

## Dry-Ice Jets

My intentions for the get wet project were to play with dry ice and to try and observe the transition from laminar to turbulent flows in a jet. I first tried playing around with dry ice to see its effects in different temperature water, using different amounts of dry ice, and using different volumes of water. I observed a lot of interesting phenomena occurring when experimenting with the dry ice. I found that when putting a piece in a relatively large volume of water, like a bathtub, it propels itself around, creating a very beautiful wake. I also observed that it is capable of creating a large amount of pressure when sealed. This can be very dangerous, but can also create some very beautiful flows when used in the right way.

The flow apparatus used for this photograph can be seen in Appendix 1. A cup, 4 inches in diameter was set on a stool in front of a camera on a tripod. The cup was filled with water, and crushed dry ice was introduced. Then a tinfoil cover was applied over the top of the cup, and three holes were punctured in the tinfoil with a toothpick. This created three channels, each with width of 1/8in. The phenomenon created was three jets of Carbon Dioxide, or CO<sub>2</sub>, each transitioning from laminar flow to turbulent flow. This happens because once the solid CO<sub>2</sub> touches the warm water, it instantly “melts,” turning from a solid to a gas without first becoming a liquid. This is why it is called dry ice. The Reynolds number was calculated to be  $1.4 \times 10^4$ .

The visualization technique used in this photograph is smoke in the form of CO<sub>2</sub>. The cup was filled with 2/3cup of water at 95°F, and 1 Tablespoon of crushed dry ice. The dry ice was crushed because this created more surface area for the ice to contact the water. This creates much more CO<sub>2</sub>, much more quickly than if I used one solid

block of dry ice. The lighting used was two lamps beside the flow, in a darkened room. I used two light deflectors to apply light to the flow, but not the background. This can be seen in the diagram in Appendix 1. The flash on the camera was also used.

The field of view in the final photograph is 6in x 4in. The distance from the flow to the lens was 16in. The lens focal length is recorded as 60mm. The camera I used was a Canon EOS Digital Rebel XTi. The pixel size in the original photograph was 3888 x 2592, with an image resolution of 72 dpi. The exposure time was 1/200 sec, with an ISO speed of 1600. There quite a bit of Photoshop work done with this photograph. The image was cropped, and then converted to grayscale. The layers were then adjusted to get the blacks darker and the white's whiter, and then some touchup was done on the background using the burn tool. The burn tool was used to get the background completely black.

The image reveals exactly what I was trying to get it to do. It shows three jets with laminar flow at the bottom, and then they transition into turbulent flow as they rise. I like the simplicity of the image, including the black and white color scale. I like how it shows the fluid physics very well, as the transitions are very apparent in all three jets. I completely fulfilled my intent for this project, but there were some aspects that I would like to improve on. I would like to have my original picture look more like my Photoshopped picture. This could have been done by having better lighting on the flow, with a background that disperses light better, such as felt. I would also have liked to try to not use the flash, just to see the outcome. To develop this idea further, I could develop a cap for the cup to create a better seal around the rim, so all the CO<sub>2</sub> has to come out of the holes. I could also use a better hole-making tool, to make them

perfectly round and all have the exact same diameter. Overall, I am very happy with the result of this image.