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Flow Visualization MCEN 4228

The purpose of the image was to explore the type of visuals that can be captured by physically manipulating the fluid flow from a high pressure public fountain. The original intent was to capture an image of the flow of water at its peak where it transitions from turbulent to laminar and back to turbulent. The phenomenon occurs when a burst of water reaches its peak and before descent is pushed out of the way by the burst behind it which causes the now laminar flow to mushroom away from the source.

In order to create the image I went to the local fountains at the Westminster Promenade. Since the flow source was pre-existing, the only difficult portions involved isolating the flow from the other fountains to photograph the phenomenon. Figure 1 shows the setup which consisted of having a black backdrop behind the fountain. The water burst was created by covering the flow with my shoe allowing only the amount that I wanted through.

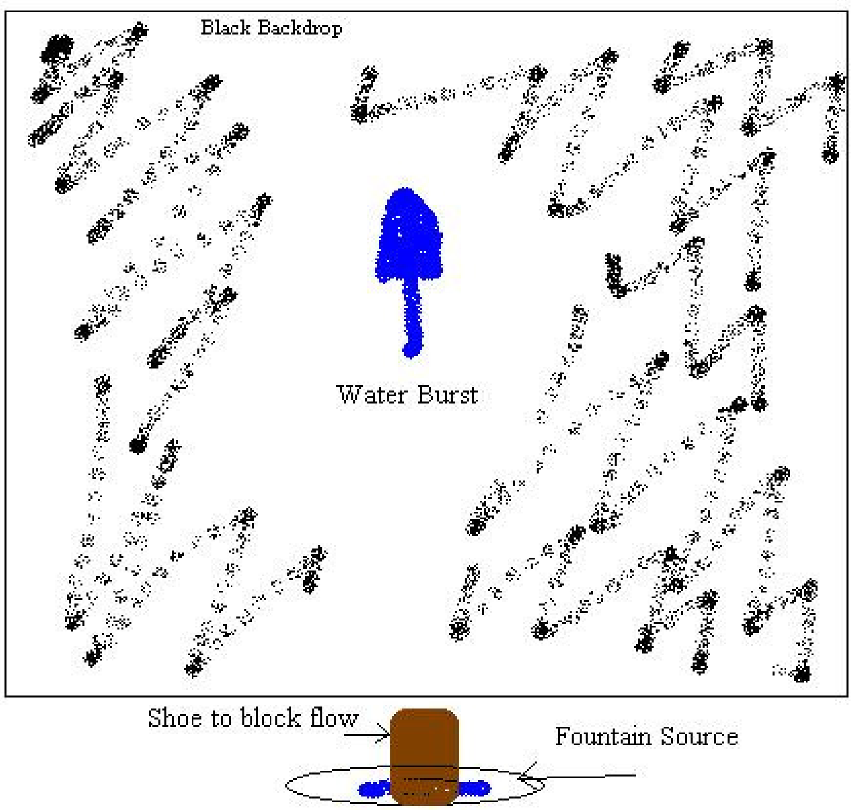

Figure 1

The flow is created by the beginning of the burst stopping at the peak and being forced from the center by the flow behind it. The full "bell" of water fills approximately 1 cubic foot of space. To calculate the Reynolds number of the flow the following values were used:

- Temperature of Water 60 F
- Density of Water 999.0 kg/m^3
- Dynamic Viscosity .0012 Pa-s
- Fluid Velocity .5 ft/s
- Characteristic Diameter .1 in / 2 in
- Fluid Density (T) 999 kg/m^3

The Reynolds number was calculated to be 322 in the film of fluid and 6450 at the end of the water burst. The flow is turbulent as it leaves the jet but transitions back to a laminar flow as it loses kinetic energy at its peak. This kinetic energy is lost in velocity, but potential energy is gained in height of the fluid. Once the flow has essentially stopped it is now laminar and stays laminar until it gains enough kinetic energy to become turbulent again. Yet, since the flow is being projected away from the stream its characteristic dimension becomes the thin film that flows from the stream. This allows for the flow to remain laminar much longer than in the stream and consequently the visible laminar flow is viewed prior to transitioning back to turbulent.

There were no specific lighting techniques used to capture the image. The one important factor was to capture the image during daylight hours, close to noon, to allow for the most natural light possible. The only visualization technique was to isolate the fountain being photographed from all the other fountains surrounding it. This was done by the using a backdrop behind the fountain.

The following information is provided to describe the photographic specifications:

- Size of the field of view- 2 feet high by 1 foot wide
- Distance from object to lens- 6 feet
- Focal Length and other specs- 23mm, Aperture priority, spot metering w/ Quantary UV Filter

The camera was a digital Nikon D40 and no tripod was used to take the photograph. The pixel size of the final photo is 1220 x 1816. The following exposure specifications are also provided to show the settings used in taking the photograph:

- Aperture f 5.0
- Shutter Speed 1/400th
- ISO 400

The photo used is not the original taken, but was processed through Adobe Photoshop. In order to finalize the picture it was first run through Noiseware. In Photoshop the picture was cropped, then defogged with an un-sharp mask, settings 14/40/0. It was then converted to black and white and the saturation levels were adjusted to make the backdrop darker.

The image shows how a fluid can make a visible transition from turbulent to laminar flow. We usually only hear about transitions from laminar to turbulent, so I like that this is different. I dislike that the picture is over-exposed at the very top of the bell, but I like how crisp and clear the water is in the photo. It may not be completely obvious, but you can see the initial jet inside at the top of the bell still flowing upwards. This shows that the flow was created from a turbulent jet, and the bell surrounding it clearly shows its now laminar flow. I would like to explore this idea with some more controllable turbulent jets, but the fact that the photograph was created at a public fountain makes it more unique.

References:

1. Efunda Reynolds Calculator: http://www.efunda.com/formulae/fluids/calc_reynolds.cfm#calc
2. Engineering Tool Box: http://www.engineeringtoolbox.com/dynamic-viscosity-d_571.html