University of Colorado Boulder

# MCEN 4151: Flow Visualization

## 2021 Fall Image/Video Third Report

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# 1. Introduction

On November 6th, 2021 I was at work ending my shift, A coworker of mine brought in some dry ice that he had used to cool down a chunk of freshly laid asphalt for testing. She needs to cool the area to be able to drill a core out for compaction and void testing. She used dry ice because the section of asphalt that was paved is required by the Colorado Department of Transportation (CDOT) to open 2 hours following paving. Normal cooling methods do not cool the asphalt fast enough so dry ice was used. The whole crew was curious about the dry ice because its not everyday you have dry ice laying around. We decided to place some in the sink and turn on the water to see what would happen. A cloud of carbon dioxide gas was rapidly formed, an image of the water and dry ice in the sink is shown below in Figure.1. A dense white cloud of fog first rises above the sink. As more fog is produced, it stops rising and flows over the rim of the sink and down to the floor. I immediately thought of this class, Flow Visualization and the visual effects of dry ice turning into a gas, I then used my phone to capture this video.

*Figure 1:Water and dry-ice in the sink*

The purpose of this video was to understand the forces of fluids better while exploring the concept of flow visualization and how to best represent a phenomenon through a lens. This report will thoroughly go through how to reconstruct this experiment, classify, and explain the flow phenomenon.

## 2. Experimental Set-up and Materials

To be able to capture pictures and videos of the water and dry ice phenomenon a physical experiment had to be conducted. Using my personal computer for video editing I was able to create the experiment using the following materials:

| Material | Description | Quantity |
|---|---|---|
| iPhone 12 Pro Camera | HDR video recording with 60 fps | 1 |
| Lighting | Lighting such that the experiment is visible | 1 |
| Cup or container | Object to hold the reaction | 1 |
| Tongs | Protect yourself from directly touching dry ice | 1 |
| Dry Ice | Reactant fluid #1 | 1 |
| Warm Water | Reactant fluid #2 | 1 |

*Table 1: This table shows the quantity of each component required to run the experiment.*

To set this experiment up you must first find a level and sturdy surface to conduct the reaction. Fill the cup or container one quarter full of warm to hot water. Next set the cup on the surface and make sure the location in a safe place where if anything is tipped no equipment or electronics will be damaged. Put thick rubber gloves on before handling the dry ice. Use tongs to place dry ice in the cup with the water. Use extreme caution when handling dry ice. It can cause a freezer burn to your skin due to its extremely low temperatures. This procedure is shown in the figure below:

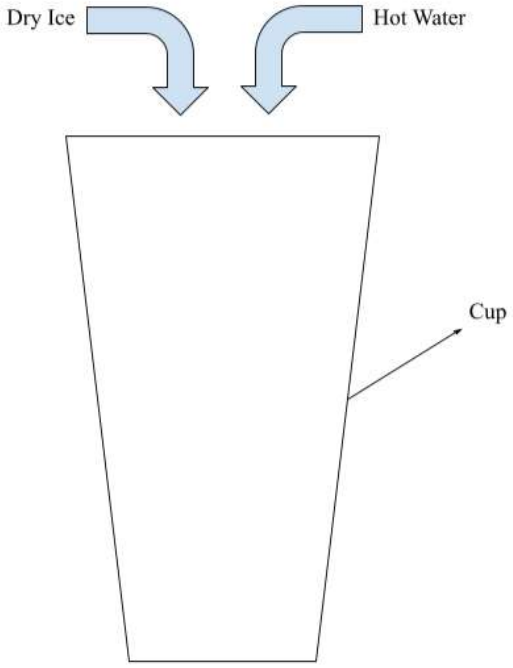


*Figure 2 Experimental Setup:*

## 3. Flow Phenomenon

Dry ice is at its simplest state is the solid form of carbon dioxide. When dry ice is added to water, it sublimes to carbon dioxide gas rapidly due to the fact that the solution's temperature is warmer than the dry ice (-77.2 degrees Celsius or -108.3 degrees Fahrenheit). Sublimation is the transition from the solid phase to the gas phase without passing through an intermediate liquid phase. This endothermic phase transition occurs at temperatures and pressures below the triple point [2]. Fog forms when water vapor in the air condenses into tiny suspended droplets. This condensation occurs when warm, humid air is cooled. The warm air over the hot water is nearly saturated with water vapor. This warm air is cooled by mixing it with the cold carbon dioxide gas that sublimes from dry ice. Initially the hot water heats the air above it making it less dense and causing the fog to rise. Eventually, the cold carbon dioxide cools the air to the point that it becomes denser than the air around the basin, and the fog sinks. This phenomenon can be represented with a chemical reaction, full chemical reaction between dry ice and water is shown below:

$$CO_2\,(g) + H_2O = CO_2\,(aq)$$

$$CO_2\,(aq) + H_2O = H_2CO_3$$

$$H_2CO_3 = H+ + HCO_3$$

$$H_2CO_3- = H+ + CO_3$$

*Equation 1: Chemical Reaction of the Experiment*

The carbonic acid $H_2CO_3$ produced is only slightly dissociated and therefore, is considered to be a week acid. Note: this is only fully true at atmospheric pressures. Dry ice skips the liquid state at atmospheric pressures-if you were to conduct this experiment in different conditions it may respond differently.

## 4. Photographic Technique

As this video was taken at the end of my shift I had little time to spend setting up the scene and getting the angles right. However, if I did have the time; I would set up the scene by placing the dry ice and the water in a glass cup on the table and a camera on a tripod across from the cup as shown in Figure 3.

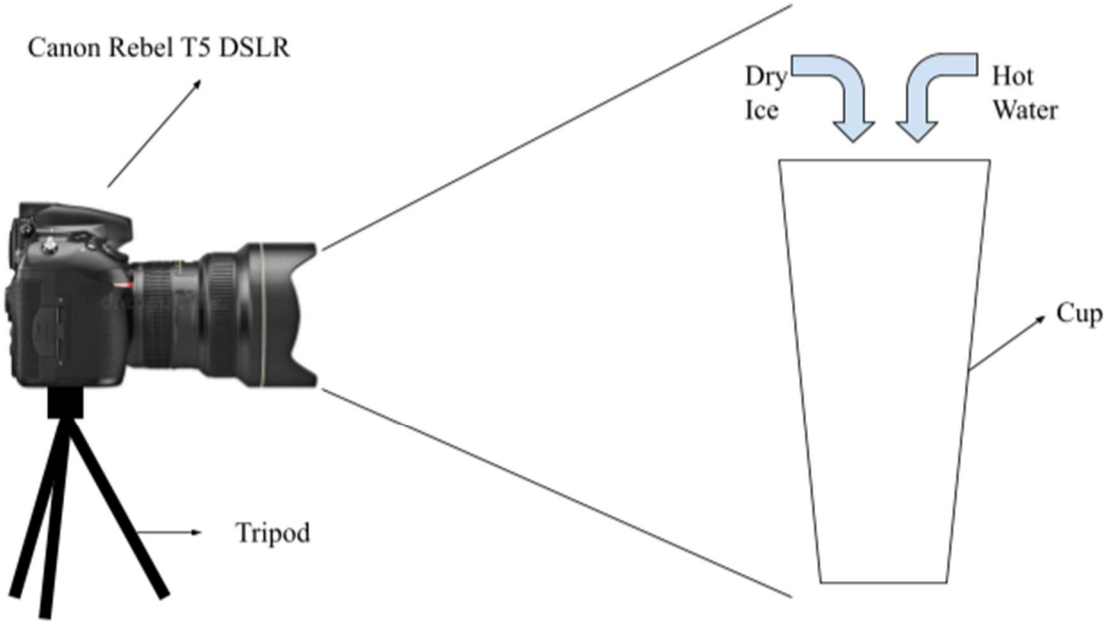


*Figure 3:Photographic Setup (if I had more time)*

Using the cameras view finder eyepiece and constantly adjusting the tripod until the camera could stand still with the card in the middle of the frame. Then place a poster board behind the scene and checked to make sure no parts of the wall could be seen in the cameras frame. I then placed two lamps on either side the camera and covered them with white towels. The apparatus is shown in Fig.3.

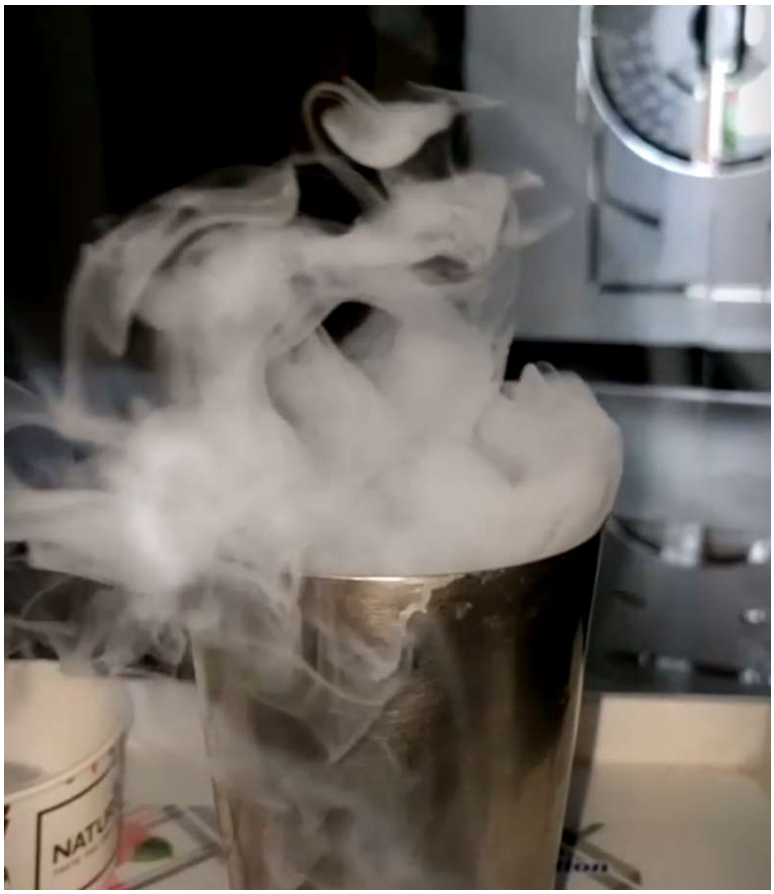

*Figure 4: Snapshot of the video*

## 5. Conclusion

After performing the experiment, recording the experiment, I was unimpressed with the quality of my work. If I was to go about doing this experiment again, there are a few things I would have changed. First being, I would have spent more time with the photographic side of the experiment. Having an apparatus with a constant background could lead to some very cool crisp photos. Secondly, the timing of everything wasn't ideal, the ice was subliming when I received it and I knew I only had a matter of mins before the little amount left would essentially disappear. Other than that, I was really cool to learn more about dry ice and why there is smoke like vapor present as well as flow photography and visualization effects. I really enjoyed making this video. For Image/Video assignment #4 I plan to do a similar experiment and prepare correctly to capture some crisp flow visualization images.

## 6. References

[1] "Station 1: Dry Ice Experiments." *Department of Chemistry and Biochemistry*, https://web.chem.ucsb.edu/~outreach/station1.htm.

[2] Anne Marie Helmenstine, Ph.D. "Here's What Sublimation Means in Chemistry." *ThoughtCo*, ThoughtCo, 9 Jan. 2020, https://www.thoughtco.com/definition-of-sublimation-phase-transition-604665.

[3] Anne Marie Helmenstine, Ph.D. "Here's What Sublimation Means in Chemistry." *ThoughtCo*, ThoughtCo, 9 Jan. 2020, https://www.thoughtco.com/definition-of-sublimation-phase-transition-604665.

[4] Shakhashiri, B.Z. 1983, Chemical Demonstrations – A Handbook for Teachers of Chemistry, vol. 2 pp. 114-120.

[5] Shakhashiri, B.Z. and Schreiner, R., 2008, Instructors Guide to Accompany Shakhashiri Chemical Demonstrations Videos p. 73.