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Flow Visualization
Team Assignment #3
Ferrofluid
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The intent of this image was to demonstrate the scientific and physical beauty of a standing wave via the use of a Rubens' Tube. In collaboration with Anna Gilgur, Jeremy Parsons, and Jonathan Fritts an approximately 8-foot long Rubens's Tube was used in conjunction with a waveform generator to create and capture standing wave flames.

Nineteenth century physicist Henrich Rubens is credited with being the first to physically demonstrate a standing wave using a flame tube[1]. A flame tube is characterized as a straight pipe with small holes evenly spaced along its length. The tube is sealed on both ends (with one end being enclosed by a speaker) and pumped full with a flammable gas. The gas can then be lit to form flames of uniform height. Standing waveforms can then be produced by using a waveform generator in conjunction with the attached loudspeaker[1]. The reason a standing waveform can be seen through the use of this tube has to do with constructive and destructive interference. As the sound wave is emitted from the loudspeaker on one end of the tube, it travels back and forth along the tube's length. As sound waves travelling one direction encounter sound waves travelling the opposite direction interference occurs. Peaks in the visible amplitude outside the tube are formed when constructive (two high pressure regions) intereference occurs. Troughs in the visible amplitude occur when destructive (high pressure encounters low pressure) interference occurs[2].

This photograph was taken on March 17th in a dark, indoor facility, with no noticeable draft. It should be noted that proper safety precautions were taken due to the flammable materials being used. For example, the Rubens' Tube was water-cooled and safety glasses were in constant use.

The image was captured using a Canon EOS Digital Rebel XS with a 49mm focal length and no filter installed. The image was shot at a shutter speed of 1/80s with an aperture of f/8 at an ISO of 200 with no flash utlized. It should be noted that flames do not always have sharp edges, and can be somewhat difficult to focus on, hence the soft flame edges present in the image. The original image was 3888 x 2592 with the final image being cropped to 3459 x 2229. Other than croping, no further enhancements were made to the original image. The camera used saves image files with a .jpg extension and the edited image was saved as a .tif to avoid further compression. The before and after images can be seen below in figures 1 and 2 respectively.

Figure 1: Original

Image Figure 2: Edited Image

References

1. Butterfield, Anthony. "Rubens' Tube." *Rubens' Tube, Teaching Modules, University of Utah, Chemical Engineering*. University of Utah, 12 Jan. 2011. Web. 30 Apr. 2013. <http://www.che.utah.edu/community_and_outreach/modules/module.php>.
2. Weiner, Adam. "Ruben's Tube." *Popular Science*. Popular Science, 14 Jan. 2009. Web. 30 Apr. 2013. <http://www.popsci.com/scitech/article/2009-01/rubens-tube>.