“Get Wet” Project Report

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Introduction

The objective for the first “Get Wet” project is to capture artistic characteristics and physics of fluid flow. This image presented itself when I was cooking stir-fry for dinner and noticed that the condensing water on the top of the cover developed into a beautiful mosaic of color, swirls, and blurred portions. I felt that this image captured my intent of showing the unknown beauty in a natural phenomenon. I chose this specific image to submit from my collection because the effect of coalescence is clearly shown along the perimeter of the large droplet being formed.

Setup

To setup this image I used a stir-fry pan (wok) to steam carrots, broccoli, peas, and green peppers and placed a glass cover on top. The wok has an eight inch diameter flat bottom with curved sides that are 5.5 inches in height. The curved glass cover has a center height of 1.5 inches and a diameter of 12.5 inches. The camera was placed approximately ¾ of an inch away from the top surface of the cover at about a 30° angle from imaginary perpendicular line to the cover that extends from the center of the image. The setup is shown in Figure 1 below.

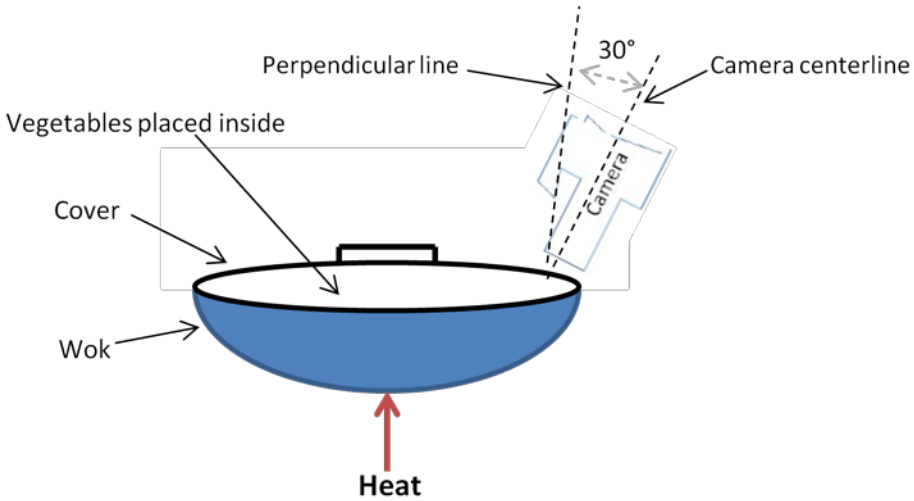

Figure 1: Setup and apparatus for the photograph

Background

The science that is happening in this image is dominated by surface tension and the coalescence of condensation. As the wok is heated, it causes steam to form and the steam-air mixture proceeds to increase in temperature. The cover remains at a lower temperature from heat losses to the environment. When the steam-air mixture is hot and the cover is below the dew temperature, condensation begins to form on the bottom side of the cover [1]. The small droplets that form are held to the cover along their contact line, a three-phase boundary, due to the surface tension of the droplet that causes a lateral force of water molecules at the liquid-gas boundary [2]. As more condensation occurs the water droplets grow and their contact lines begin to merge causing them to coalesce. The droplets eventually become large enough for gravity to overcome the surface tension effects causing the droplet to run down along the inside of the cover [1]. The droplets create a lens effect causing the vegetables below to be magnified and distorted. Since this picture was taken before the drops have enough weight to run, this flow is moving extremely slow, leading to a very small Reynolds number where surface tension effects of the droplets dominate.

Visualization Technique

The image was taken in an indoor environment with an ambient air temperature of 72°F. Vegetables were placed inside the wok and heated by a stove at medium heat. As the wok was heated, water began to condense and coalesce on the cover. Immediately after the coalescence began this shot was taken of one of the first droplets that began to form to about a 0.1 inch diameter. The flow is basically at a standstill and has only traveled a distance on the order of microns during the exposure. A built-in camera flash was used to provide sufficient light. The flash on the camera was about 5 inches from the object, but the camera had to be tilted at about 30° from the normal to prevent distracting glare. The type of flash is not specified in the owner's manual or online, but is most likely a low wattage xenon flash that is used in most modern cameras at a typical duration of 1/1000 of a second [1].

Photographic Technique

This image was shot using a point-and shoot Sony DSC-H10 8.1MP camera. To get close enough the camera's macro mode was used at a distance from the lens of about 13/16 of an inch, which correlates to the minimum camera specification distance. The approximate field of view of 85° was determined using the camera's distance of 13/16 inch and the scale of 1.5 inches that was found by taking a similar photo with a ruler in it. It is calculated by equation 1 as [3],

$$FOV = \tan^{-1}\frac{Y}{X} * 2 = \tan^{-1}\frac{1.5/2}{13/16} * 2 = 85°. \quad (1)$$

Since the camera used to take this photo does not have a manual adjustment for shutter speed and it is not found in the file information, the exact value is unknown. The image stabilization of the camera was on, which would lead to a faster shutter speed estimated at around 1/75 of a second [4]. The photo was taken

with an ISO setting of 200, a focal length of 0.25 inches (6.3mm), and an aperture of 0.3 inches (0.79mm).

This image originally had a well balanced contrast from top to bottom and was balanced very evenly throughout the RGB color range when viewed using the curve option in Photoshop. Modifying the contrast to brighten up the bottom part of the image made the colors seemed unrealistic. The natural warming colors of the image provided a better feel and an easier reproduction of the image, so the contrast remained unchanged in the final version. The image had an original size of 2048x1536 pixels, but was cropped down to 1618x1536 pixels to remove excessive glare and out of focus portions from the sides of the photo along with providing symmetry. The top and bottom of the image were not cropped to provide a good range of vertical contrast and retain the fluid effects captured by the coalescence of the small droplets into a larger one. To reduce unsightly glare and remove an unwanted watermark from the large droplet, the stamp tool in Photoshop was used by covering up these spots with similar colors in nearby regions of the image. The original image had sufficient contrast and focus, but lacked symmetry. Enhancing the image in Photoshop fixed the symmetry issue and helped remove distraction potions that did not aid in capturing the flow phenomenon.

Conclusion

This image reveals the surface and coalescence effects that happen during condensation. These effects are shown by the formation of small droplets that hang from the cover and start to merge to form a larger droplet. My favorite part of this image is the artistic feel created by the mosaic of droplets distorting the vegetables below. I dislike that some portions of the picture had distracting glare, which I later edited in Photoshop, but it was impossible to eliminate it all from the final image. To setup this photo perfectly, I would acquire the necessary lighting that would help eliminate reflections and use a camera that has an adjustable aperture to increase the depth of field and bring more of the picture into focus. It would also be interesting to experiment with different objects under the cover to bring more color into the photo. I felt like this project accomplished for me what it was meant to, through it I became familiar with the settings in my camera and created a beautiful image that reveals artistic and scientific phenomena of the flow.

References

[1] Munson, Bruce, Donald Young, and Theodore Okiishi.Fundamentals of Fluid Mechanics. 5th ed. John Wiley & Sons, Inc., 2006. 24-27. Print.
[2] Qian, Tiezheng. "Molecular Hydrodynamics of the Moving Contact Line." SISSA. Italy, Trieste. May 2007. http://people.sissa.it/~desimone/Conferences/Presentations/Qian.pdf
[3] Jongerius, Jerry. Measuring Lens Field of View. PanoHelp, n.d. Web. 9 Feb 2011. <http://www.panohelp.com/lensfov.html>.
[4] Wikipedia contributors. "Flash (photography)." Wikipedia, The Free Encyclopedia. Wikipedia, The Free Encyclopedia, 31 Jan. 2011. Web. 9 Feb. 2011.

Image Assessment Form
Flow Visualization
Spring 2009

Name(s)

Assignment: Date:

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

Art	Your assessment	Comments
Intent was realized	!	Easy to see phenomena
Effective	√	
Impact	!	
Interesting	!	Could Stare at for a while
Beautiful	!	Colorful Mosaic
Dramatic	√	Droplet coalescing = Semi-dramatic
Feel/texture	!	Lots of texture in this image
No distracting elements	√	Little distracting glare
Framing/cropping enhances image	!	Makes it symmetrical

Flow	Your assessment	Comments
Clearly illustrates phenomena	!	
Flow is understandable	√	Might need initial description
Physics revealed	!	Show large droplet forming
Details visible	!	Sharp
Flow is reproducible	!	everyday event
Flow is controlled	√	all about timing
Creative flow or technique	!	Unrealized natural phenomenon
Publishable quality	!	Crisp, beautiful photo

Photographic technique	Your assessment	Comments
Exposure: highlights detailed	!	Really towards top
Exposure: shadows detailed	!	Pronounced at bottom
Full contrast range	!	
Focus	√	For the most part
Depth of field	√	Lack aperture adjustment
Time resolved	!	Little motion
Spatially resolved	√	
Clean, no spots	!	Edited out spots
OK, simple print	!	N/A
Mat	!	N/A
Mounting	!	N/A

Report		Your assessment	Comments
Describes intent	Artistic	!	Mosaic
	Scientific	!	Explains Natural Phenomena
Describes fluid phenomena		!	
Estimates appropriate scales	Reynolds number etc.	✓	Not many calculation needed for this flow
Calculation of time resolution etc.	How far did flow move during exposure?	!	Very minimal
References:	Web level	!	Investigated internet thoroughly
	Refereed journal level	✓	Hard to find applicable sources
Clearly written		!	Understandable
Information is organized		!	In order
Good spelling and grammar		!	
Professional language (publishable)		!	Precise wording
Provides information needed for reproducing flow	Fluid data, flow rates	!	Setup explained well
	geometry	!	
	timing	!	
Provides information needed for reproducing vis technique	Method	!	Explains when to take photo
	dilution	!	N/A
	injection speed	!	N/A
	settings	!	Not very many, but covers all
lighting type	(strobe/tungsten, watts, number)	✓	Unknown flash specs
	light position, distance	!	Gives angle / distance
Provides information for reproducing image	Camera type and model	!	
	Camera-subject distance	!	
	Field of view	!	Explain calculation
	Focal length	!	
	aperture	!	
	shutter speed	✓	Unknown
	film type and speed or ISO setting	!	
	# pixels (width X ht)	!	
	Photoshop techniques	!	
	Print details	!	
	"before" Photoshop image	!	