photo and brightened it using the contrast map. Below is a before and after comparison. In the before image you can see a shadow from the acrylic ramp. This shadow was the main reason for cropping the photo.

Image 2 – Original vs. Final Image

Conclusion

In conclusion I am pleased with the final result of my Get Wet project. I feel that my image clearly illustrates the interaction of multiple streams of wax and Cleary shows sheering affects on viscous fluids. I was excited to capture a fluid as it was in the process of changing states. This was one of my first experiences with photography beyond cell phones and I loved it. There is a bit of a learning curve, especially with photo editing but I now feel empowered to create more images. I feel the brilliant colors I was aiming for really came threw and I was happy with the sharp color contrasts. I was a bit disappointed with some of the blurriness. The image was not quite as crisp as I was hoping for but I think I can overcome that with more practice. I would like to see how the wax interacts with other types of liquids. I think it could be interesting to work with a hot bath of multiple types of fluids including wax.

Works Cited

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