

For a Want of Ice Cream

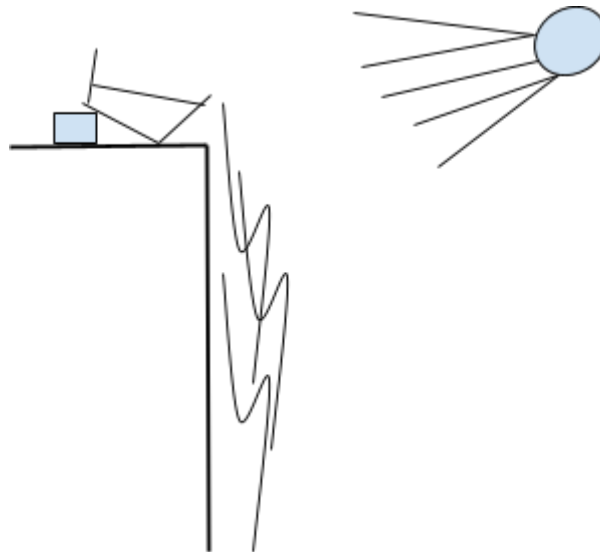
Flow Visualization ATLS 4151

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There are many things in the modern world that would send a victorian into a dramatic faint; or send our goat herding ancestors into instant shock; or just genuinely baffle anyone that stumbles across some key pieces of information. Of course, this refers to dry ice, which deigns to leave a solid state at -109 F (-78.5 C) or potentially 20 C lower according to certain research.(1) There is something to be said for the fact that something cold enough to make the Ice King shiver can be bought from a grocery store with minimal effort and even fewer questions. What that something is can be left entirely to individual discretion. But dry ice has some interesting properties, when it becomes a gas, a lot escapes as a stark white vapour, but some is left behind if it was submerged in a liquid, carbonating said liquid. A process which allows the creation of fizzy ice cream. There are nuances in the process and many ways it can go wrong, but during the making vapors tumble over the side like witch's cauldron. With Halloween on the horizon, something striking, heavy and a bit ominous seemed a good idea. In order to accomplish this and not have a mess dry ice was set in water to increase the rate of sublimation and flowed off an edge.

To make the flow a steel bowl was filled with warm water, powdered dry ice was dropped into that bowl in order to expel gas that cools the surrounding water. This gas is denser than air and under the pull of gravity flows downwards. The chilled gas makes the water in the air condensate reflecting light and creating a nice pale white fog. The bowl was placed atop a black speaker so the edges aligned to create a clean flow. It was tipped at a 30 degree angle in order to funnel gas in the intended direction. As it flowed the gas spread over a wider area and its temperature increased causing the "fog" to disperse. (Or in this case cease visibility.)



A lamp was pointed directly at the falling gasses from an angle to the right and above the speaker wall, leading to that side being brighter. There is a bit of trouble finding a good dimensionless number for the given flow as there was no value for kinematic velocity for CO₂ vapor at dry ice temperatures. A rough calculation of Reynold's number is shown below and marks the flow as extremely turbulent with a value around 42000.

$$Re = \frac{UD}{\nu}$$

This calculation involved a 2.5 foot height of the box which took about 3 seconds for the vapor to cross and a kinematic viscosity of $0.476 \times 10^{-4} \text{ ft}^2/\text{s}$ (2) which could be pushed even higher as the limit was -56 C before the tool stopped working. Overall the Reynolds number is extremely high, and the context behind it beyond my ability to explain or rationalize beyond the barest basics.

The video was taken in a darkened room with almost no outside light. A 7 inch diameter steel bowl was placed at a 30 degree angle with the mouth pointing towards the edge of two stacked wooden speakers coming up to about 5 feet in height such that it's edge aligned with that of the speakers. From there $\frac{1}{3}$ of a cup of powdered dry ice was added to 105-110 F water; 5 seconds after that the video begins. The only light in the room came from a single 60 watt LED bulb pointed towards the speaker from above and to the right from about 8 inches away. From there the image was framed in order to capture the highest amount of the flow as possible; in as much detail as possible. From there the post processing was to crop out distracting elements on the side, increase contrast, lower the lighting and apply a monochromatic filter. This was done to enhance the starkness of the contrast, remove the visual noise of the woodgrain and draw attention to the central flow. The final result is a video that encapsulates the fact that gasses are fluids. It also shows how temperature and density alter patterns of gas mixing. The video overall doesn't quite fulfill the intent, it is striking, but it lacks the weight that would have been ideal. Along with lacking any sort of fear factor, it is shaky and blurry where it shouldn't be. An improvement may be made if the white is replaced with red, the edges are made sharper and in future cases more forces act upon it to induce a larger scale pattern. Slowing the flow but maintaining volume and including music may capture the artistic intent better.

On the positive side, fizzy pomegranate vanilla ice cream was made. The damage to the kitchen was absolutely worth it.

(1) Experimental and theoretical investigation of the dry ice sublimation temperature for varying far-field pressure and CO₂ concentration

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