Multi chamber air filtration system – MCAFS

by

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1. High level summary

Our filter consists of three separate chambers that increase in refinement. At first, the dirty air is spinning inside a centrifugal force chamber; The heavy particles fall into a waste bin. Secondarily, the air is blown through a water tank with a diaphragm pump, causing most filth to remain in the water. In the last and finest step, the air flows between polarized plates, so charged particles stick to them. Thus, the air is free of all unwanted particles and ready to be returned into the environment.

We combined cyclone, water, and electric filter technology to one new filter system.

2. How does the project address this challenge?

We developed a prototype air cleaner according to the challenge “Purify the Air Supply”. To protect oneself and all living beings from Covid-19, other viruses and diseases, clean and fresh air is crucial.

3. Development

Right after we decided to take on the “Purify the Air Supply”-Challenge we started talking about a chamber system, which attracts filth in the air with electric current. That was the decisive idea and our bottom line.

We searched around, brainstormed and had several ideas of which in the end we chose our three filter technologies to focus on. We ended up combining these, because these technologies themselves are very application specific, they don’t do a very good job, at filtering all particles out of the air alone. That is why we decided to combine them.

1. Electrostatic air filtration

When we initially had the idea of filtering air with electricity, we did not know much about the subject and started searching about the field in a broader way. After a while we found a Wikipedia article for industrial type applications of this technology. This also led us to the name of electrostatic precipitators and so to the consumer type devices, which gave us some ideas on how to maybe even build a working prototype.
And that is how we started: Some of our group went to the local electronics store and bought the necessary components to build a decent DC to AC converter which we needed in order to drive a flyback transformer, one of us had lying around from an old TV. We learned a lot about electronics in general, especially about high voltage electronics. After self-winding our own little transformer, to get a high enough voltage output, to produce a high enough voltage at the output of the flyback transformer. After trying some

things, and also some failed attempts, we got it working! Using 12V DC which were converted to about 100-300V AC, we drove our flyback transformer, which, using this voltage, was now able to produce about 2-3cm long arcs. The only problem left was, that we needed a high voltage DC power to actually ionize and then attract any particles. We therefore added a lot of diodes to one output of our setup, to convert the output to DC. We also created out own little high voltage capacitor using some plastic sheet and aluminum foil to make sure that our setup had a little buffer for better performance and to compensate us only using half a sign wave of our AC output. As seen on our short video, we then connected the output to a fine metal grid, which all the air had to pass through, as well as an old computer heatsink, we used as a collector, cause it featured a higher surface level, than just using normal aluminum foil.
This system is of course just a tiny proof on concept and not optimized or capable of large throughput at all, but we think even the accomplishment of getting a working prototype without much experience in this short amount of time, is a great success. We want to note, that while we met up in school, we weren’t able to test this device well, because of its not so large filtering capacity and the particle size limitations. This was apparently a big problem and is one of the main reasons, we came up with the other filtering technologies to try and clean up as much of any big particles and reduce the particle count in general, before passing everything over our electrostatic filter. To note, after our second meetup this Sunday, one of our group took the filter home and tested the filter with several types of smoke, especially the ones being created by soldering. We saw a bit of black buildup on some of the cooler plates, which showed us, that indeed our filter worked! There are definitely some things to consider when using such a filter, especially the possibility of ozone creation, which is not a bad thing if not forming in too large amounts and even helps killing all the bacteria and microbes passing through the system.

2. Water tank

Much like in an aquarium the air is blown through a tube on the bottom of the water tank and rises to the top. During that process, the heavy and unwanted particles merge with the water and leave cleaner air which again can be transferred to the next chamber. That theory was confirmed by the amount of dust (and later baking powder) we saw in the water. We had to exchange the dirty water manually with clean water. To optimize this, we had two more ideas. Either the water in the tank is hot enough to neutralize bacteria and viruses or we use algae/bacteria to purify the air even more. That would be an optimization realizable with more time.

3. Cyclone filter

One of the ideas, we stuck to, is to use the centrifugal force chamber. We were surprised, how good and efficient it worked. Several tests showed, that by only this filter, we could filter about 90% of the dust and dirt we threw into it. Due to us being a student group, we didn’t have access to high level testing stations to determine the number of aerosols left in the air in the system. We decided to simulate the pollution by using backing powder. The filter effect can be observed by the human eye. For the much smaller particles, we planned the water tank and finally the electrostatic air filtration. We build the cyclone filter by using a 3D-printer. The model we chose was already existing and we used thing 3966446 from thingiverse.com. We scaled it down by the factor of 4:1. This rather small version of the filter already worked very well for our filter system. This filter seemed perfect as a first stage to our system, because it filters larger particles well, but has problems collecting the smaller ones.

According to the circumstances of Corona, we worked with face masks and were connected with other team members through a video conference. With the beginning of the challenge we met up in school and developed our idea while facing many problems and things to discuss. How does the air supply on earth differ with the one on the ISS? How do we dispose the unwanted particles in space without creating dangerous space trash? What harmful particles are even in the air? Having done the theoretical planning, we worked from home, researching, and collecting useful materials for our build.
The next morning, we started to build the three chambers and tried many different materials to optimize our prototype and determine its efficiency.

We actually managed to get each station of its own working and to test each one alone. But we did not have the capabilities to make all of them work together. But this can be achieved with more time. In our video we show how the three filters combined should work.

We were very surprised about how productive we were in our first ever hackathon and are motivated to do it again!

4. Demonstration

We demonstrate our project in a video: https://youtu.be/cgpGRMXylo0

5. Code: No code was needed.

6. References

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7. Tags

#FreshAir #Covid-19 #InternationalSpaceStation #waterFilter #electronic #innovation #JAXA #spaceappschallenge #cnes #CSA #ASC #SpaceApps #COVID-19Challenge #PurifyTheAir #SpaceX
#studentsagainstcorona #willigisgegencorona #wefightcorona #NASA #ESA