

Solutal Convection

Third Team Project

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MCEN 4151

Flow Visualization: The Physics and Art of Fluid Flow

5/4/18

Background

The purpose of the Team Second image assignment is to capture a fluid, or combination of fluids, to understand the physics of the flow in the experiment. The experiment must be controlled so it can be repeated. In this experiment, I wanted to examine the interaction between different fluids.

Setup

The materials needed for this experiment are a paper plate, Tia Maria liqueur, table cream, a spoon, and a camera.



Figure 1: Liquids needed for experiment

To get this experiment set up, pour about a third of a cup of Tia Maria onto the paper plate, as seen in Figure 2. Make sure the camera is filming and take a tablespoon of table cream and gently spread the cream on the liqueur on the plate, as shown in Figure 2.



Figure 2: Tia Maria poured onto a paper plate (Left) Table cream poured onto liqueur (Right)

Fluid Dynamics

Convection is defined as a method of heat transfer during which heat is taken away from a source by the circular movement of liquid or gas¹. Convection can occur in a variety of ways. Convection cells are the systems that allow weather to happen. They can also occur inside your home. For example, if we look at of how air circulates in a room, we can see that a convection cell is present (Figure 3).

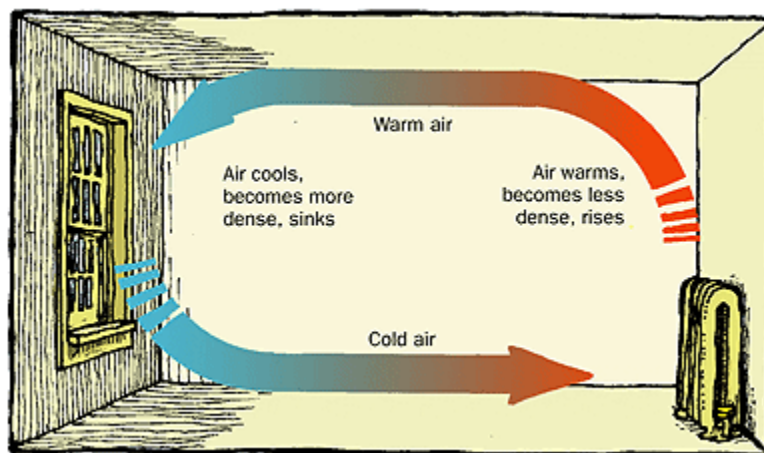


Figure 3: Example of a convection cell in a room¹

In this experiment, what allows the cream to seem like it is spinning around in the alcohol is known as solutal convection. In this experiment, solutal convection occurs when alcohol rises to the top of it's surface, some of that alcohol evaporates, making the fluid denser ². That fluid sinks back to the bottom of the pool of alcohol, where the process is repeated ². The cream plays a role in this experiment as well. The cream has a higher surface tension than the alcohol and provides a stable region for the alcohol to move around. This phenomenon creates a spinning effect with the cream, clearly forming visible convection cells, as shown in Figure 4. I noticed that the spinning always appears to start from the outside of the cream and move in toward the center. I'm not sure why that is the case but is certainly interesting.



Figure 4: Convection cells formed by solutal convection

Visualization Technique

This experiment was performed in my kitchen and was illuminated by five incandescent light bulbs placed around the setup. I also chose to use a paper plate instead of a plastic plate to get a good contrast between the alcohol and the cream. With these conditions, I believe I was able to get great results in the video that I created.

Photographic Technique

The camera used for this experiment was my iPhone 8 Plus. It is a 12 MP camera model with a wide-angle and telephoto lens. The videos were all taken at 1920 x 1080 pixels with a frame rate of 60 frames per second. I chose to film this with my phone because my phone offered a higher framerate than my DSLR camera, which shoots at 24 frames per second at 1080p. I chose to get

videos of the cream being poured into the alcohol as well as some close-up videos of the convection cells that formed. In the first shown convection cells, shown in Figure 4, I chose to slow down the film by a factor of two, so the audience could see what was happening in slow motion. The second film is left at 100 percent speed (see Figure 5). The video was edited in DaVinci Resolve and had a final resolution of 1920 x 1080 pixels and a frame rate of 60 frames per second. I chose to cut out all of the audio from the video clips due to random background noise and added some background music to add to the effect of the video that I was looking for.



Figure 5: Solutal convection cells in second half of the video

References

- 1 “Density Creates Currents.” *Properties of Matter Reading Selection: Density Creates Currents*, 15 Sept. 2005, www.propertiesofmatter.si.edu/density_creates.html.
- 2 Mould, Steve. “Spinning Alcohol Experiment.” *YouTube*, Steve Mould, 15 Oct. 2015, <https://www.youtube.com/watch?v=x2yAPjFHG-Y>