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Is It Possible to Make Truly-Sustainable Air Filtering Equipment?

"Yes", is the new answer.

Air filters refine, clean, or treat the air. Products vary in their methods to achieve these objectives, as does their effectiveness. However, few qualify as having true sustainability as defined by the Cambridge dictionary: "able to continue over a period of time" and " causing little or no damage to the environment and therefore able to continue for a long time".

To show how new technologies finally provide a "Yes" to this key question, let's first review the existing filtration technologies.

Most air-filtration equipment uses some type of media to block and capture unwanted particulates, respiratory droplets, and other contaminants suspended in the air.
Since these kinds of media have a limited storage capacity, they all eventually clog. As they clog, they increasingly impede airflow, reduce air pressure and, thereby, increase energy consumption. Hence, no media-based filtration system can qualify as truly sustainable.

Here is an explanation of how filter media cleans air and other gases: the filter elements—cartridges, bags, sheets, screens, wet mesh, or other types—capture the particles using one or more of four different methods. As you will see, each of these methods collects the debris and, therefore, eventually saturates the holding capacity of the media:

- **Interception** takes place when a contaminant particle passes a filter fiber closely enough to touch it; the fiber stops it and removes it from the flow of air.
- **Inertial impaction** occurs when a relatively large particle, unable to adjust to the change in air direction caused by a filter fiber, becomes trapped on the fiber. The particle's momentum carries it along its original path and prevents it from moving with the flow of air as it moves around the fiber, which captures it.
- **Diffusion** depends on the Brownian motion of gas particles. Small particles (typically 0.1 μm or less in size) tend to travel with the flow of air erratically because they make random motions as they interact with gas molecules. This erratic motion causes the debris particles to stick to filter fibers instead of avoiding them with the airflow.
- **Electrostatic attraction** occurs when the particle and the filter media have different static charges. The charges on the media can be permanent or transient.

Designers and manufacturers have developed numerous ways to make "self-cleaning" media filters. However, no cleaning ever brings the media back to its initial pristine condition so they impede the airflow even after cleaning. Each time they self-clean, they leave a little more debris in the media. As a result, they increasing restrict the air and eventually they can no longer sustain the required airflow and must be replaced.

What types of "self-cleaning" systems exist in the market today, with and without media? One of the most highly used in industry is the bag filter, often installed in groups in a baghouse. The makers of the bags choose a fabric, or other material, with an initial porosity that will block particles larger than 5 µm or 10 µm, or other size. The reality is that as they—and most other filter media—collect the particles that they trap, the debris begins to reduce the size of the passageways through the media and often increases the effects of one or more of the other three trapping methods discussed above. Hence, as the media increasingly clogs the filter media traps smaller particles than when they are new. Many manufacturers count on this clogging when they rate their filters; their new elements often do not reach their intended effectiveness for the smaller particles until after they have been clogging for a while. You can imagine the problems that this initial ineffectiveness with tiny contaminants could cause in a food-packaging plant or in an operating room.

Note: we refer to "bags" here because it facilitates the explanation. However, many self-cleaning filters use other types of media such as tubular cartridges, sheets, wet media (over which water runs to flush them), and rolls of filter media that move to expose clean material to the airflow.

The media filters become self-cleaning when combined with a piece of energy-using equipment that cleans them out. Some literally turn them upside down and shake out the debris. Others use compressed air to blow out the dust, also an energy-<u>in</u>efficient way to clean them, in part because it takes additional energy to compress the air.

Reminder: No matter how good at self-cleaning media-based filter systems are, eventually all elements become so packed with debris that they can not be cleaned sufficiently to remain effective and/or economic, and they must be replaced. Then the elements become an additional strain on the environment: the material must be disposed of—perhaps in a landfill or by incineration—or if they have concentrated-enough hazardous contaminants they must be treated as hazardous waste, which could result in using even more environmentally-damaging procedures. Then new media must be manufactured, purchased, transported to the site, and installed, often with the use of energy-consuming equipment.

Some manufacturers offer ever larger, and otherwise modified, filter elements to absorb more debris before they require changing. However, they still stop and trap the particles and cause the same energy-inefficiencies as the smaller or less deep media; they just do it for longer periods between changes. They purport to have increased sustainability, but they mean it only within the first definition of "able to continue over a period of time". They are not sustainable in the sense of "causing little or no damage to the environment and therefore able to continue for a long time".

A type of self-cleaning filter that does not normally use media is the cyclonic system.
This system uses high-pressure air to drive the dirty air into a cylinder, usually tubular in shape, usually installed vertically and usually with a gradually-reducing diameter at one end. They work simply: as the dirty air enters the cylinder, the high-pressure air directs it to spin around inside. Since air flows into the cylinder steadily it must escape somewhere, and most exits as cleaned air. The devices remove particles from the air by using the energy-consuming process of spinning it so that the inertia of the debris suspended in the air moves toward the inside wall of the cylinder. They utilize the momentum of the particles to drive them to the outside wall of the cylinder where the air spinning along the wall captures them temporarily. Since the weight and

density of the particles are greater than that of the air, the cyclonic systems use their mass and often gravity to have them settle toward the discharge end, normally the conical bottom of the cylinder. The cleaned air flows out the other end of the cylinder.

Although cyclonic filters do not use media, their dependence on high-speed air to spin the air around inside the cylinder reduces their energy efficiency along with that of the overall system of which the cyclone is a part. In addition, cyclonic systems need a valve to open and close so that the collected material can leave the cylinder. These valves often stick or have other operational problems. Some valves also need controls and someone trained to operate, monitor, and maintain them, plus they sometimes have difficulties with sticky, corrosive, and other problematic materials, further lowering the energy efficiency.

An older type of self-cleaning air filter is the spin block. Like all the other devices and systems discussed above, they need an outside blower to move the contaminant-laden air through them. The blocks work passively—they consist of one or more tubes entering from one side of the block and an equal number of smaller-diameter tubes exiting on the far side of the block. Inside the larger tubes, near their entry, is a set of small fins designed to make the air start spinning inside the tube.

As in the cyclonic systems, when the high-energy incoming air starts to spin, the momenta of the particles carry them to the outside of the larger tube, leaving the cleaner air in the middle. The smaller tube from the other side of the block is inserted into the larger tube part-way across the block, and after the particles of debris have migrated to the outside walls of the larger tube. Therefore, only the clean air in the center enters the smaller, downstream tubes and passes out the other side of the block to the application. The larger tube also stops partway through the block so that the debris traveling along its walls shoots out of the tube and eventually falls to the ground or is pulled away by a second, energy-consuming suction blower.

Spin blocks have proven themselves in many applications, among the most frequent uses being providing clean air for locomotives by removing track dust to supply feed air for diesel engines and cooling air for traction motors. However, their energy inefficiency makes them costly to operate: one locomotive manufacturer designs its systems around a 9-11" w.g. pressure drop. For perspective, filter manufacturers usually rate their clean media at around a 0.5" pressure drop, and the energy needed to push air increases geometrically as pressure drops increase.

A key point in this discussion is that all media filters, and the non-media filters discussed above, need a separate source of power (e.g. a blower or fan) to drive the air through them. *They will not do anything without air forced through them*. Therefore, since they impede the flow of air to clean it, they all must cause a loss of energy efficiency, air flow, and air pressure.

Recently our New York company, Air-Cleaning Blowers, LLC, received several patents and is now designing and producing filter-blowers. These units blow and clean air without the use of any filter media, valves, or controls. With no filter media to clog (and maintain) they produce constant and predictable air flow, air pressure, air quality, and energy consumption.

These and other features of the Air-Cleaning Blowers™ (ACBs) make them the first truly sustainable air-filtration system because they do not clog and, therefore, vary little in performance and efficiency over time, even in remote locations where servicing equipment is difficult and infrequent. As blowers, the ACBs eliminate the need for an independent source of air flow and pressure, thereby preventing energy-consuming pressure drops. In fact as blowers they increase air pressure and airflow and can replace other blowers that might have otherwise been needed in a system.

How do they work? The impellers installed inside the units use the inertia of the debris particles to throw them to the inner side of the outside wall of the housing. Once against the wall, the devices use the flow of air going to the application to carry the debris to the discharge point where the units forcefully eject the contaminants from the blower. Since they do not use gravity to remove the particles the direction of orientation is unrestricted, and they scale in capacity from fewer than 50 CFM (cubic feet per minute) to thousands of CFM. Users have installed them in a diverse group of applications including steel plants, mines, electrical-equipment manufacturers' products, powdered-food packagers, U.S.-military satellite tracking, and residences.

Hence, Air Cleaning Blowers™ provide the first "Yes" answer to the question "Is It Possible to Make Truly-Sustainable Air-Filtering Equipment?" that meets both definitions of the concept of "sustainability".