Getting Wet

Flow Visualization Spring 2012

Gasoline On A Mirror

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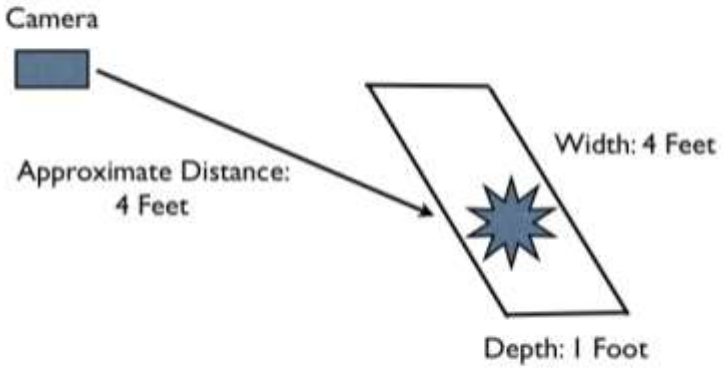
Gasoline On A Mirror

It was a Sunday morning and the snow was still falling. It was light out and the sky was grey. I could see from my window that the snow on the shed must have been a foot deep already. The biggest snow of the winter thus far had just hit Boulder and I wanted to incorporate the feeling into my flow visualization. So far I had tried to think of something that could capture the snow fall in a way that would be original and interesting, but couldn't come up with anything. As I toyed with the idea I wandered around my shed outback, camera in hand, and took a few shots to get the feel for the light. That's when I saw the gas can in the corner and got excited. A bright orange flame would be a great study for this class. I very much like the idea of putting fire and ice together. I asked myself if gasoline would burn on snow, and considering to be a certainty I set to work. It certainly was fun to watch but the contrast just wasn't there for a good image. To enhance the lighting I grabbed a mirror from the corner that had gone unused for a while. That's



when I got the idea to burn gasoline on the mirror. The mirror went into the snow and the flame was lit.

The main attraction in terms of flow here is the soot from the combustion of gasoline in the presence of oxygen. The adiabatic combustion is described as such:

$$\mathbf{2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O}$$

However, octane cannot burn adiabatically in air, because adiabatic assumes no losses to the surroundings. Given that there are losses and and the flame's ingredients are diffusion mixed,

there are unburned hydrocarbons that result. This means that the flame seen is in a rich state. This is achieved in this photo with undiluted gasoline. The unburned hydrocarbons make up what is visible as they give off blackbody radiation when they are hot. Unfortunately there is no way to tell the flame temperature just from its color in these conditions, but the bottom of the flame can be estimated to be 900 degreed Celsius [1]. This is the continuous flame region just above the combustion. Above the continuous flame region is the intermittent flame region. I really enjoyed capturing this image because of the small bird-like plume that appears, detached from the main radiation area. This shows how unstable the intermittent flame region can be. Here temperatures continue to decrease to about 320 degrees Celsius. Gasoline will burn in our atmosphere at a fairly narrow range of 1.4% to 7.6% gasoline by volume [2]. Unfortunately I feel there isn't much data available here to calculate the time resolution or the reynolds number of the flow here. This isn't usually a barrier to combustion, however, as gasoline vapor spreads and mixes very easily.

To really visualize all that was going on in this combustion process I wanted the gas to burn in a way that would show all the components of the mixture. The mirror does this perfectly. With the diffuse natural light, one can see the way the gasoline still in its liquid for spreads across the mirror. Also, through reflection, I feel the mirror highlights the mixing and combustion area of the flame. The snow also provides some warmth, reflecting the radiation from the flame, and highlights the orange colors. See sketch below for approximate dimensions.

Figure 1: Proportions

As the mirror fills the frame from side to side, the field of view for the picture must be about 4 feet wide by about 5 feet long. From this angle I was able to capture the entire height of the flame in the mirror, and provide some contrast in the mirror with the reflection from the trees overhead. The flame is about 4 feet from the lens, as I was standing in the doorway to my shed to protect my camera from the falling snow. For this shot I used a focal length of 18mm, and ISO of 1250, and an aperture of f/22. The shutter speed was set to 1/200 to give the flame just a bit more emotion instead of being frozen. I used my Nikon D70 with an ability of 6.1 MP. The original image was 3008x2000 pixels, but I cropped it to 2982x1191 pixels. Besides the crop I enhanced the contrast a bit, and brought out the blacks.

I like this image because it has a feeling of progression from one side of the mirror to the other. I like that it has a weight that is shifted to the right side of the image. I feel like this image

shows very well the transition of the gasoline liquid to vapor, and then combustion. It also includes elements the elements of flame plumes that show their transitory nature, and highlight the movement of the hot gasses. I fulfilled my intent with this picture, but I wish I would have used a lower ISO for less grain. Also, after looking at the original image I wish I would have done less post processing to retain the original delicacy of the flame. If I were to develop this idea further perhaps I would investigate a flame tube or different fuels.

Appendix

Sources

1) http://www.doctorfire.com/flametmp.html

2) http://www.engineeringtoolbox.com/explosive-concentration-limits-d_423.html

Original Image

Image Assessment Form
Flow Visualization
Spring 2010

Mitchell Stubbs

Assignment: Date:

Scale: +, ! = excellent = meets expectations; good. ~ = Ok, could be better. X = needs work.
NA = not applicable

Art	Your assessment	Comments
Intent was realized	!	
Effective	!	
Impact	!	
Interesting	Check	
Beautiful	!	
Dramatic	!	
Feel/texture	Check	
No distracting elements	Check	Cropping
Framing/cropping enhances image	!	

Flow	Your assessment	Comments
Clearly illustrates phenomena	!	
Flow is understandable	!	
Physics revealed	Check	
Details visible	~	
Flow is reproducible	!	
Flow is controlled	Check	
Creative flow or technique	~	
Publishable quality	~	

Photographic technique	Your assessment	Comments
Exposure: highlights detailed	Check	
Exposure: shadows detailed	~	
Full contrast range	~	
Focus	Check	
Depth of field	Check	
Time resolved	~	

Spatially resolved	Check	
Clean, no spots	Check	

Report		Your assessment	Comments
Describes intent	Artistic	!	
	Scientific	Check	
Describes fluid phenomena		Check	
Estimates appropriate scales	Reynolds number etc.	~	
Calculation of time resolution etc.	How far did flow move during exposure?	~	
References:	Web level	!	
	Refereed journal level	~	
Clearly written		~	
Information is organized		~	
Good spelling and grammar		~	
Professional language (publishable)		~	
Provides information needed for reproducing flow	Fluid data, flow rates	Check	
	geometry	!	
	timing	!	
Provides information needed for reproducing vis technique	Method	!	
	dilution	Check	
	injection speed	~	
	settings	!	
lighting type	(strobe/tungsten, watts, number)	~	
	light position, distance	~	
Provides information for reproducing image	Camera type and model	!	
	Camera-subject distance	!	
	Field of view	!	
	Focal length	!	
	aperture	!	
	shutter speed	!	
	film type and speed or ISO setting	!	
	# pixels (width X ht)	!	

	Photoshop techniques	Check	
	Print details	Check	
	"before" Photoshop image	Check	