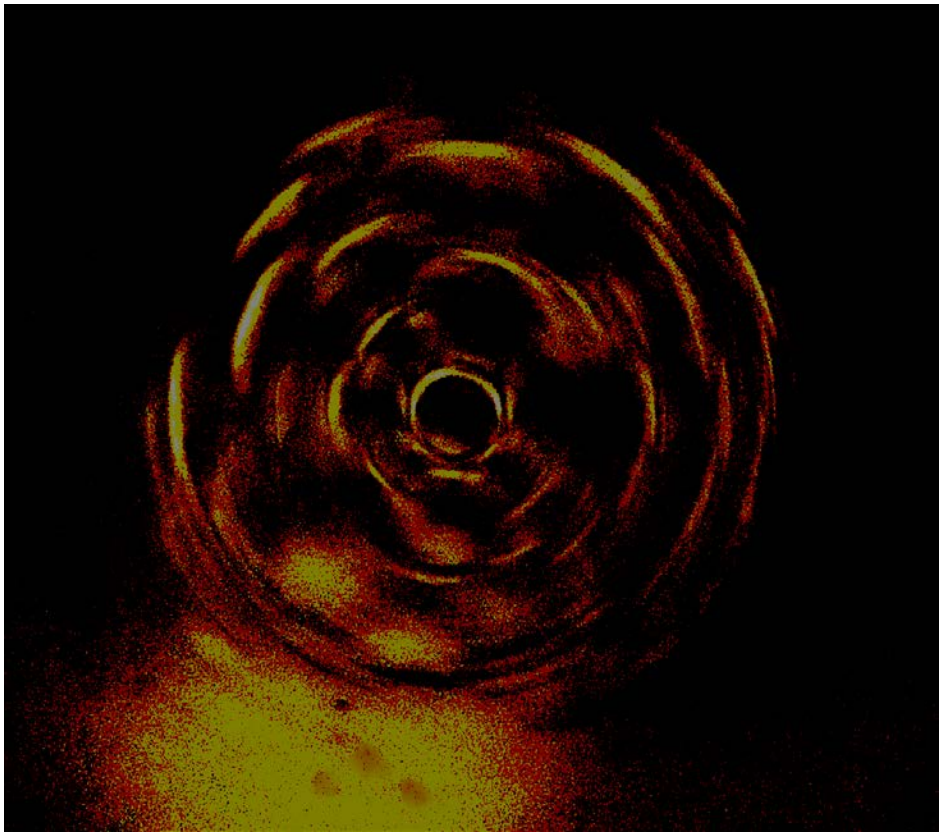
MCEN 4151
Flow Visualization

Instructor:
Jean Hertzberg

Andrew Locke

Assignment #6: Team Image



Introduction

The image above shows a container of water undergoing rotational inertia, and the effect this inertia has on the out-gassing air bubbles. The initial intent was to spin a container of fluid in a container, and then inject die into the resultant stream. I wanted to visualize vorticity in this setup. However, during experimentation, I noticed that air bubbles escaping the flow would stick to the surface, and I decided to image that instead. The image was captured on April 23, 2013. No other individuals were present in creating this setup.

Setup

I stood approximately four inches away from the effect. The motion blur was approximately one inch across, in a five inch diameter beaker. I gently shook the beaker in a circular motion, and no other apparatus was used. About 400 mL of distilled water was poured into the beaker, at ambient temperature and pressure.

The Physics

The physics here are quite simple; when an object spins, the tangential velocity at any given point can be given as a function of its distance from the center;

$$\upsilon = \omega r$$

where omega is the rotational velocity, measured in radians per second, and remains constant. Upsilon is the tangential velocity, in inches per second, and r is the distance from the point to the center of rotation, in inches. We can use these facts to estimate the rotational speed of the bubbles in the image.

For this analysis, I assume that the bubbles go through approximately 25 degrees of rotation in the shot.

$$degrees = \frac{Radians * 180}{\pi};$$

$$\frac{\pi * degrees}{180} = radians;$$

We plug in 25 for the degrees;

$$\frac{\pi * (25)}{180} = 0.436 radians;$$

We know the exposure time, 1/30s

0.436 radians traveled in 1/30 seconds = 0.436/(1/30) = 13.09 radians per second. We then use this to determine the tangential speed of the outer edge of bubbles:

$$\upsilon = \omega r = 13.09 * 1 inch = 13.09 \frac{inches}{second}$$

Technique and Post Processing

No special techniques were used. Several post processing techniques were used, most notably in large changes to the contrast. In doing this, the graininess texture arose. Normally, a high ISO value causes this effect, though an ISO of 250 would not explain the level of graininess shown. Additional editing softened a few bright patches as well. The unedited shot is shown below:

Camera Technique

FOV Approximately 4 inches
Distance from object to lens: 4 inches
Lens Focal Length: 5 mm
Digital camera: Canon EOS DIGITAL REBEL 4320 x 3240
F-stop: 2.8
Exposure time: 1/30s
ISO: 250
Aperature: 2.9727

Intent and Assessment

The originally desired effect was circumvented in favor of the spinning effect shown. In this regard, I am very happy with the quality of the image, and would not choose to change anything if I were to redo it. I have received some criticism for the grainy texture in the image, though I like it in the final image for aesthetic reasons.

References

http://en.wikipedia.org/wiki/Rotational_speed