DAVID GAGNE

FLOW VISUALIZATION MCEN 4151

THIRD IMAGE REPORT

Mechanical Engineering

UNIVERSITY OF COLORADO **BOULDER**

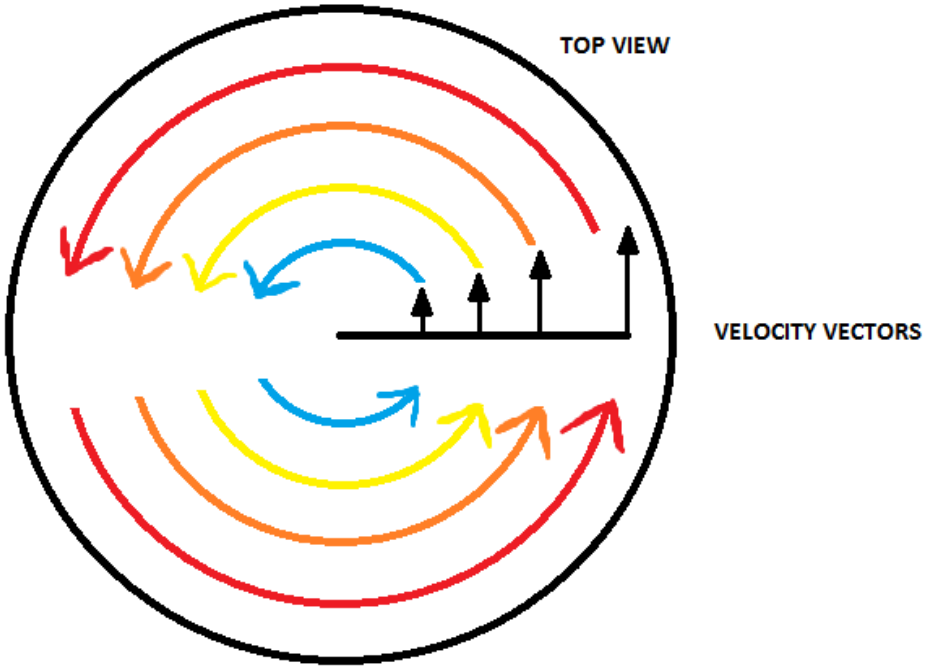
Team Image 3

Diffusion of Dye in Water

The film I created was first done inadvertently. I had initially desired to feature Bernoulli's principle and combination water atomizer, and to do this I had mixed blue dye into water in attempt to make the flow more visible. I had to do this several times, and every time I did I noticed an interesting mixing phenomenon that occurred in the cylindrical container. When the dye was dropped in, if the water in the glass had been "swirled", the dye would act in a manner that was very laminar. But if the speed of the water was increased only slightly, the dye displayed characteristics of turbulent flow. I was more curious about this event, and it also produced a more visually stimulating image. So I left Bernoulli until next time, and focused my attention on the mixing of dye and water. With the help of Dillon Thorse and Zachary Brunson, we were able to effectively capture the effect that I desired.

To visualize the flow we utilized a cylindrical glass beaker, tap water, and blue food dye/coloring. In order to get the diffusion desired, the water in the beaker was slowly stirred so that the water would be moving around the beaker. The image below shows how the water would be moving in the beaker as viewed from above. Though the water has the same radial speed, the instantaneous velocity at any point is different. The water at the edge of the glass has greater tangential velocity than the water towards the center. This creates an interesting environment where Reynolds number can vary describing a turbulent environment or a laminar one. The ideal scenario that is shown in the film has enough rotational speed where there is a

relatively low Reynolds number at the center and increasingly greater Reynolds towards the outside of the container. What is happening in the container is very hard if not impossible to see until dye is added, and once it is a beautiful show is put on. As the dye diffuses downwards in the beaker, at the center the water rotates the dye and spreads it in layers which remain structurally sound for some time rotating in the glass. This is indicative of the laminar region. But as the dye spreads outwards in the beaker, there are no sheets or layers formed, but instead just diffusion in flow that looks very turbulent.



The technique used to visualize the flow, in this case food dye, was the event itself. What it describes though is the border between turbulent and laminar flow for fluids like water. I found it interesting that the same fluid in one container could have distinctly different Reynolds numbers, different enough to put them in different flow regimes. To capture the image we used a start white background with overhead lighting. The camera used was a higher end point and shoot type camera which gave me the ability to shoot at 30 frames per second at 1080p HD.

For the photographic technique, I used, as stated, a simple P and S camera to film several videos in order to capture the phenomenon several times in order to choose from the one that displayed the flow most effectively. I was less than .5 meters away from the object when filming it, with a relatively small field of view.

I like the final image for what it shows, which is the laminar and turbulent characteristics of a fluid, and how diffusion and momentum transfer take place. To develop the film further, I would have like to change the hue as the flow diffuses, then change it back. This would only be to make the video more visually stimulating, but would not change the flow that is being visualized. It would also be interesting to do the project on a larger scale, maybe a liter sized beaker, or something the size of a 5 gallon pail. This would allow for the use of more dye, it would also be easier to see the boundary layer created between the laminar region and turbulent region. The turbulent region near the wall would also be much more turbulent, and it is possible that the laminar region would be “more laminar” in that the sheets created may last longer.