Group Project I

The purpose of this project was to observe a flow for our first group project using the Hele Shaw Cell. Our intention was to help each other to observe the Saffman-Taylor instability. We used many different types of liquids in the Hele Shaw Cell, including different types of oils and injecting either air or water. Air created very beautiful examples of the Saffman-Taylor instability, but it was difficult to see the boundary between oil and air. The final image was produced using Canola oil with water injected with blue food coloring.

The flow apparatus used for this photograph can be seen in Appendix 1. There was a white piece of plastic on a stand, and another white piece of plastic angled on the floor. The white plastic on the stand had dimensions of about 1.5 ft x 2.5 ft. The plastic on the floor was used to direct light up the plastic on the stand. There was a small hole drilled into the white plastic on the stand. Then, oil was poured onto the white plastic on the stand, with the hole in the middle. Next, a piece of clear plexi-glass was laid on top of the oil to create a very thin layer of oil. Finally, a syringe was used to force air or water in through the hole from below. This process created the “fingering” formations, also known as the Saffman-Taylor instability shown in my photo.

The visualization technique used in this photograph was using water died with food coloring injected into a thin film of canola oil. This created the Saffman-Taylor instability. This happens when a less viscous fluid pushes on a more viscous fluid. The less viscous fluid, the water, was pushed very slowly through the more viscous, the canola oil. “The presence of a yield stress leads to very branched patterns at low velocity, where the yield stress plays an important role” (Maleki-Jirsaraei, et al.). The

shear between the two fluids causes them to yield. The fact that the two do not mix is due to the surface tension of the fluids. The flow is definitely in its laminar region, so the Reynolds number is less than one. The lighting setup for this flow can be seen in Appendix 1. It consists of one 240 watt light bulb shining onto an angled piece of white plastic. The light then gets reflected onto the bottom piece of white plastic. This lights up the flow from behind, as seen in the photograph.

The field of view in the final photograph is 3in x 2in. The distance from the flow to the lens was 12in. The lens focal length is recorded as 62mm. The camera I used was a Canon EOS Digital Rebel XTi. The pixel size in the photograph is 1630 x 1892, with an image resolution of 72 dpi. The exposure time was 1/30 sec, with an ISO speed of 400. There quite a bit of Photoshop work done with this photograph. The image was cropped, rotated. The layers were then adjusted to make the colors look better, and then some touchup was done on the background using the heal tool.

The image reveals exactly what my group was trying to get it to do. We were trying to use the Hele Shaw Cell to observe the Saffman-Taylor instability, and this is exactly what this photograph shows. I really like the colors in the image, and it shows the phenomena very well. I completely fulfilled my intent for this project, but there were some aspects that I would like to improve on. To develop this idea further, we could have used a much more diverse range of fluids. We could have tried much more different viscous fluids like glucose, molasses, or some other. I have also seen some done using black lights, which would have been fun to try. It would also be nice to

mechanically push on the syringe so we could know an exact speed that the fluid was injected. Overall, I am very happy with the result of this image.

Source:

Maleki-Jirsarei. “Saffman-Taylor Instability in Yield Stress Fluids.” Journal of Physics: Condensed Matter (2005).

Appendix 1

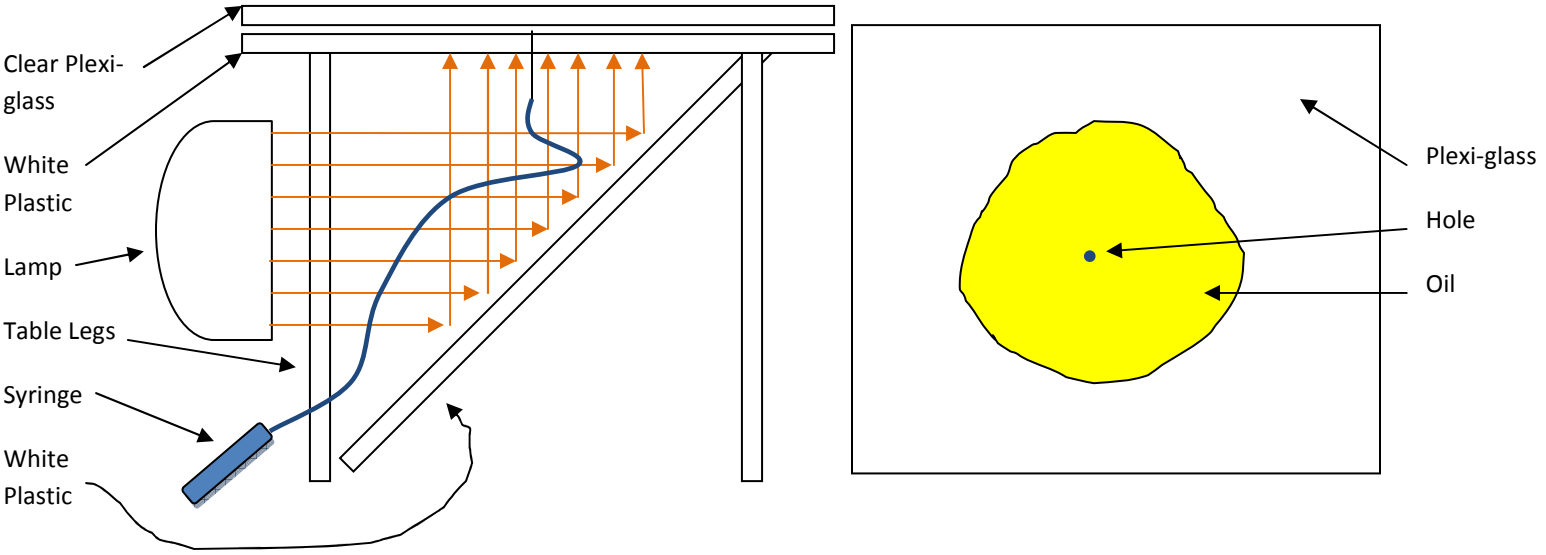
Clear Plexi-glass
White Plastic
Lamp
Table Legs
Syringe
White Plastic
Plexi-glass
Hole
Oil

Image Assessment Form
Flow Visualization
Fall 2007

Justin Cohee
Assignment: Date: 10/25/07
Scale: +, ! = excellent Ö = meets expectations; good. ~ = Ok, could be better. X = needs work. NA = not applicable

Art	Your assessment	Instructor assessment
Intent was realized	+	
Effective	+	
Impact	+	
Interesting	+	
Beautiful	+	
Dramatic	+	
Feel/texture	+	
No distracting elements	+	
Framing/cropping enhances image	+	
Flow	Your assessment	Instructor assessment
Clearly illustrates phenomena	+	
Flow is understandable	+	
Physics revealed	+	
Details visible	+	
Flow is reproducible	+	
Flow is controlled	+	
Creative flow or technique	+	
Publishable quality	+	
Photographic technique	Your assessment	Instructor assessment
Exposure: highlights detailed	+	
Exposure: shadows detailed	+	
Full contrast range	+	
Focus	+	
Depth of field	+	
Time resolved	+	
Spatially resolved	+	
Clean, no spots	+	
OK, simple print	+	
Mat	N/A	
Mounting	N/A	

Report		Your assessment	Instructor assessment
Describes intent	Artistic	+	
	Scientific	+	
Describes fluid phenomena		+	

Estimates appropriate scales	Reynolds number etc.	+	
Calculation of time resolution etc.	How far did flow move during exposure?	+	
References:	Web level	+	
	Refereed journal level	+	
Clearly written		+	
Information is organized		+	
Good spelling and grammar		+	
Professional language (publishable)		+	
Provides information needed for reproducing flow	Fluid data, flow rates	+	
	geometry	+	
	timing	+	
Provides information needed for reproducing vis technique	Method	+	
	dilution	+	
	injection speed	Ö	
	settings	+	
lighting type	(strobe/tungsten, watts, number)	+	
	light position, distance	+	
Provides information for reproducing image	Camera type and model	+	
	Camera-subject distance	+	
	Field of view	+	
	Focal length	+	
	aperture	+	
	shutter speed	+	
	film type and speed or ISO setting	+	
	# pixels (width X ht)	+	
	Photoshop techniques	+	
	Print details	+	
	"before" Photoshop image	+	