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MCEN 4228 – Flow Visualization

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[PROJECT #3]

The Weissenberg Effect

Introduction

For this project, I decided to image the Wiessenberg effect with a synthetic polymer. This effect happens when a spinning rod is inserted into a liquid polymer and the polymer “climbs” up the spinning rod. This effect is named after Karl Weissenberg. This occurs because the polymer chains become tangled with each other instead of getting thrown away from the spinning rod like water they get drawn towards the rod. When the polymer chains wrap around the rod they are stretched in tension and it wants to reduce this tension by moving up the rod. Because there the diameter is much smaller in those areas, diameter is equal to the rod diameter including the polymers wrapped around the rod, the tension in the chains are relieved.[1]

Experimental Setup

To demonstrate the Wiessenberg effect the experiment was setup using a drill press. The entire setup composed of a drilled press, a smooth metal rod, a liquid synthetic polymer in a Petri dish, a felt backdrop, a fluorescent light source, a tripod, and two stands to hold up the backdrop, Figure1.

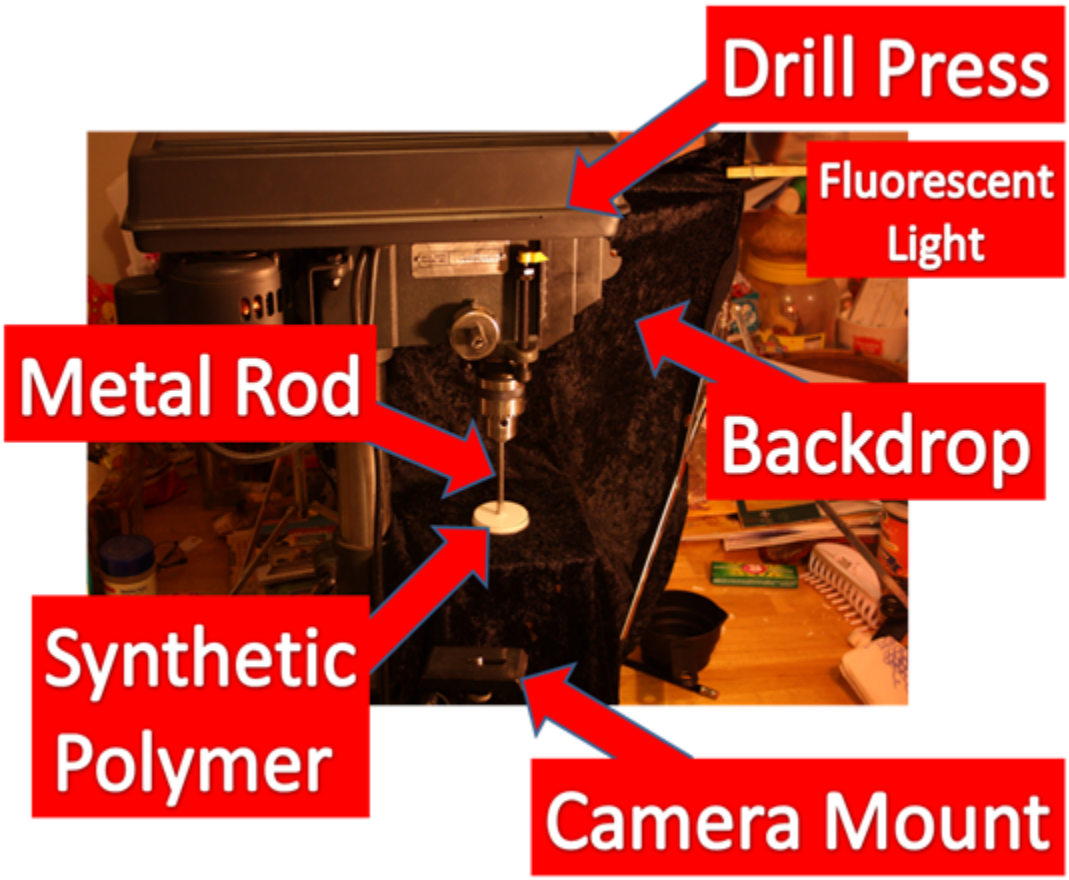

Figure 1: Photo Shoot Setup

The only two variables in this experiment are the drill speed and the type of synthetic polymer. The slower the drill speed the better, so it was set at 600 rpm which is the slowest speed that can be attained by the drill press. The polymer was created by the use of Elmer's™ glue as the long polymer chains and a sodium tetraborate solution, made with Borax™, as cross-linkers. The liquid polymer was placed in the Petri dish and the spinning rod was placed into solution to create this phenomenon. The distance the polymer "climbs" up the rod is highly dependent on the amount of cross-linking in the polymer. I personally chose the drill press because it was much easier to focus on the capturing the image because I did not have to worry about the spinning rod moving around like it was done by a hand drill like other experiments. This was the most optimal when trying to image this phenomenon.

Visualization Technique

The synthetic polymer was created using Elmer's™ White Glue and Borax™ detergent. One tablespoon of Borax™ was mixed with 2 ¼ cups of water to create a solution[2]. The Borax™ solution acts as the cross-linker between the glue molecules which are the long polymer chains.

The synthetic polymer created from this mixture can be varied from fairly rigid to fairly soft depending on the ratio of glue and the Borax™ solution. The more solution to glue ratio the more rigid the polymer because the polymer are more cross-links within the bulk. For this specific experiment, a ratio of 3:1 of glue and Borax™ solution was used to create the synthetic polymer. There was no flashed used when taking this image because of the possible glare from the small Petri dish and the metallic rod therefore a florescent light was used instead. A black felt material was used as the backdrop material so the white polymer could stand out.

Photographic Technique

The image was taken using a 12.2 mega pixel Canon Rebel XSi digital single-lens reflex (DLSR) camera. An 18-55mm image stabilizing lens with was mounted on camera. The distance that the object was away from the lens is approximately 4 inches from the center of the metal rod and the focal length of the lens was 49mm. The size of the original and final image is 4272 x 2848 pixels; the original image was shot in RAW format and converted to a TIFF for the final image. The aperture, shutter speed, and ISO setting was F6.3, 1/13 second, and 800, respectively. No Photoshop processing was done to the image.

Conclusion

Personally, I like the image because I like the color contrast and the effect it visualizes. The part of the image I dislike is the motion blur of the spinning metallic rod and some of the polymer in motion but this cannot be avoided because of the speed of the rod could not be lowered, this was the lowest speed possible for the drill press. The over all, I felt like this image demonstrated the Weissenberg effect very well and the image came out pretty fairly clean.

References

1. “Weissenberg Effect.” < http://en.wikipedia.org/wiki/Weissenberg_effect>

2. “Choose Your Ooze.” Chemistry in the K-8 Classroom. OMSI, 2007. < http://www.omsi.info/teachers/ChooseYourOoze.pdf>