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Project 3

The goal of this project was to photograph a fluid flow phenomenon while making a visually appealing picture. To do this the Hele-Shaw Cell was utilized to create a Saffman-Taylor instability. When this instability is created in the apparatus an interesting fingering pattern can be created. The difference in viscosities of the two fluids allows this pattern to form. A dye was added to one of the fluids to help distinguish the normally colorless fluids.

The apparatus used in this photograph is called a Hele-Shaw Cell. Figure 1 shows a diagram of the physical apparatus. The apparatus consists of a white acrylic layer on which a glass sheet sits. The rest of the apparatus is for support and drainage. The glass and acrylic are approximately 2 feet by 2 feet. The white acrylic layer has a small hole in the middle, which is used to insert a fluid.

Figure 1 - Hele-Shaw Cell
http://www.colorado.edu/MCEN/flowvis/course/SaffmanUser.pdf

The flow is created by first applying a more vicious fluid on the middle of the white acrylic layer, where the small hole is. Then the glass is placed on top of the fluid just above the acrylic. This creates a layer of the fluid that touches both surfaces. Next a fluid with a smaller viscosity is inserted through the hole into the first fluid using a syringe. As the second fluid flows into the first fluid it creates an outward fingering pattern, which was photographed. When a fluid with a low viscosity is injected into a fluid with a higher viscosity an instability occurs. This phenomenon is known as the Saffman-Taylor Instability. [1]

To visualize the Saffman-Taylor Instability two fluids were needed. The first, more viscous, fluid used was hand soap. It had a clear color that provided good contrast between itself and the second fluid due to the white background. The second, less vicious, fluid used was water with

black food coloring. When the black food coloring was injected into the clear soap, it made for a very nice contrast with the white background and clear soap. The original intent of the image was for more of a black and white effect. However when the Hele-Shaw cell was lit with the halogen lamp, it created more of a yellow color instead of white. The lamp was placed below the white acrylic base off to the side of the cell. The side positioning made for a small gradient in color between the bottom left and top right in the picture.

The size of the photograph is approximately six by six inches. The object was one foot away from the lens. The lens used was a Canon Zoom Lens EF-S 18-55mm 1:3.5-5.6. The photograph was taken with a focal length of 34 mm. The camera used was a Canon Digital Rebel XT. The original size of the photograph was 3456 x 2304 pixels, the cropped version is 2386 x 2111 pixels. The exposure setting were an aperture of f/10, a shutter speed of 1/160 sec and an ISO of 400. In Photoshop adjustments were made to improve the image. First the image was cropped so that the flow was the only thing in the picture. Second an air bubble that was in the center was removed using the clone stamp tool. The bubble took away from the picture and was not actually part of the flow so it was determined that removing it did not change the flow, only helped the picture. Third the color curve was changed to bring out the colors in the background. Originally the background was a pale yellow color with a slight gradient to it. When the color curve was adjusted a very nice red to yellow fade was brought out. The black dye also took on a slight green tint and the small lines in the flow were accentuated. The only other changes were made to the brightness and contrast to make for nicer transitions between colors.

This image shows the Saffman-Taylor in a visually appealing way. The photograph accurately shows how the fluid flows in this situation. I like the contrast in colors between the flow and the background. I think it helps to visualize how the flow is moving. I also like the small lines that formed inside of the flow. They also help to show the outward movement of the flow. Although the picture is of only a fraction of a second, they look like streamlines of how the flow was moving. I really like my final picture. I feel that it does a good job illustrating how the flow is moving while also being a very interesting picture to look at. The one thing I would change would be to try and remove the small bubbles from the water. The bubbles are actually in the soap and the water went around them. If there is a way to remove the bubbles from the soap before the water was injected, the image would have turned out even better. The other thing I would try next time would be dying the soap then injecting different colored water. This was attempted once, however we ran into the problem above. When the dye was mixed into the soap it created even more air bubbles that really took away from the picture. If a good method of removing bubbles could be found this could make for an interesting photograph.

References

[1] "Instabilities of two-fluid flow in Hele-Shaw geometry." NJIT Math. 31 Mar 2009 <http://m.njit.edu/Undergraduate/Capstone/Spring2002_kondic/a/index.html>.