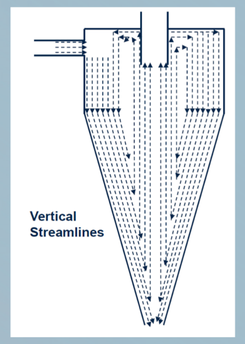
Classifying Cyclones and 3D Printing

Patrick Lui

Department of Energy and Mineral Engineering

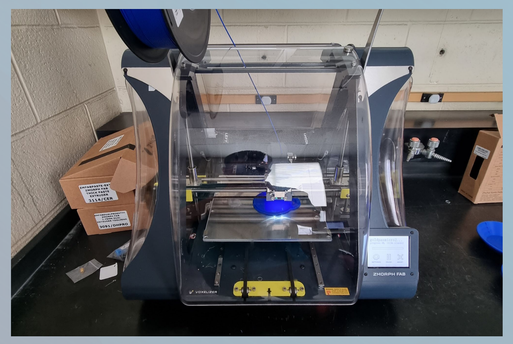
INTRODUCTION

Classifying cyclones are the most commonly used technology used for small particle size separation. A classifying cyclone is comprised of a cylindrical section feeding into a conical section. Due to the constricted apex of the cone, the flow going to the underflow stream is restricted, leading to a portion of the stream being forced back up. This upward movement carries the fine particles to the overflow stream. The problem is that this process is not very efficient. This is because the water recovered in the underflow stream contain ultrafine particles that should be in the overflow stream.



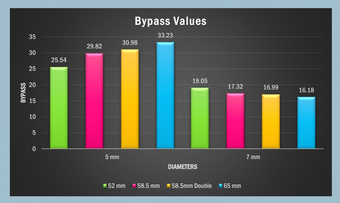
OBJECTIVES

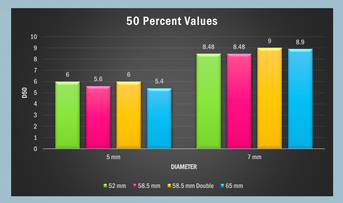
The main objective of this project was to use 3D printing to see if different parts could be printed to improve the efficiency of the performance of our classifying cyclone. I wanted to see if different length and inlet diameter vortex finders would yield better results. Other objectives included wanting to set up and get acquainted with our 3D printer, so we would be able to use it for further applications down the road. I also wanted to test out different materials to see how they behaved, and to see if we could use them for this project or for future projects.

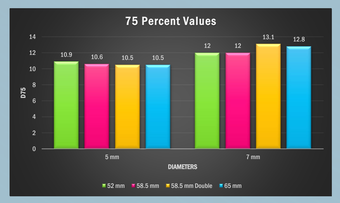


RESULTS

The bypass values for the 5mm inlet diameter vortex finders increased incrementally from 25.54% for the 52mm long vortex finder, all the way to 33.23% for the 65mm long vortex finder. For the 7mm inlet diameter vortex finders, the value decreased incrementally from 19.05% for the 52mm long vortex finder to 16.18 for the 65mm long vortex finder. The D50 (median particle size) for the samples ran through the 5mm inlet diameter vortex finders fell in the range of 5.5-6um. For the 7mm inlet diameter vortex finders, the values were around the range of 8.5-9um. The D75 (upper quartile particle size) for the samples ran through the 5mm inlet diameter vortex finders fell in the range of 10.5-11um. For the 7mm inlet diameter vortex finders, the values were around the range of 12-13um.







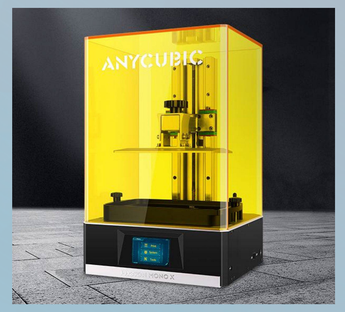
MATERIALS AND METHODS

For this project, I used a standard filament extruding 3D Printer. I tested with different materials ranging from standard PLA (Polylactic Acid) to flexible TPU (Thermoplastic polyurethane) all the way to Aluminum-Infused PLA. The TPU specifically, was used to make a converter, that will allow us to connect our cyclone to the system. After printing out multiple parts, Professor Arnold and I came to the conclusion that the quality of the prints were not adequate. For example, I noticed that with the vortex finder, there appeared to be beading, and there were small pieces of over-extruded plastic stuck inside the chamber. I also noticed that the accuracy of the parts were not up to par. Because of this, we decided to purchase a resin 3D printer, as they produce far more accurate prints. Once that printer was calibrated, I was able to print the parts as we desired.

CONCLUSIONS

After the extensive testing I have done, I have come to the conclusion the vortex finders with the larger inlet diameter yields better results than the ones with the smaller diameter. The amount of ultrafine particles carried to the underflow stream is far lower when we used the 7mm vortex finder as opposed to the 5mm vortex finder.

The length of the vortex finder on the other hand, did not seem to have as much of an impact. The only thing that it seemed to have an effect on was the bypass values. I have also come to the overall conclusion for parts like this, that resin printing is definitely the way to go, as it produces parts at a quality that regular filament printing simply can not achieve. Lastly, I came to the conclusion that the particle size analyzer that was used to analyze our samples might not have been the most accurate way to do it, as it did not do a very good job with the smaller particle sizes.



REFERENCES

"Amit 145: Lesson 2 classifying cyclones," *Mining Mill Operator Training*. [Online]. Available: https://millops.community.uaf.edu/amit-145/amit-145-lesson-2/#:~:text=An%20inherent%20inefficiency%20of%20classifying,referred%20as%20ultrafine%20by%2Dpass. [Accessed: 25-Jul-2022].

ACKNOWLEDGEMENTS

I would first like to thank Dr. Xinwei Niu from my native campus at Harrisburg for first introducing me to this program and telling me about it. I would also like to thank Dr Rachel Conaway for organizing this fantastic program and being willing to take somebody with a background in EE, with little to no experience in mining or minerals. A big thank you also goes to Multotec for being generous enough to share there part designs with us. This project would not be possible without them, Last but not least, I would like to thank Dr Barbara Arnold for taking me under her wing for the past couple of months. She taught me everything I needed to know about the industry, when all I knew about was the 3D printers. If it wasn't for her, this project would have been far more difficult for me to figure out.

PennState College of Earth and Mineral Sciences | John and Willie Leone Family Department of Energy and Mineral Engineering