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Team Second Report

The purpose of the team second image/video is to continue the work of capturing artistic fluid flow but hopefully in a more advanced manner as students understand the capabilities of their team. Originally, our team was planning on creating a fluidized bed with sand and air as the fluid. The beds are fascinating because with the correct air to solid material ratio, it can appear as though the solid is a liquid. Unfortunately, we did not have the correct ratio of fluid to sand as well as not enough pressure to maintain a constant pressure across our tube. On the other hand, the air coming from the tube pushed against the sand to make mesmerizing vortexes and small sand geysers, which is what our team decided to switch to photographing. In the end, our team was excited with our final product and capturing air movement rather than water since the sand outlined the shape of the air escaping to the surface. The two images above are screenshots from my final video, which incorporates footage from the swirling vortexes and the sand geysers. The experimental process was constructed mostly by Sam Brown, and the remainder of the team assisted in further construction and photography (Meg Ivy, Dawood Ahmad, and Faisal Alismail).

Bubble physics is a complex and heavily studied area in engineering. While bubbles seem relatively straight forward, their infinitesimally thin layers and ability to take the form of their surrounding shapes require both theoretical and experimental studies to accurately depict the phenomenon. The transfer of air bubbles has also been extremely helpful in various scientific applications such as air sparging, bioslurping, trench aeration, and VOC removal [2]. Air transport through a granular media such as sand is formed either through discrete air channels or discrete air bubbles [1]. In our experiment, we are working with channel flow since the granular spacing is less than 1-2 mm, so we can treat pressure as uniform throughout the experiment [1].

Estimating the rise velocity is out of the scope of knowledge within this class and other grad classes, therefore a literature review is used to develop equations (no quantitative values can be provided as there is no intuitive way to estimate the partial derivative of velocity with respect to time). The equation below represents the force balance on the x-direction, which is just mass times acceleration. The values inside the parenthesis is acceleration as a function of time and position, where the mass is represented by volume times density.

$$\sum F_x = \frac{4}{3}\pi {R_b}^3 \rho_g \left(\frac{du_b}{dt} + u_b \frac{du_b}{dx}\right)$$

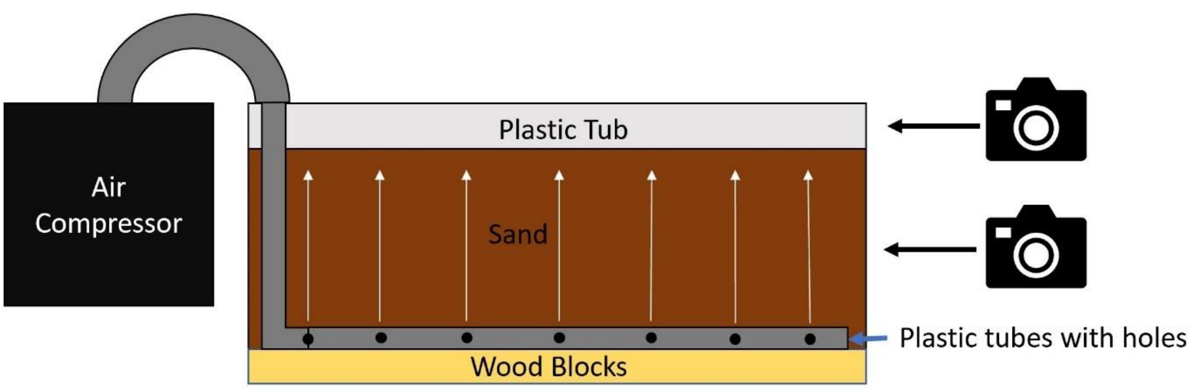
While there exists a term for the radius of the bubble, it becomes an average radius as the bubble stretches and squeezes its way through the porous medium [1].

In addition, another equation that is less familiar is utilized in Corapcioglu et al stemming from a modified Ergun equation, in which viscous energy losses are expressed through laminar flow and kinetic energy losses are expressed by the Burke-Plummer equation [1].

$$F_d = A\left[\frac{150\mu_b u_b}{d_p^2}\frac{(1-n)^2}{n^3} + \frac{1.75\rho_g u_b^2}{d_p}\frac{(1-n)}{n^3}\right]\frac{4}{3}\pi R_b^3$$

The Ergun equation represents the combination of drag forces and momentum transfer between phases due to kinetics. The equation above was generated empirically rather than mathematically due to the complexity and variation of air bubbles [1].

The setup for the experiment was intensive since it was originally used to create the fluidized bed. The team acquired a plastic, clear container (18” x 8” x 8”), approximately 30 lbs of sand, 4 feet of plastic tubing, and an air compressor. Using a teammate’s drill press, we first drilled holes in the plastic tubing with a 1/16” drill bit spaced 3 inches apart. By drilling through the tube, we then created two equally spaced areas for the compressed air to escape. To stabilize the tube, we tapped the tubing to blocks of wood and lowered it into the plastic container. During taping, we were careful not to block any of the drilled holes. After ensuring the wood and tubing were secured to the bottom of the container, we poured 30 lbs of sand over the experiment. With the experiment set up, we attached one end of the tube to an air compressor charged at 40 psi and allowed air to flow through for roughly 15 seconds. The camera (Nikon 3300) was placed approximately 3 inches from the container. Below is a visual of the final experimental set up.



The experiment was completed in a garage, as it was easier to clean after sand had escaped from the plastic container. The light in the experiment was only a garage overhead light, although the lack of light in the video, I believe, did not have much affect on the quality of the image since I darkened the original in post processing. The camera was situated a 3” inches from the container and from the sand geysers to find the optimal focus and capture the full effect of the fluid flow. The focal length was 20 mm, aperture f/3.8, ISO 800, 60 frames/second, and original/final size of 3840 x 2160 pixels as I did not crop the original video.

In post processing, I used a couple free video editing software from Microsoft. First, when my video was imported in Windows, I used the Movies and TV app to slow the video. I wanted to reduce the frame rate to clearly capture the air moving through the sand, but if I went overboard the video would look choppy. It turns out reducing the speed by 25% looked nearly natural. Both of the videos were reduced by 25% before being stitched together and adding music. The videos were trimmed to focus on interesting fluid flow and part of the decision to trim the videos depended on the growth of the music. Next, I moved to the Windows Video Editor application to add filters and music to my clips. As one of my lessons learned from this experiment, I would like to explore better options for video editing software. Within the video editing application, I added the Denim filter and title cards to introduce the project and music. I also added the music: Fading by Sappheiros. The music choice was determined by the changes in rhythm that could align with the footage. The images below show the video before post-processing.


Overall, I think our group did a great job working with what we had after our first experiment was not successful. Clearly, there are many lessons learned from this experiment and I would like to apply it to further projects. First, I would like to use another video editing software that could assist with editing music clips to match the speed of my video. I think in the end this was my greatest weakness with the assignment since the program I used was not nearly as robust as Photoshop. Luckily, I found some software recommended by classmates during my in-class critique that I will use for the next assignment. I would also like to use a tripod next time we attempt a video. It is not apparent in the screenshots I have in the report, but the video is a bit shaky at some points – something I tried to combat in editing by reducing the speed of the video. Other critique and recommendations are welcome and appreciated to improve my videography and post processing techniques.

References:

[1] Corapcioglu, M, et al. (2004). Rise velocity of an air bubble in porous media: Theoretical studies. *AGU100*, Vol 4(4). Retrieved from: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2003WR002618

[2] Roosevelt, E.S, et al. (1998) Air bubble migration in a granular porous medium: Experimental studies. *Water Resources Research*, Vol 34(5), pp 1131-1142. Retrieved from: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/98WR00371