Environmental Systems and Societies

Extended Essay

Topic

"Effects of air filters on air pollution"

Research Question

What is the effect of air filters on industrial companies on air pollution?

1.Introduction: The importance and the value of the nature is not really known well by the people. Humans don't understand that we are destroying something that we need in order to live a proper life. Without any human effects nature has its own balance in it. When humans are included the system started to lose its balance and the negative outcomes of this unbalanced system could be the biggest threat to the worlds ecosystem. For example there is a carbon cycle in the world, living organisms breath and release CO2 or the death organisms made decomposers release CO2. This system includes CO2 which is not a beneficial gas for world but because there is a perfect balance in the system it in a way be beneficial for the world. When humans are included with combusting fossil fuels, coal etc. the balance is broken down and pollute the air. Even though there are lots of ways humans effect negatively the environment in this article the main focus will be air pollution. The way to decrease the industrial air pollution rates and clean the air is using air filters in factories. There are several types of industrial air filters all used in different purposes (filtering different types of matters). These are SOx Filters (DSI(dry solvent injection), Scrubber(wet solvent injection)), NOx Filters(SCR, SNCR) and Dust Filters (Bag Filter, Electrostatic Filter, Cyclone). The main aim of this article is to observe how really is the industrial dust filters effective in air pollution and how can they be improved.

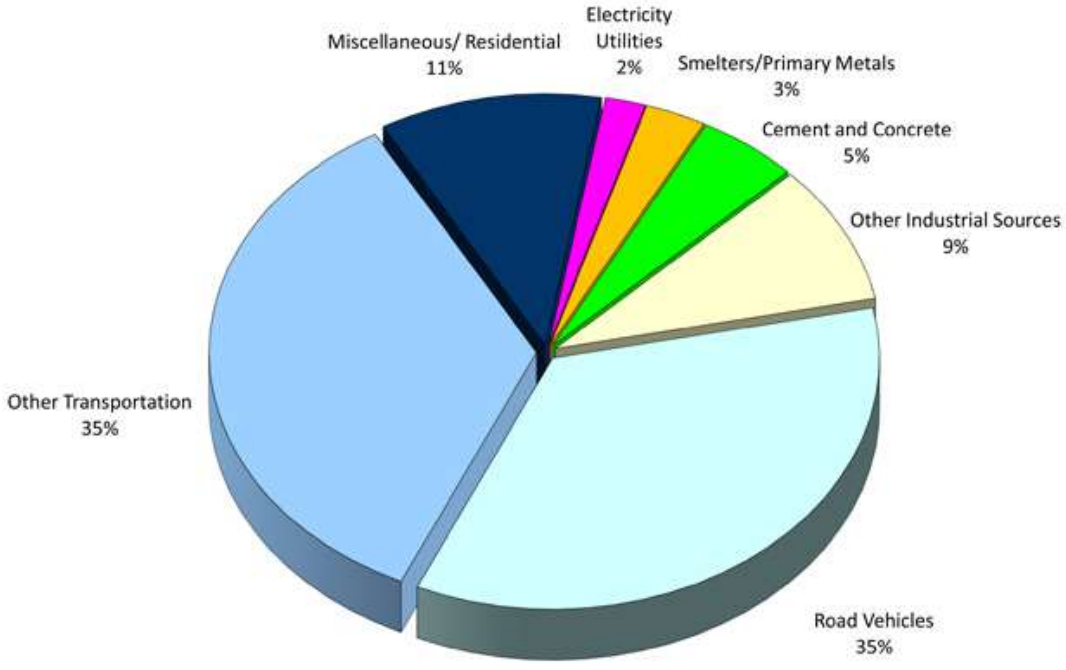
2. Air Pollution: Air pollution is the contamination of air due to the presence of substances in the atmosphere that are harmful to the health of humans and other living beings, or cause damage to the climate or to materials. With the advancements in technology and the increase in human population air pollution became one of the most important environmental problems. More people need more housing space more housing space means cutting more trees, running more heaters at houses and running more factories that do needs of people. The main causes of air pollution are separated to 3 topics: Anthropogenic (human made) sources, Natural sources, and Emission factors. Human factors are mostly about combustion of fuels. Fossil-fuel power plants and biomass power plants both have smoke stacks which if these smokes aren't filtered they would harm the air and decrease its quality. These smokes mostly contain dust, NOx and SOx gases and CO2.

2. Water Pollution: Water pollution, unwanted harmful substances, water quality at a measurable rate. It is the event of mixing with water in the amount and density that will enable them to spoil. Houses, industrial establishments, thermal power plants, fertilizers, chemical pesticides (pesticides), industrial wastewater are the main sources of water pollution. All of these directly or indirectly harm living and non-living things.

3. Soil Pollution: Soil is the general name of the group of substances that contain a large living community on and inside, which is the resting place and food source of plants, and which contains a certain amount of solid, liquid and gas. Soil pollution can be caused by substances that pollute the air and water. For example, rain droplets that pass through an atmosphere with a high sulfur dioxide content come to the soil as "acid precipitation". These acidic waters entering the soil damage tree roots, plant and animal soil creatures. By affecting the reaction of the soil, it disrupts the nutrient balance and makes the ground waters undrinkable. Likewise, water leaking from garbage heaps, dirty irrigation water, fertilizer solutions, radioactive materials, fly ash, heavy metals, industrial wastes are substances and sources that pollute the soil.

4. **Matters causing air pollution**: There are many types of air pollutants but the following matters appear most in industrial areas.

   4.1. NOx Gases: NOx gases in other name Nitrogen Oxides are a group of poisonous gases that appear when the fuel is burned at high temperatures. NOx kind of pollution's main cause is seemed as usage of automobiles and vehicles but it appears an important part of NOx pollution is caused by the constructions of machines in industries.



As it seen in the figure net value of industrial NOx release is 30% but a big part of the other transportation part in the figure is included in vehicles that are in industrial fields.

4.2. SOx Gases: SOx gases are compounds of sulfur and oxygen molecules. It is a colorful gas which has a shard odour Those gases at high concentrations can harm trees and plants by damaging foliage and decreasing growth. Sulfur Dioxide (SO2) which is the most known of these gases can contribute to acid rain which harm ecosystems as well. Emission of SO2 occurs in the combustion of sulfur containing fuels like coal and fuel oil and during industrial processes on raw materials and additives containing sulfur.

4.3 CO2: Although CO2 is not considered as an air pollutant when the concentration of CO2 is higher than it should be in the air it causes the Earth's temperature to rise. It acts like a blanket trapping the heat inside and do not let it go outside. This extra trapped heat disrupts many of the systems in our environment. On the other hand, the high concentration of CO2 in air lowers the air's quality so humans breathe a less healthy air.

4.4. Dust Inside the Smoke: Industrial dust, also known as process dust, is generated during the manufacturing or production process. For example, cutting, drilling, grinding, or sawing generates dust. It can also break out from materials, chemicals, or ingredients used in the production process, such as flour, sugar, and pharmaceutical products. This dust also contains beneficial materials which are used in the process so the dust is not only pollutes the air but also causes the inefficient usage of beneficial materials of the industry. The loss of materials inflicts the company to an economic damage. The dust could contain different harmful elements to the environment for example chemicals that are harmful for living organisms when breathed.

5. **Air Pollution from Industries:** Chemical gases, dust and fumes from the chimneys of factories pollute the air. The fuels burned in the factories for energy needs and the pollutants formed from the process in the factory are thrown into the air with the chimney, causing pollution. What is important here is both to continue development and to protect the environment. Workplaces and factories should take the necessary precautions not to pollute the environment.

5.1 Industrial emission directive: Industrial production generates emissions of greenhouse gases and acidifying substances, wastewater emissions and waste, that all together account for a considerable share of the overall pollution in Europe. There are around 52,000 large industrial installations in Europe and the emissions of just 5 pollutants from these industrial installations account for €164 billion in annual health costs, without even considering the costs in environmental damage. On December 2007 the EU Commission proposed the Industrial Emissions Directive (IED) in order to minimize polluting emissions in the atmosphere, water

and soil, as well as waste from industrial and agricultural activities, with the aim of achieving a high level of environmental and health protection. In particular, the environmental obligations industrial installations must undertake with respect to the IED include: preventive measures against pollution; the application of best available techniques (BAT); causing no significant pollution; reducing, recycling or disposing of waste in the manner that creates the least pollution; maximizing energy efficiency; preventing accidents and limiting their impact; remediating sites when activities come to an end.

5.2 Industry Emission Limits: After industrial processes, some waste materials that pollute the air arise. These substances must be kept under a certain limit. Some substances released after industrial processes and their limits are shown below. The emission limits in the industry vary according to the sectors. Emissions in some sectors below.

5.2.1 Emission Limits at Turkish Cement Sector:

Dust:

Current Plants 75-120 mg/Nm3

New Plants (year 1993) 50mg/Nm3

NOx:

Dry system 1300 mg/Nm3

Lepol 1500 mg/ Nm3

Wet System 1800 mg/Nm3

SO2:

300 mg/Nm3 (according to declaration of cement industry)

400 mg/Nm3 (according to regulations)

6. What is an air filter: As mentioned in previous topic some waste materials are formed after industrial processes. Although it impossible to reduce the waste materials from the processes to 0 with today's technology it is possible to reduce it. Air filter is a machine which ,just like its name, filters the dirty air getting out of the factories and separates the useful compounds in the air to make them be usable again. There are different types of filters which are being used for different branches and this cause them having different working principles. These are;

Dust Filters (Bag Filter, Electrostatic Filter, Cyclon): Dust collector systems work in general by drawing dust and particulates from the air through a filter that first captures and separates the matter and then discharges purified air back into the workplace or environment. SOx Filters (DSI(dry solvent injection), Scrubber(wet solvent injection)) and NOx Filters (SCR, SNCR): Emissions from appliances that burn oil, wood, pellets and biomass can contain high levels of nitric oxide (NO), nitrogen dioxide (NO2) and sulphur dioxide (SO2). The presence of these gases can cause errors when carbon monoxide is being measured with electrochemical sensors. In order to clear these gases coming out of machines and emissions SOx and NOx filters are used. These filters mostly work by srubbing the exhaust gas through a cloud of water thereby removing SOx and NOx and reducing the harmful emissions generated by burning fuel.

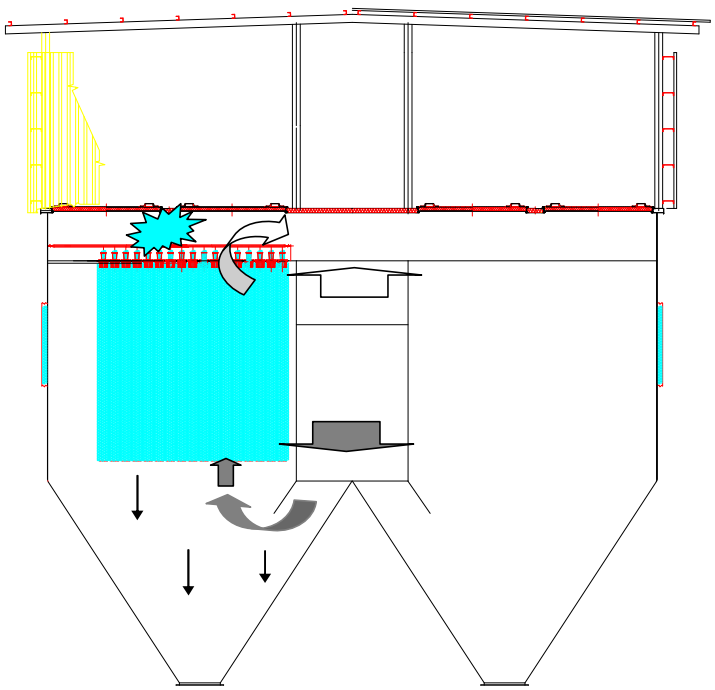
1.1 **Dust filters (This essay focusses on the dust filters):** As it is said above there are three types of dust collectors: Electrostatic Filter, Bag filter, Cyclon. All of these filters are used in separating the dust from the air. These filters has different working principles on their own.

6.1.1 Bag Filters: Bag filters are used in industrial facilities to keep dust particles formed in the production line and spread to the environment, and to separate these dusts from the air and transfer them to the desired point or store them. They are generally preferred as central dedusting for all suction points. They can be used in almost all sectors and all processes. Variable according to the dry and moist conditions of the dusts spread in the environment. Bag filters can be used as final filtration or pre-filtering together with other filter systems.

They improve indoor air quality for working personnel. They also help in maintaining the outdoor air quality. The suction capacities and the filter material to be used are determined by the manufacturer according to the nature, chemical structure and density of the sucked dust. Its overall dimensions are specially designed according to operating conditions. While they are used as a dedusting filter in some processes, they are also used in feeding the product to the production line by separating the product and the air during the transfer of the product with air. They act as a sort of separator.

These filters have steel structured bodies. It works as a whole with the filter materials selected in accordance with the process in the body, the pouring equipment necessary to transfer the captured dust to the desired location, the compressed air air injection system and electronic timer control systems. They are the systems with the highest efficiency among the dry type dedusting systems. These filters have 99.9% efficiency and are used up to 2-3 micron particles**.**

6.1.1.2 Bag Filter Operation Principles



1) Dust-laden gas enters the filter,

2) While dust-laden air passes through the filter bags to the clean gas section, dust accumulates on the filter bag.
3) There is an air movement that allows it to be cleaned once, the powders spilled from the bag surface are poured into the bunker and shipped from there.

The type of bag to be used in bag filters is of great importance in terms of filter efficiency. In the table below, the operating temperature and strength information are given according to the bag material.

MATERIAL	PP	PES	PAC	PPS	APA	PI	PTFE/GLS
TRADE NAMES	Polypropilen	Polyester	Poliakrilik	Rylon	Nomex	P84	Fiberglass / Fiberglass Teflon Membrane
TEMPERATURE °C							
CONTINIOUS	90	135	125	190	200	240	230
PEAK STATUS	95	150	140	200	220	260	260
STRENGTH							
ACID	5	4	4	4	2	4	5
ALKALI	5	2	3	4	4	2	5
HYDROLYSIS	5	1	4 - 5	5	2	2	5
OXIDATION	3	5	3	1	3 - 4	-	5
ABSORSION	5	5	3 - 4	3	5	4	3

6.2 Scrubber: Scrubber systems are systems designed for the purification of industrial waste gas and steam before they are released into the atmosphere. Gas purification, washing or filtration systems are applied to keep and render harmless the gases resulting from production in San yi facilities.

It works on the basis of gas absorption, oxidation, neutralization, and purification by dissolving methods. As a result of spraying the chemical that will react or hold it against the direction of

the air flow, the gas, which is activated by the fan, meets with the droplets descending from the tower by gravity and performs the reaction. During this reaction, depending on the reaction, measurements (PH , ORP, CL and conductivity, etc.) are made and the necessary additives and chemicals are dosed automatically.

6.2 Cyclone Dust Collector: Cyclone dust collectors are used in industrial facilities to reduce the dust load on the filter. It is used as a pre-separator to hold the coarse particles before the filter. In this way, bag filters work more efficiently. Necessary parameters for the selection of the appropriate cyclone;

• Flow rate and temperature of the carrier gas,

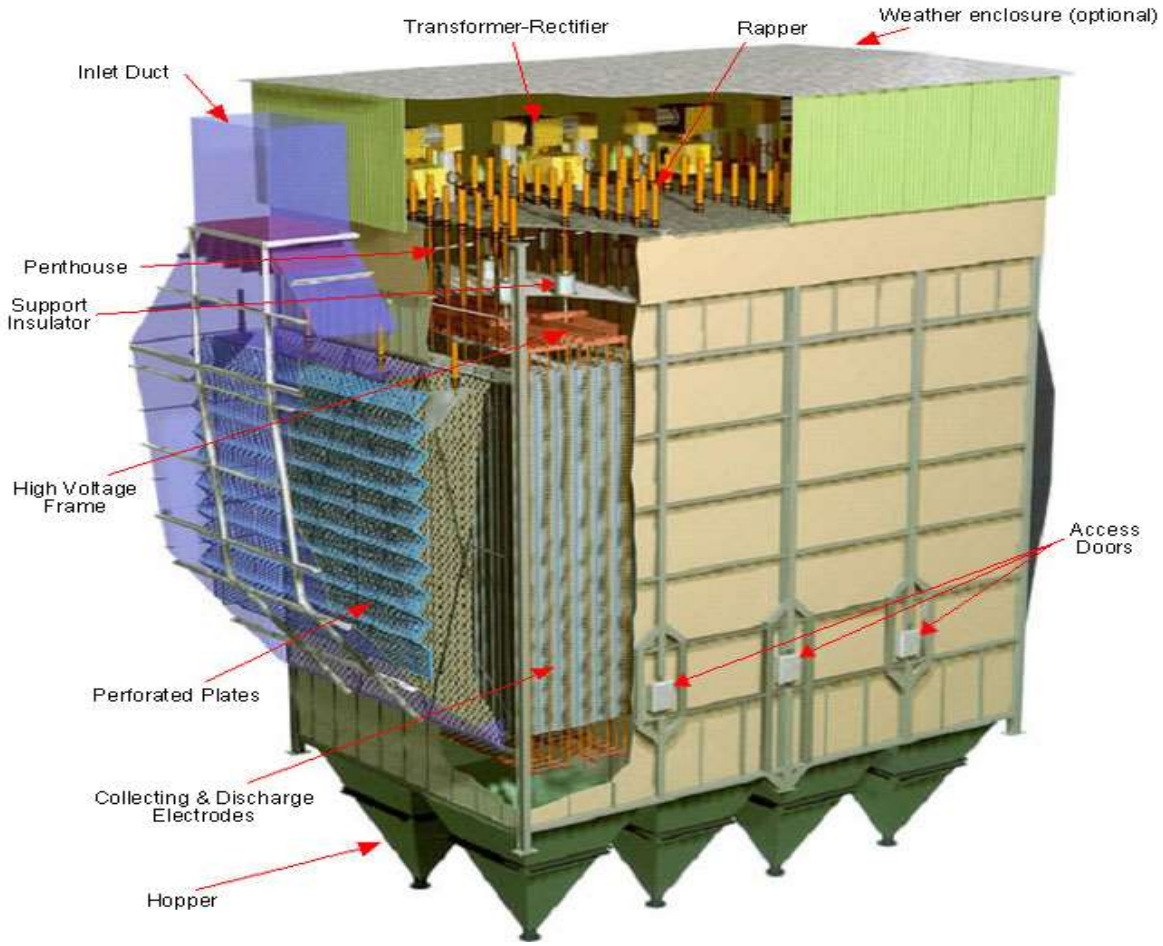
• Particle size analysis of the material to be collected, dust distribution

• The specific gravity of the material to be collected,

• Desired dust load of cyclone outlet

• Targeted collection efficiency, ie the ratio of the material held in the cyclone to the material entering the cyclone.

6.3 Electro Filters: The polluted air drawn by the fan passes through the washable metal pre-filter. This filter traps coarse dust and oil particles. Then, the oil, smoke and soot in the air coming to the electrostatic filter, which works according to the principle of ionizing the particles, are negatively charged by the high voltage charge. As the negatively charged polluted air passes through the positively charged area in the second stage, the oil, smoke and soot particles in the air are strongly attracted by the collector plates and adhered to the filter surface. The air that enters the electrostatic filter as dirty comes out cleaned. Normal bag filters rely on filter media to 'catch' particles larger than the gap between the media as they pass through material. Instead of filtration media, Electrostatic Filters use an Ionizing effect to attract positively charged particles to a negatively charged Anode plate.



1) **6.3.1 ESP Operation Principles: Ionization** – Loading of the Particles

2) **Delivery** – Delivery of the loaded particles through the collection surface

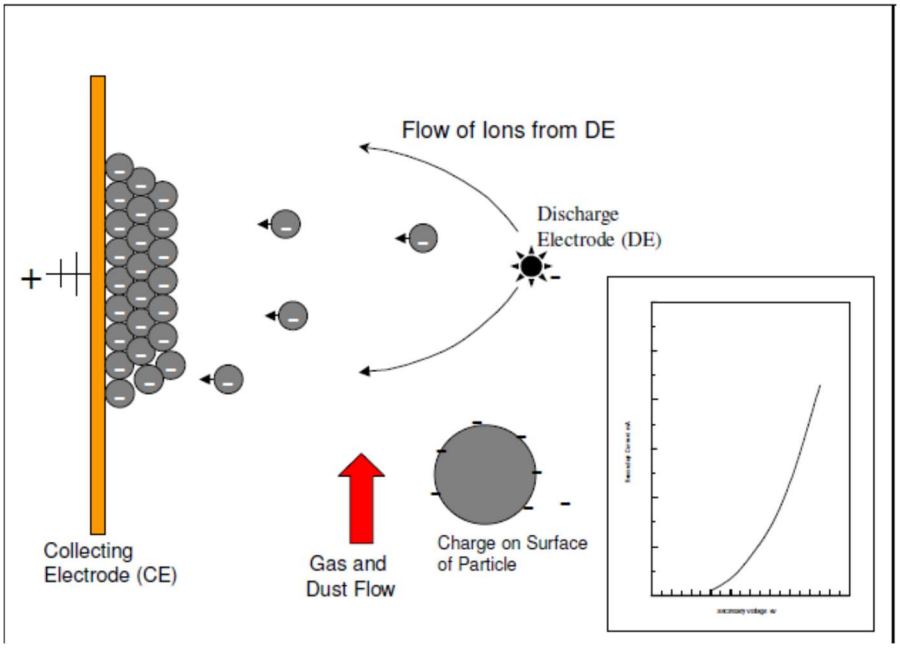
3) **Collection** – Accumulation of the loaded particles through the collection surface

4) **Load Discharge** – Neutralisation of the particles placed over the collection surfaces

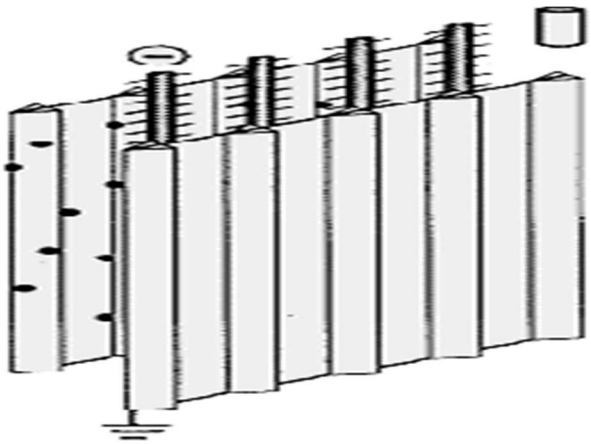
5) **Particle Replacement** – Particle pouring placed over the collection surfaces through the bunker by hammering

6) **Particle Carriage-** Particle transfer from bunker to collection silos

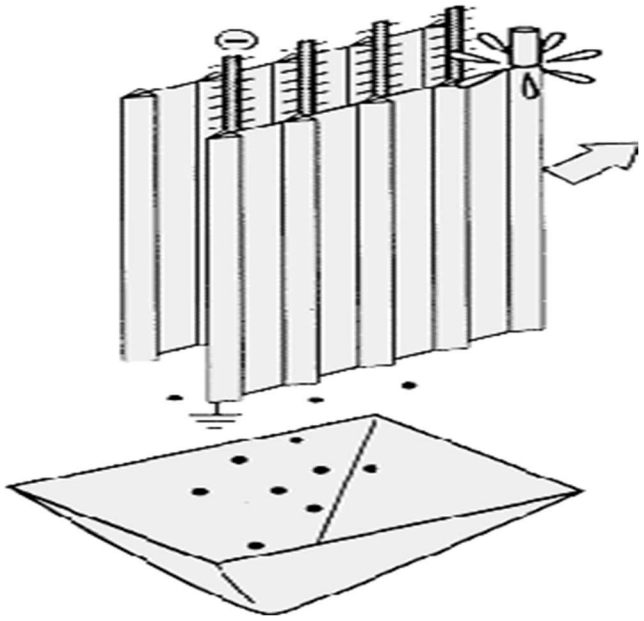
Once the air, loaded with dust or ash type particles penetrates through the filter, faces with an ionized area surrounded by high voltage electrodes. In the aftermath of this cycle, dusts loaded by electrons which is called (corona effect).



Once negative charged dusts flow through the high voltage area, they end up with directing towards collection plates.



Charged dust, start to discharge once they are accumulated over the grounded plates. Afterwards, collected dust pours into the bunker system by means of hammering system.



2. **Experiment:** Calculating the amount of dust releases from a cement producing machine than calculate it again with a bag filter with varying wing angles.
3. **Hypothesis:** As the angle of the wings approach to 45 degrees the efficiency of the filter will increase and when the angles exceed 45 degrees the efficiency of the filter again starts to decrease. The reason for that is I think that the wings can capture the most dust when they are put as 45 degrees.
4. **Materials:**
   - A prototype miniature bag filter
   - A censor that detects the amount of air molecules pass through
   - A timer
   - A machine that grinds limestone in micron level in order to produce cement
5. **Independent Variable:**

The wing angles of the fans inside the air filter will be the independent variable for this experiment. Changing the wing angle by 15 degrees per every trial will show that if there is or not a correlation between the wings' angle and the amount of dust pass away.

6. **Dependent Variable:** The amount of dust pass away the system will be the dependent variable. From the aspect of my hypothesis I believe that as the angle gets close to 45 degrees the gas and dust leakage would be decreased.
7. **Controlled Variables:**
   - The filter would stay unchanged throughout the experiment. It will be used again as the angles change.
   - The trials will done spontaneously in order to keep the pressure and temperature as same as possible.

- The room will be cleaned after every trial so that all the test give correct results
- The machine will stop working after every trial.

Procedure: The experiment will take place in an air filter company so that the needed materials are produced and I could get some help from the engineers working there on start and stopping the machines or changing the wing angles. The cement producer machine will put on an empty room of 250 m3. Than the amount of dust released by the machine will be calculated. After that the filter will be placed in the room and the amount of dust released will be calculated again. As the angle of the wing in the filter change this procedure will start over and over.

	TRIAL 1	TRIAL 2	TRIAL 3
The Machine alone	302 +/- 0.01 g/m3	308 +/- 0.01 g/m3	297 +/- 0.01 g/m3
15 degreed wing filter	50 +/- 1 mg/m3	47 +/- 1 mg/m3	56 +/- 1 mg/m3
30 degreed wing filter	42 +/- 1 mg/m3	40 +/- 1 mg/m3	37 +/- 1 mg/m3
45 degreed wing filter	27 +/- 1 mg/m3	29 +/- 1 mg/m3	24 +/- 1 mg/m3
60 degreed wing filter	12+/- 1 mg/m3	10+/- 1 mg/m3	14+/- 1 mg/m3
75 degreed wing filter	48+/- 1 mg/m3	42+/- 1 mg/m3	46 +/- 1 mg/m3

Evaluation:

First thing needs to be mentioned is that the effect of the air filter on the dust release. The machine alone released 300g/m3 dust average but when the filter took place in the room even if it is or not the optimum wing degree the dust release has reduced to a value between 10 and 60 mg grams. 1gram being equal to 1000 milligrams, an air filter reduced the amount of gas released from the machine by approximately 2965mg/m3. Another thing is that my thought about the correlation with the wing angle and dust release turned out to be correct. But my hypothesis about 45 degrees being the optimum degree was proved to be wrong. As it seen from the data above the dust release values change as the degrees change. It turned our that 60

degrees was the most efficient one. The most and least efficient degreed values differ as 41mg/m3 approximately. This may seem that the change is so very little but when u think about a big period of time this machine works for it really is an important amount. Overall even though a part of my hypothesis is incorrect the experiment showed that there really is a correlation between the wing angle and dust release and how much does an air filter reduce the dust release to the environment.

Risk Assessments and Development that could have made:

Risks:

- The sharp razors in the fan of the filter are dangerous and could cut some body parts while arranging the degrees of the wings. That's why the arranging part has done in an empty room by me with usage of thick gloves.
- Starting and stopping a working machine is dangerous. The electricity it includes, the sharp metal moving parts and the particles it reveals can really hurt people. That's why the start stop part has done with a long distance remote control.

Developments:

- Using the same filter over and over could have effected its performance which could have effected the results. If more than one air filters which have the same properties were used the results would be more accurate.
- Only one type of air filter is tested so it only shows its performance. Other types could have been tested in order to achieve a better judgement.

Uncertainty:

The censor used to calculate the dust amount had an uncertainty of 1mg/m3 that's why the all the results found has an uncertainty of the same amount. This amount of uncertainty is negligible because the findings has a clearly readable difference. A better gauge can be used of course but at the company the experiment have done that was the best possible gauge they had.

Conclusion:

The environment is polluted by many different pollutants as mentioned. Besides every pollutant this essay mainly focusses on the air pollution by the industrial sites and machines. This kind of pollution can only be cleared by air filter at least for todays technology. In essay I tried explain what really is an air filter, how effective really air filter are and how can the machine be modified in order get a better efficiency out of it.

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