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Flow Vis Spring 2013

Team Project #3: *Ink Blasts*

Figure 1: An image of food coloring manipulated with compressed air

The above image is my submission for the third team project in the spring 2013 section of the Flow Visualization course at University of Colorado Boulder. The assignment was to create an interesting demonstration of fluid flow with a group, then photograph and document it. In this case the group consisted of me, Elizabeth Crumb, and Jon Horneber. The idea for this image was originally to manipulate paint with compressed air and photograph the results. We wanted to see some chaotic patterns; splashes, splatters, etc. This proved fairly difficult with paint as it was far too viscous to do anything of real interest. The team then decided to try the same procedure with food coloring. As you can see above, the less-viscous fluid behaved beautifully under the compressed air. We would come to find out that it behaved differently when subjected to different velocities of air. This is the effect I believe I am demonstrating with this image.

To give the image some scale, what you see in Figure 1 is just larger than a normal sheet of 8.5x11 inch paper and the thicker lines of color are about a quarter of an inch thick. It took a few steps to create this image. Firstly, a drop of each food coloring was placed in the center of a sheet of white paper. Next, compressed air was blown, slowly, straight down between the 4 drops of food coloring.

This created the straight, thick, contained paths that propagate outwards radially from the center. Lastly, compressed air was “blasted” in short, fast bursts at various angles towards the ends of the paths initially created. The food coloring had gathered here and the faster bursts of air split the fluid up into much thinner lines as you can see in the image. Once the food coloring had dried, I took the sheet of paper outdoors to be photographed in the sunlight. I created several of these “paintings” but none were quite as interesting to me as the one I created first without knowledge of what would happen, so this is the image I submitted.

What is really interesting to me about this image is the two different ways the food coloring behaved under slow and fast air flow. I think this has a lot to do with viscosity, surface tension, and cohesion forces. These things are all related themselves, but thinking about each of them helped me to understand what I was creating. Viscosity was early in the thought process because the thick, viscous paint did not create anything interesting when subjected to the compressed air. I attributed this to the fact that it simply did not flow easily enough. A small blob of ink just turned into a larger blob of ink. This brings me to cohesion forces. Since the food coloring is largely water, I assume that water is a suitable analog for analysis. Hydrogen bonds and Van der Waals forces are the primary sources of cohesion in water; these forces make water stick together. When subjected to slow air flow, the food coloring stuck together and moved as one big droplet. I assume this is because I did not overcome the cohesion force of the water. The faster “blasts” of air broke up the droplets and sent them in different directions, leading me to believe that I had, in fact, overcome the cohesion forces of the food coloring and caused it to spread out. Another interesting effect is that the food coloring likes to be where it has already been. This is because of the same forces. The fluid is attracted to itself more than it is attracted to the paper, so where the paper is dry, the fluid will not go unless forced (or absorbed over time). This effect is especially visible in the corners of the image where “blasts” of air were applied. You can see that some of the thinner lines of fluid are shorter than their counterparts because they encountered another line and spread out within it rather than progressing across it. Surface tension is simply a result of the aforementioned cohesive forces but this image would not be possible without its effects. Without surface tension the initial drops of food coloring would have simply absorbed into the paper.

This image was captured with a Canon Digital Rebel XS. As mentioned previously, the field of view in this image is slightly larger than an 8.5x11 inch sheet of paper. The “painting” is roughly a foot and a half from the lens of my camera. The camera settings are as follows:

- Shutter Speed: 1/1250 second

- Aperture: F/11
- Focal Length: 33 mm
- ISO Speed: 200
- Flash: No
- Exposure Bias: 0

This image was not a challenging one to capture as there was no motion. My photography knowledge starts and ends with what we have learned in this course so the approach that worked best was to take a variety of shots at different aperture settings and choose the one with the brightest colors and best focus. For post-production I used a free, open-source program called RawTherapee. The only tweaks I made to the photo were in an effort to make the colors as bright as possible without oversaturating them and to make the background as pure white as possible. I did not want to be able to see the wrinkles or structure of the paper at all. I think I mostly achieved this although I wish the background were a more uniform white. This is most noticeable when the picture is placed on a pure white background (such as this report!).

Overall, I am very happy with the results from this team project. At first there was little hope with the paint, but food coloring gave us the results we were after. I believe I successfully demonstrated a contrast in fluid behavior related to the velocity of the gas driving it. I have some deeper questions regarding laminar and turbulent gas flow and how that may affect the behavior of fluids on a flat surface but they will have to wait for another day of experimentation. I would also be interested to see if the effects change when the scale is drastically increased (think buckets of food coloring on a windy day). I love the way this image turned out; it reminds me of fireworks every time I look at it. I think it serves as proof that you don't always need complicated equipment to demonstrate interesting fluid phenomenon, sometimes all you need is food coloring and patience.