

Live Laugh S'more

The fluidity of flames is quite captivating and their bright, stark contrast against any background makes for an easy focal point in any picture. I wanted to capture the brilliance of a bright flame against the dark background of the night, and it happened to be a windy night, blowing the flame almost completely flat. This flame was produced from my fireplace on my back porch, and as I was walking around to get a better angle, the flame spiraled upwards from its horizontal position. I wanted to capture the effect that a well placed blockade and rolling winds would create –vortices. The fluid of interest is of course air in this case but the flame illuminates the pattern that is created –almost like a dye in smoke.



Figure 1: Rotating flame on a fireplace.

Vortices are usually created from turbulent flow, and in this case the air coming around the towel is rolling away from the leading edge of the towel (63"x31") and taking the fire with it. This is best represented by Figure 2, where the flow around the sharp edge of the square turns turbulent.

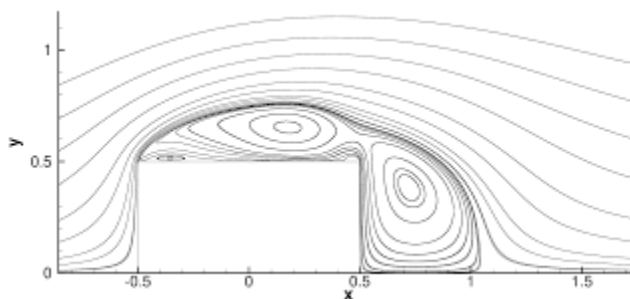


Figure 2: Streamlines around a square/sharp edge [1].

To estimate the turbulence of the flow as few approximations are made: the wind speed was moderate, so around 5mph (2.2m/s), the height of the flame was around 2ft (0.609m), and the dynamic viscosity and density are taken as nominal at $1.81 \times 10^{-5} \frac{kg}{m-s}$ and $1.2 \frac{kg}{m^3}$ respectively.

The Reynolds Number, is a measure of the turbulence and as seen from:

$$Re = \frac{\rho v l}{\mu} = \frac{(1.2 \frac{kg}{m^3})(2.2 \frac{m}{s})(0.609m)}{1.81 \times 10^{-5} \frac{kg}{m-s}} = 88,826,$$

it is well above 10,000 (limit for laminar flow). This large Reynolds Number also indicates a large vortex –which is apparent given the size of the flame.

As mentioned before, to visualize the vortex from blocking the wind strategically, a flame produced from natural gas was used similarly to how smoke is used to highlight streamlines in smoke. The flame will follow the wind as it lifts and spirals vertically and illuminates the path.

To see the flame most naturally, and to do as little post-processing as possible, this was shot on a cloudless night, well after sun set. My back porch also has a significant amount of reflective surfaces (i.e. a wall of floor-to-ceiling windows, fire extinguisher casing, and stainless steel grill), so I focused more on getting the flame away from reflective surfaces and took the picture in a full 3:2 aspect ratio. The only post processing that was done was cropping out the surroundings.

Since I was the one taking the photos and moving around the flame at picture height did not produce the same effect, my mom held a large beach towel up and down quickly to block the wind. Up close shots –about 1 ft away from the flame– of the base of the flame twisting did not give the full effect of the spiral, so I moved my lens back to about 3 ft. I also wanted a subtle nod to the source of the flame, so it was immediately obvious how it was produced, and left the slight reflection of the fireplace stone in view.

This session was shot on my Canon EOS Rebel SL2 with the 18mm-55mm lens. This photo clearly has no flash, and the shutter speed and exposure were adjusted for the bright image of the flame. There was a definite sweet spot with the settings, as flames produce so much light it can easily overexpose the image, and the final settings I settled on were 23mm focal length, f/5.6, 1/640s, ISO 800, and EXP -2.7. The full image was 6000x4000 pixels and the cropped, final image came out to 3644x2656 pixels. Keeping the ISO and shutter speed in this low-to-mid range did not allow for as many light particles to be captured and so the trade off with this camera is that the definition will not be as clear, but the background can almost completely disappear.

I think this image captures the effect of the “experiment” I was hoping for initially, however, I do not believe that it is the crispest image that can be produced by this camera. This camera does better in bright light and focuses on large and small objects equally as nice, but it is perhaps because this camera is not as “nice” that it didn’t capture the background at all and produced the high contrast. The flame itself is so opaque compared to real life that it almost looks like a fluid itself.

I also think that since we are so used to brilliant flame pictures that we have become desensitized to their movement and that my photo does not immediately convey the physics at hand. It seems, even to me, that it is easy to disregard the twist of the flame at first glance. However, after discussion and understanding the purpose behind the image, I think it is very clear to see the spiral in the flame and how it is a product of the wind itself. In this regard I do believe that I accomplished my goal in visualizing this effect –even if I have some reservations about how an uninformed audience might perceive this.

Next steps for this photo process would be to either get a better camera or more realistically play with focal length and exposure settings. I would like to improve the transparency through the flame so it is less opaque and more similar to a flame you would see with your eyes. I think the major sticking point I have with accomplishing this is: what more could I adjust with my settings given the quality limitations of my camera? This might come down to needing more experience with cameras in general, but I would rather capture a photo more naturally than use post-processing techniques for something so simple.

Sources:

- [1] *Turbulent Flow around a Square Cylinder at Reynolds Number ...* - Core, core.ac.uk/download/pdf/41829261.pdf. Accessed 26 Sept. 2023.