ENERGY EFFICIENCY IN AIR POLLUTION COTNROL

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Dust/Fumes

Dust or fumes consist of fine particles which contaminate ambient air. Any of the following could be the source of this dust or fumes:

a. A process of production – for example a bench grinder, or a mixer of powders.
b. Due to material handling – e.g. material feeding into a hopper or discharge from a mixer, unloading of bags of cement, etc.
c. Entering a premises with air

The heavier particles settle down on the floor, machines, etc. Finer particles float and take much longer to settle down. The finest particles, which are below 10 micron or even of submicron sizes, float till eternity. We cannot see individual particles below 10 microns. Course particles inhaled by us are exhaled or coughed out. Particles below 10 microns get embedded in the tissues of our lungs and can get absorbed into blood.

A word of caution. It is better not to use a dust collector that removes large visible particles and allows the fine, non-visible dust out with air exhaust, because we let our defenses down (like not using masks) under an impression that the dust collector is letting only clean air out.

The main objectives of APC equipment:

a. To protect workers from exposure to toxic dusts/fumes
b. For protect the product from contaminants.
c. To protect the equipment from dust/fumes.
d. For lower downtime of production equipment
e. To reduce maintenance cost of production equipment.
f. For the recovery of expensive raw materials
g. To prevent spread of contaminants indoors or outdoors.

Dust/Fume control – different approaches:

a. Ambient air cleaning
b. Dust suppression
c. Dust capture from source and collection
d. Dust proofing
e. Job or equipment cleaning and dust collection

Process of dust/fume collection

An APC equipment essentially has following components:

1. Suction hood – an interface between the source of dust/fumes and the APCE – that ensures right air velocity at the right place in the right direction.

   Kinetic energy is transferred from moving air to the static or moving particles. This energy is meant to move the particles or gas to a desired direction at a desired magnitude.

   There is one critical air velocity at which the particle will start moving in the desired direction at a required velocity. Let us call it V_c. The capturing velocity has be more than this V_c. We have to take into account other factors such as turbulence due ventilation fans, other fast moving parts, etc. too.

   The hood may be located at a distance from the source point of dust – which means the velocity at the particle location will be much less than the velocity at the mouth opening of the hood.

   Shape of the hood can affect the capturing efficiency and the pressure drop required to achieve the required airflow through it.

2. Duct – a network of rigid and flexible pipes to carry air and particles from the suction hood to the collection unit.

   It is important that the air moves fast enough in the duct to carry the particles else they will start settling down. Also, high speed will mean high frictional loss resulting into high pressure drop which means high energy consumption. So we have to optimize – depending upon the particle density, particle size, etc.

   Ducts have to be made out of right materials – MS, SS, GI, FRP, Rubber coated, etc. depending upon the physical and chemical properties of the dust/fume. For example, for non abrasive dusts thin GI made ducts (spiral wound ducts) can be OK, but for abrasive dusts thick welded MS ducts will be required.

   In a multi-utility system, where one dust collector is catering to two or more application points, ducts have to be sub-divided to direct required airflow to respective source points on one or more production machines.

3. Separation devices

   The dust carried to the dust collector has to be separated from carrier air. There are several methods that are used for this – e.g. cyclone, multi-cyclone, fabric filters, wet separators, Electrostatic precipitators, etc. The choice of separation system depends on nature of dust, fineness, quantum, temperature, etc.

   A single cyclone is essentially meant for large and heavy particles. In most cases it is used as a pre-separation device to reduce dust load on the subsequent fabric filter. Multiple smaller cyclones arranged in parallel are more efficient in terms of separation efficiency for finer particles – but only to a limit. Cyclones have an advantage – they do not use consumable materials like filter bags, and can work at elevated temperatures.

   For finer particles fabric filters are used. Bag filters are made out a variety of mediums – such as cotton, polyester, PP, Glass fiber, and some special materials which can withstand high temperatures and certain chemicals too. Fabric filters get choked with fine dust and need regular cleaning for which different methods are used, like manual shakers, motorized shakers, reverse pulse-jet, and reverse air washing.

   A yet another improvement over fabric filters is cartridge filter systems in which fabric media is arranged in pleated shape and, therefore, much larger filter area can be accommodated in a smaller space. The cartridge media can filter very fine particles too and can be cleaned with reverse-pulse-jet.

Where temperature is very high, and/or materials are corrosive wet scrubbing provides a very good solution. For dust collection venturi scrubber, also called high energy system, can clean up to 0.1 micron sized particles with over 99% efficiency.

4. Suction and airflow generator

   All dust and fume collection is done with the help of suction air. Centrifugal blowers are most commonly used for this purpose. Axial fans are used where high airflow with low pressure combination is required. For high pressure-low airflow combination twin-lobe blowers are used.

5. In addition to above there are auxiliary items such as rotary airlock, screw conveyor, stack, etc.

ENERGY CONSUMPTION

In all the above elements of a dust collector the only item that consumes electrical power is a blower. But energy is consumed by every other item.

While designing a dust or fume collection system primarily we have to determine how much airflow is required. Referring back to suction hood, we need certain air velocity at the point of application, and that point is at a distance from the opening of the suction hood. The velocity of air at the suction hood opening multiplied with area of opening is the volume of airflow per unit time. Sum of airflow required for all suction hoods in a network is the total airflow of a dust collector.

Having established airflow in the different sections of a network, we have to determine pressure drop of the “system”. The system includes following components:

a. Inlet loss – air is moved from its static to dynamic state, which needs energy.
b. Hood loss – air faces friction with the walls of the hood.
c. Duct loss – air has to pass through various parts of the duct – like straight duct, bends, reducers, nozzles, etc.
d. Separation loss – cyclone or bag filters offer resistance to the flow of air.
e. Other parts of the system.
f. Energy required to carry the material – which is negligible in case of fumes.

ENERGY SAVING

Energy consumption or motor power is proportional to the product of airflow and pressure loss of the system. This means the most fundamental mantra for power saving in case of dust or fume collection systems is that we must optimize the design to work at the minimum possible airflow and minimum possible pressure drop.

Airflow optimization

As stated earlier we have to achieve a specific velocity at the source point of dust or fumes. The depletion of air velocity over the distance from the opening of the suction hood is exponential. The shorter the distance lesser is the velocity loss. So the first and foremost concern should be to minimize the distance between the suction hood and the dust source.

The net effect of the reduction in distance can be dramatic in terms of power consumption and capturing efficiency.

The hood design is also very important. A smoother air entry and aerodynamic movement of air within the hood reduce losses and therefore the need for larger airflow. An innovative design of suction hood can make massive changes in the energy requirement of system and since it is an application specific issue no generalization is possible.

Pressure optimization

At every step pressure is lost in a dust collection system. Some of the important factors that we can control are as following:

a. The duct should be made in the largest permissible diameter. But, we have to maintain a minimum air velocity in the duct too to ensure that the dust does not start falling off the air. Also, larger ducts mean higher capital cost and more space required.
b. We should minimize the number of bends in the duct. Every bend, depending on the diameter and radius of curvature, is equal to straight duct of five to 100 times the diameter of the duct.
c. The bends should be made in large radius of curvature, at least 1.5 to 2.5 times the diameter.
d. The internal surface of the ducts should be as smooth as possible, with clean joints.
e. The reducers should be made in acute angles. Sudden changes in diameter cause a lot of pressure drop.
f. The tees in the duct network have to facilitate smooth airflow. The sharp tees where a pipe at right angle suddenly meets another pipe, cause heavy pressure loss.
g. Choice of right separation device, right filter media, etc. are important factors that contribute to energy saving.
h. While dust cake buildup on the face of filter media enhances filtration efficiency, it causes higher resistance to the airflow. A careful optimization is absolutely essential.

i. Reducing dust load on the filter can be achieved by facilitating gravity separation before dusty air hits the filter media. This can be achieved by ensuring very low air velocity in the zone preceding filtration.

SUGGESTIONS FOR PLANT ENGINEERS

While deciding for a dust or fume collection system following points should be taken care of:

1. Do not accept the "status quo". Because dust collection has always been done in a particular way does not automatically make it the only or the best way.
2. Production is important but lives of people are more important. There cannot be a compromise on this.
3. Do not assume. Measure, test and catalogue the parameters.
4. A funnel shaped hood is too simplistic and is most inefficient method of capturing. Let a professional design a hood.
5. Factors external to production and dust collection, for example comfort cooling, indoor material transportation, etc. can cause havoc with dust/fume collection system. Take them into account.
6. Designing a Dust collection system is not the job of a fabricator.
7. You may be experts of production, maintenance, etc. but dust collection is not your area of expertise. Let the professionals handle it.
8. You have to go close to the point of generation of dust/fumes. If that interferes with work, or maintenance, keep an open mind. There are solutions possible that will allow close point suction as well as freedom of work.
9. If production equipment or method of work has to be modified to accommodate a suction hood, be willing because what is new or awkward today will become normal tomorrow.
10. Take your team of workers and supervisors into confidence. Their resistance to change will melt away once they can appreciate that they will be most befitted with the introduction of anti-pollution devices.
11. Pollution control is profitable for the company. A good system will ensure better working environment, more production, better quality of produce, less rejections, less breakdowns, etc.