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MCEN 4228 – Flow Visualization
Group Project 2: Group Alpha

Water Wall

This was the submission for the third group project for Group Alpha; however this image was another solo project on my part. The purpose of this image was to capture the interesting effect produced by falling water on a vertical wire screen. The display where the picture was taken can be found in the lobby of the Engineering Center at the University of Colorado at Boulder. Although I am not aware as to its purpose in the Engineering Center (signage says it is an experiment, but it looks like a decorative, indoor fountain), the flowing water is quite beautiful as it flows irregularly down the screen wall. I did not know what kind of image I would be able to capture though, as what I saw with the naked eye did not seem to correlate to what the camera would capture. It was a challenge with the camera to focus in on the flowing water rather than the screen. The final image is looking directly up at the oncoming flow as it falls down the screen.

The flow apparatus is quite simple in principle, although I have no idea how it was made or how it works. It appears to be an 8x3 foot black wire screen built within a metal frame. There is most likely a reservoir at the bottom containing water and a pump that propels water up along the sides and out on the top of the frame. The water is then left to fall down the screen by gravity. A schematic of the apparatus and camera placement can be seen below in Figure 1. By all best estimates it took the water 1-2 seconds to fall from top to bottom as the screen provides considerable resistance to the flow. Using the kinematics equation [2]:

$$\Delta h = v_2 t - 0.5 g t^2$$

With $t = 1.5s$ the final velocity of the water can be estimated as

$$v_2 = \frac{8ft + 0.5\left(32.2\frac{ft}{s}\right)(1.5s)^2}{1.5s} = 29.5\frac{ft}{s}$$

The Reynolds Number can then be calculated from the following:

$$\mathrm{Re} = \frac{\rho \vec{v} L}{\mu}$$

For water at room temperature (70 degrees F) $\rho = 62.30 \frac{lb}{ft^3}$ and $\mu = 6.556 \times 10^{-4} \frac{lb}{ft \cdot s}$

The Reynolds number is calculated to be

$$\text{Re} = \frac{\left(62.30 \frac{lb}{ft^3}\right)\left(29.5 \frac{ft}{s}\right)(8\,ft)}{6.556 \times 10^{-4} \frac{lb}{ft \cdot s}} = 22.5 \times 10^6$$

Reynolds Number greater than 10,000 indicates a turbulent flow [2]. Turbulent flow over the screen is most likely what causes the water to flow in such an interesting, erratic manner instead of simply falling straight down.

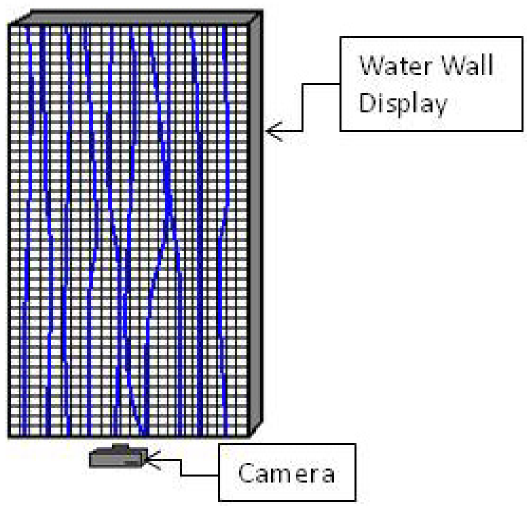

Figure 1

The visualization technique was to simply observe the peculiar nature of the flowing water as it grouped together and traveled down odd/random paths. The right capture of light off the water and screen better helped emphasize the phenomenon. The *water wall* was located indoors directly in front of a large window. The lighting was predominantly from the fluorescent bulbs in the building with a small amount of natural light shining through the rear. The flash on the camera was not used in order to avoid glare off the water. The lighting was effective in capturing the phenomenon, however the inclusion of larger lights aimed directly at the apparatus could have potentially better highlighted it.

The camera was positioned approximately 1-2 inches from the wall's surface and angled almost 80 degrees above the horizontal directly at the oncoming flow. The cameras specs for the image are given below.

- Camera Type: Olympus FE-340, 8.0 megapixel, 5x optical zoom
- Lens: AF ZOOM 6.3 – 31.5mm, 1:3.5-5.6 in a Macro setting
- Field of View: Approx 12 inches wide x 30 inches tall
- Shutter Speed: 1/400 sec
- Focal length: 7.7 mm
- F stop: f/4.0
- Aperture: 3.5 mm
- ISO: 64
- Resolution: from camera = 72 x 72, final image = 12059 x 9044 pixels
- No Flash
- No Zoom

A few Photoshop processes were used to produce the final image, though they are very slight. The curves adjustment was used to better enhance the contrast, and the calculations function was used to emphasize the grey scale. I feel the final image has nice color and texture. Care was taken to avoid any color or feature washout.

The final image reveals a very nice sampling of water flowing down the screen. Both the screen and water can be seen clearly. Water can be seen grouped on both sides of the screen which I particularly like because that is one of the aspects that causes the overall *water wall* to be so eye-catching. The way light strikes the image is both positive and negative I feel. It creates a lovely contrast and helps emphasize the water on the screen, but it also sort of feels skewed and haphazardly placed. Also, the image is nice and reasonably focused, but at first glance it is confusing as to just what you are looking at. It does not bother me, but I'll leave that matter to the observers. Altogether I do not necessarily feel that it was my finest submission of the semester, yet I feel that it is still interesting and of a style that I enjoy.

Reference:

[1] "Kinematics Equations for Linear Motion" Retrieved 28 April 2009. http://math-wizard.com/kinemeqs.pdf

[2] Smits, Alexander J. *A Physical Introduction to Fluid Mechanics*. Princeton University Department of Mechanical Engineering. John Wiley & Sons, 2000.