Free baghouse filters report example

Health & Medicine, Stress

INTRODUCTION

Baghouse filters are fabric filter units consisting of one or more isolated sections containing an array of fabric bags (Vatavuk, 1998). Shapes of these bags range from round, flat, tube-shaped, to pleated cartridges. In theory, gas containing high particulate matter level passes through the fabric bag surface. The particulate matter is retained while the cleaned gas is either recycled to the process or vented off the exhaust. This paper attempts to discuss the different concepts behind baghouse filters in relation to environmental engineering. Specifically, this paper discusses (a) particle pollution, (b) baghouse filter principle, (c) filter media selection, (d) types of baghouse filter, and (e) best practices in baghouse filter design.

PARTICLE POLLUTION

According to the U. S. Environmental Protection Agency (2000), air pollution is the degradation of air quality resulting from unwanted chemicals or other materials occurring in the air. Sources of these pollutants can either be stationary or moving; point, line, or area; or natural or man-made. These pollutants include, but are not limited to particulate matter, sulfur oxides, nitrogen oxides, carbon monoxide, lead, ozone, chlorofluorocarbons (CFC’s), and dioxins. The primary pollutant that the baghouse filter addresses is the particulate matter.

Generally, particulate matter size range from less than 1 micron to hundreds of microns in particle diameter. They consist of a wide range of liquid and solid particles known in the environmental sciences specifically as aerosols. Particulate matter characteristics vary in size, mode of formation, settling properties and optical properties. In terms of mode of formation, particulate matter can form into dust, smoke, fumes, fly ash, mist or spray. Sources include vehicular emissions, combustion fuels in power plants, wood and coal burning, natural sources like volcanic eruption, burning of agricultural wastes, construction activities, quarrying, industrial processes, and cement manufacturing. High levels of particulate matter in the air result into health hazards. PM causes upper respiratory infection, cardiac disorders, bronchitis, and asthma. Aside from these, PM’s from incinerators are known to be toxic. Also, PM’s from carbonaceous particles are suspected to be carcinogens. The toxicity and the health hazards particular matters pose is attributed to their particle sizes. PM’s whose diameter is smaller than 10 microns (or micrometer) are emphasized because they can enter the human body easily through the respiratory system. It passes through the throat and nose, and can enter the alveoli of the lungs. Once accumulated in the body, PM’s cause serious health problems such as the infections and diseases enumerated above. Particle pollution can be divided into two classes: (a) PM 10 and (b) PM 2. 5. First, there is PM 10 whose diameter is bigger than 2. 5 microns but lesser than 10 microns. PM 10 are inhalable coarse particles which can be found near roadways and dusty industries such as cement manufacture and coal mining. PM 2. 5, on the other hand, are fine particles such as those found in smoke and haze. Their diameters are less than 2. 5 microns. PM 2. 5 are emitted from primary sources such as forest fires, or from the reaction of flue gases of power plants, industries, and automobiles with air.

Aside from the health effects described, PM’s also have environmental effects such as: reduced visibility (or haze), increased acidity of lakes and streams, nutrient balance changes in coastal waters and river basins, reduced levels of nutrients in soil, damage to forests and crops, reduced diversity in ecosystems, and damage to stone and other materials (U. S. Environmental Protection Agency, 2014). Reduced visibility happens due to the optical properties of PM. The other environmental effects area is caused by the reaction of the specific particulate matter. Organic compounds such as polyaromatic hydrocarbons (PAH) and some combustion products react with the surface waters such as the lakes, streams and rivers, causing increased acidity and nutrient imbalance. Some studies have also discussed possible correlation between high particulate matter levels in the air with reduced levels of soil nutrients and soil and materials erosion. These slight changes in the environment has been associated with reduced crop yield, forest damage, and even reduced biodiversity of some ecosystems.

The particulate matter discussed is of considerable importance to the design of baghouse filters to be used. There are many industries currently using baghouse filters in their processing and waste treatment systems. Baghouse filters are successfully installed and used in coal-fired boilers, waste incinerators, aluminum processing, gray-iron fasting and engine block manufacturing to control PM emissions (Cora & Hung, 2002).

BAGHOUSE FILTER PRINCIPLE

Baghouse filters basically utilize unit operations such as sieving, impaction, agglomeration, and electrostatic filtration. The main objective is to remove solids from a gaseous exhaust stream. Baghouses maximize the filtration area by configuring the fabric filter media into a series of long small-diameter fabric tubes referred to as bags (See Figure 1). They are tightly packed into a housing wherein the dust laden air moves across the bag fabric thereby removing it from the gas stream and building up a filter cake which further enhances air cleaning. A repressurizing valve is needed to assure a constant pressure differential. The filter operates by batch as: (a) normal operation involving a longer service cycle, and (b) intervals for intermediate cleaning. In intermediate cleaning, the accumulated particulate matter forming a surface resembling a cake is removed from the filter bag. The filter cake is removed to hoppers by various shaking means. This is the bag cleaning mode step seen in Figure 1.

Figure 1: Baghouse Filter Schematic Diagram

Looking microscopically into the filter bag, the layer of dust cake which accumulates in time aids in the high removal efficiency (usually at 99 to 99. 9 percent). The dust cake serves as a barrier with microscopic holes that collect dust particles. This results in a significant pressure drop of 0. 18 to 0. 72 pounds per square inch. This pressure drop needs to be accounted because it is part of the energy consideration during the design. Higher pressure drop means higher energy losses accounted to loss in kinetic energy of the gases to be cleaned.

BAGHOUSE FILTER DESIGN PARAMETERS

Malcolm Swanson (1999) of Astec Industries tackles two key design parameters for baghouse filters. The understanding of these two factors can help integrate the engineering standards of the design engineer and the better operability and cost-effectiveness for the process owners. These are: (a) air-to-cloth ratio and (b) can velocity. Air-to-cloth ratio is the gas velocity through the fabric filter, while the can velocity is the upward gas velocity between the filter bags. Air-to-cloth ratio is measured at the filter bag while the can velocity is measured below the bags. For air-to-cloth ratio, the rule of thumb in design is between 4: 1 to 6: 1. This means that 4 to 6 foot per minute air velocity passes through one square foot of the filter surface. It is interesting to note that the smaller the particle size, the less air-to-cloth ratio can be used. Smaller particles are lighter compared to larger particles. Another design factor is the can velocity. This factor depends primarily on the size distribution of the particles. Since can velocity is upward in direction, there is a need to balance it and the fall of the particles from the filter bags. Dust particles need to fall-off at a close to constant rate so that bag cleaning is minimized. Too high can velocity results in dust particles migrating through the filter medium. The effluent gas then is not cleansed and still contains the particulate matter. Thus, standard can velocities in the industrial baghouse are in the range of 265 to 285 foot per minute.

FILTER MATERIAL SELECTION

Filter material selection can be based on Table 1. Table 1 summarizes the most common filter media used in baghouses. Fiber types range from cotton, polyvinyl chloride (PVC), polypropylene (PP), nylon, homopolymer acrylic, polyester, polyphenylene sulfide (PPS), aramid, polyimide, polytetrafluoroethylene (PTFE), and even fiberglass. They fall under different brand names, and can be processed into different thickness, and weaved into different forms. Key design considerations are the temperature limits, resistance to acids, alkalis, hydrolysis and oxidation. Vatavuk (1998) discusses that the filter media selection is based on the contaminants of the gas to be cleaned. In terms of maximum temperature, PTFE and fiberglass fibers can withstand up to 500°C and 550°C respectively. In terms of resistance to acids, the polymers PVC, PP, PPS, and PTFE are good candidates. These four polymers have excellent resistance to acids. In terms of excellent resistance to bases or alkalis, aramid and nylon can be added to the preceding list. Hydrolysis is the decomposition of a substance in the presence of water. Therefore, in applications involving humid (high moisture) gases, polyesters and aramid fibers need to be avoided. With respect to applications involving strong oxidizing agents, polypropylene as filter media needs to be avoided too. Different applications treat effluent gases with contaminants of different particle sizes, and chemical composition. Care needs to be taken in assessing what filter media to use. The worst case scenario might be that contaminant particles still pass through the filter media, or particles might adhere to the filter media matrix, or the filter media is degraded or decomposed by the contaminant particles.

Also, cost considerations and strength of materials need to be thoroughly evaluated. In terms of strength, some filter media a polymer membrane is laminated with a fabric backing. The resulting filter media is termed to as scrim. This is to address the penetration of particles during the phase when the dust cake has not yet accumulated. The key is understanding the effluent gas. For instance, coal-fired boilers operate at a temperature of 204°C. The exhaust from this utilities equipment is very acidic due to the high sulfur oxide content. In this application, woven glass bags are coated with silicon graphite or PTFE. The fiberglass filter is chosen due to the inherent high temperature of the effluent gas. The silicon graphite or PTFE coating serves as lubricant.

TYPES OF BAGHOUSE FILTERS

Baghouse filters are classified according to the way they are cleaned during operation. The three major types of baghouse filters are the: (a) reverse air baghouse, (b) pulse jet baghouse, and (c) shaker baghouse (Neundorfer, Inc., 2014). First is the reverse air baghouse. In this type, bags are placed in compartments. It is named as such because during cleaning there is a reversal of air flow. The upward effluent gas flow is stopped. A separate fan produces the necessary downward stream of air. This termed to as backwashing. The air pressure is low resulting in gentle cleaning. The advantage of this type is that bag life is prolonged. Basically, a reverse air baghouse system consist of isolation dampers, filter bag tensioning system, anti-collapse rings, and a reverse air fan. The second type is the pulse jet baghouse. A high pressure jet of air is used to do the intermediate cleaning. However, the dust bags are supported by ring structures to withstand the high pressure. The system permits automated cleaning. Since a pulse jet pressure is higher than the normal pressure of effluent gas. A typical pulse jet system consists of compressed air source, compressed air storage header, solenoid valve, diaphragm valve, and a blowpipe. Lastly, there is the shaker baghouse type. This type is the most energy-extensive of the three since it uses mechanical agitation (pneumatic, hydraulic, or motor-actuated). Similar to reverse air type, cleaning is done offline. The system consists of attachments for top and bottom of each bag, movable frame from which bags are hung, and a shaft and rod attached to an external motor.

Hoeflinger (2010) discusses on a hybrid type of baghouse filter which is increasingly becoming popular. The hybrid technology is a combination of electrostatic precipitation and baghouse filter. Electrostatic precipitation enhances the filtration process. The individual disadvantages such as: (a) low efficiency for electrostatic precipitation and (b) high pressure drop and (c) premature clogging are reduced or eliminated. The integrated system has high separation efficiency and low pressure drop. Furthermore the system becomes cost efficient and allows for longer operating cycle (minimal downtime). With the low pressurized air consumption, it is considered cheaper than either technologies standing alone. For this system, the electrostatic precipitation section comes first. Electrostatic precipitation alone has lower efficiency at 90% compared to the 99. 9% of baghouse filters. Putting the baghouse filter in series at downstream significantly reduces the cleaning load of the baghouse filter.

BEST PRACTICES IN BAGHOUSE FILTER OPERATION

Based on experience by design engineers, consultants, and end-users, troubleshooting can be attributed to 3 classes of factors: (a) high differential pressure factors, (b) opacity factors, and (c) short bag life factors.

First is high differential pressure. These can be the result of several root causes. For air-to-cloth ratio, recommended ratio is at 4-6 fpm per square feet of cloth area. Excessive air-to-cloth ratio results in migration, leading to low cleaning efficiency. Another reason is particulate adhesion which can be caused by moisture, amine slippage, steam leak, and dew point temperature. Also sufficient cleaning is recommended as oppose to over-cleaning. This is because the particle dust cake aids in the filtration mechanism. Blinded filter bags can also be the reason for high pressure differential. Here, the pores of the filter bags are likely to be clogged. Sometimes process changes in raw materials alter the baghouse system significantly. For instance, low quality coal can result in more PM emissions due to incomplete combustion.

Another area that is to be included in the baghouse checklist are the opacity factors. Opacity here refers to the efficiency of the filter pores to trap contaminant particles. Bag failure may be caused by leaks either caused by natural wear and tear or mechanical failures of the bags. At times, incorrect startup procedures result in preliminary blinding of filters. Insufficient cleaning might also contribute to the scenario. Lastly, short bag life can be accompanied by cost implications. Strategies have to be done to address short bag life. Incorrect design procedures in terms of air-to-cloth ratio and filter bag media are the main suspects. However, inefficient methods in terms of startup procedure, excessive cleaning, or frequent cleaning can also result to short bag life. Process changes and frequent startups and shutdowns are also likely causes.

The key point here is that by addressing the root cause, selecting the right courses of corrective action is easier.

CONCLUSION

Particle pollution is a real health hazard to mankind and also to the environment. With the passing of laws in different countries concerning clean air standards, regulations are implemented to adhere to the standards. Industries are looking at different technologies such as electrostatic precipitation, wet scrubbing, cyclone separation, and baghouse filters. Baghouse filters in particular are used extensively because of its high particle separation efficiency at 99 to 99. 9%.

The future looks promising for baghouse filter technology due to the industry experience, onsite verification, and current researches by firms specializing in this technology. Many design considerations have to be assessed and looked upon to install and operate and efficient and cost-effective way of reducing particulate matter contaminants. This allows industries to discharge effluent gases that pass current environment standards.

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