Pulverisation or crushing equipment: The pulverisation or crushing equipment is categorised into three types according to the type of force that the machine exerts on the solid to crush it finely. That is, the equipment that uses pressure by sandwiching the material to be crushed between two surfaces, the one that uses impact by hitting the material with a hammer so that it is crushed instantly by a high speed collision of a hard body, and the one that uses shear force exerted perpendicular to the direction of sear force.

Polishing process: Polishing is an operation that finishes the surface of material by using the polishing machine such as the belt sander, drum sander and wide belt sander. The belt sander polishes the surface of material by moving the polishing paper or cloth with 2–4 pulleys. The drum sander polishes the material by rotating a cylinder, wrapped around with the polishing paper or cloth, at high speed.

The wide belt sander is a machine to polish the material by upper and lower drums wrapped with an endless polishing paper. These machines are used in the factories for paper and pulp manufacturing, furniture manufacturing, and plywood manufacturing, and produce dusts.

Sieving of particles: The sieve discriminates between smaller particles, which pass through small holes, and larger particles, which do not. It is used to classify the dust that corresponds to a mesh of the sieve by moving the dust on it. The mesh and thickness of the sieve are specified by the Japanese Industrial Standard (JIS). If the dust is classified by stacking a sieve with a larger mesh on another sieve with a smaller mesh, its particle size distribution can be obtained.

For industrial purposes, the rotation sieve which has a sieve of cylindrical wall and the flat sieve which uses a moving flat sieve are used. The dust is generated at the particle feed portion, on the mesh of a sieve, and at the particle discharge portion. The protection measures such as cover and a dust collecting equipment are installed.

Transportation of particles: For the transportation of particles, belt conveyers and bucket conveyers are used, and they also scatter dusts. The belt conveyer is a transportation facility which has an endless belt stretched between two pulleys on both ends of a frame and transfers loads on the belt by moving it continuously. This facility is quite economical for transporting loose materials such as coal, ore, or gravel, but sometimes accompanied by dust scattering. Also, the bucket conveyer is a facility to transport loose materials from the lower to higher positions vertically or at a steep angle. Buckets are attached at a constant distance to a chain or a belt stretched upward, and loose materials thrown into the bucket are continuously transported upward. When it is used for transporting dusts, they are scattered around. The protection cover is installed or the dust is collected by a dust collecting equipment while arranging an enclosure hood.

Pile of particles: Industrial raw materials such as coal and ore are often stored in the open air as a pile, but some are lost through the scattering of dust. For instance, it is reported that about 6.4 mg per 1 kg per year will be lost from the pile of coal. Also, about 13.2 pounds (1 pound = 0.4536 kg) per acre of pile area (1 area = 4046 m^2) per day of rock and gravel is reported to be lost from the rock pile operated 24 hours a day. Measures such as the water sprinkling or the chemical sprinkling by a sprinkler are used.

Mist

Mist is a phenomenon of small droplets suspended in air. It can occur as part of natural weather or volcanic activity, and is common in cold air above warmer water, in exhaled air in the cold, and in a steam room of a sauna. It can also be created artificially with aerosol canisters if the humidity conditions are right. The only difference between mist and fog is visibility. This phenomenon is called fog if the visibility is one kilometre (1100 yards) or less (in the UK for driving purposes the definition of fog is visibility less than 200 metres, for pilots the distance is 1 kilometre). Otherwise it is known as mist. Seen from a distance, mist is bluish, and haze is more brownish. Religious connotations are associated difficult to maintain corona discharge and hence back-ionisation occurs decreasing the efficiency. Particles of high resistivity may be conditioned with moisture to bring them into the acceptable range. This can be achieved by spraying water or steam into the gas stream at the inlet. If the resistivity is less, particles are charged easily, but dissipate it so quickly that the particles are re-entrained in the gas stream, again decreasing the efficiency. 'Dust resistivity' is a function of the composition of the dust, the continuity of the dust layer, operating temperature and the voltage gradient in the dust layer. Thus, when dust resistivity is high, the collecting electrodes should be cleaned to 0.2 to 0.3 cm of dust thickness, by rapping or vibrating the collecting electrode. The dislodged particles are collected in the dust hopper. If the particulates are 'liquid droplets', they are automatically drained into the hoppered bottom by gravity. Both collecting and discharge electrodes must be cleaned of dust to reduce electrical resistance of the dust layers and permit continued operation. Dust build-up on wires is difficult to be removed and occasionally, the deposited dust resembling 'dough nuts' or 'grape fruits' must be removed by hand cleaning or electrode rapping. The frequency and intensity of the rapping cycle have an important effect on the collection efficiency of the precipitator. A high collection efficiency requires that the dust, when rapped loose from the collecting plate, should fall as coarse aggregates, so that it is not redispersed into the gas stream. Cylindrical ESPs are preferred to collect liquid particles with high efficiency.

Re-entrainment

In the derivation of collection efficiency equations, re-entrainment of the deposited dust is usually neglected. The re-entrainment has no effect on liquid droplets but for dry particles, re-entrainment losses can markedly reduce efficiency. There are a number of different causes of re-entrainment. Gas flow through the hoppers can sweep the collected dust back into the gas stream. This can be minimised by providing baffles in the hoppers to reduce gas circulation.

Advantages and disadvantages of electrostatic precipitators

Advantages

1. High collection efficiency.
2. Particles as small as 0.1 micron can be removed.
3. Low maintenance and operating costs.
4. Low pressure drop (0.25 to 1.25 cm of water).
5. Satisfactory handling of large quantities of high temperature gas.
6. Treatment time is negligible (0.1 to 10 seconds).
7. Cleaning is easy by removing units of the precipitator from operation.
8. There is no limit to solid, liquid or corrosive chemical usage.

Disadvantages

1. High initial cost.
2. Space requirement is more because of the large size of the equipment.
3. Possible explosion hazards during collection of combustible gases or particulates. Well trained personnel are needed.
4. The poisonous gas, ozone is produced by the negatively charged discharge electrodes during gas ionisation.
5. Precautions are necessary to maintain safety during operation (i.e. proper gas flow distribution, gas resistivity, particulate conductivity, etc.).
6. Gases cannot be removed by ESPs.

historical monuments and works of art. Sulphurous and sulphuric acids formed from sulphur dioxide and sulphur trioxide when they react with moisture may also damage paper and leather. Details are given below.

Effects of SO_2 on materials

1. SO_2 also rapidly attacks marble, limestone, roofing, slate, electrical contacts, paper, textiles and buildings. It can even dissolve nylon. Some textile fibres obtained from vegetable sources lose strength when exposed to H_2SO_4. However, wool is somewhat more resistant to SO_2.
2. Paper also absorbs SO_2 which is oxidised to H_2SO_4, causing it to become brittle and fragile.
3. Leather too has much affinity towards SO_2, which affects its strength and causes it to disintegrate.
4. SO_2 is also involved in erosion of building materials such as marble, mortar and in the deterioration of statues.
5. Pollutant emissions of SO_2 from the nearby railway marshalling yard, thermal power stations and about 300 foundries are accelerating the deterioration of world famous Taj Mahal in Agra. Pollutants from Mathura refinery may also cause serious damage to the Taj Mahal.
6. Petroleum refineries, craft paper mills, smelters and industries liberating SO_2 adversely affect historic monuments.
7. Acid rain produced by the oxidation of SO_2 corrodes metals, attacks fibres and washes out basic materials like lime from the soil. The rapid attack of H_2SO_4 on marble is known as 'stone leprosy'.
8. Long exposure to SO_2 increases the drying and hardening time of paints. It affects durability in paint films. For example, exposure of linseed oil paint films 1–2 ppm SO_2 increased drying times by 50–100 per cent.
9. SO_2 polluted air accelerates corrosion rates of metals such as Fe, steel, Zn and Cu. High humidity, particulate matter and temperature also enhance the corrosion of metals.

Effects of SO_2 on man

SO_2 affects human health in various ways:

1. It causes intense irritation to eyes and respiratory tract even at 2.5 ppm levels.
2. SO_2 is absorbed by the nasal system, leading to swelling and stimulated mucus secretion. It severely affects the aged and chronically ill persons.
3. Lung cancer is known to result from increased levels of SO_2 in the atmosphere.
4. SO_2 inhalation causes bronchitis, emphysema and other lung diseases. The intensity increases with the increased atmospheric concentration of SO_2.
5. London or sulphurous acid smog, called the killer smog of January 1956, was formed when SO_2 concentration rose to 0.40 ppm. As a result, the mortality rate among the aged increased from 130 to 180 per day.
6. Moisture and fog enhance SO_2 danger due to the formation of H_2SO_3 and H_2SO_4, and also sulphates. H_2SO_4 is nearly 5 to 20 times as irritant as SO_2.
7. SO_2 is considered as the most serious single air pollutant causing health hazard, obstructing breathing.
8. Oxides of sulphur are the major contributors to lung diseases, cough and choking. Their increased concentration causes acute and chronic asthma.
9. SO_2 is a severe allergenic agent.

of ciliated cells in the tracheal and bronchiolar epithelium, and (ii) lymphocyte infiltration of the bronchial submucosa. Some exposed animals responded similarly to controls to aerosol methacholine challenge, whereas a subgroup of exposed rats were hyperreactive to concentrations as low as 1 ppm.

Male rats were exposed to 0, 10, 200, or 400 ppm H_2S for 4 hours. Samples of bronchoalveolar and nasal lavage fluid contained increased inflammatory cells, protein, and lactate dehydrogenase in rats treated with 400 ppm. Lopez and associates later showed that exposure to 83 ppm (116 mg/m^3) for 4 hrs resulted in mild perivascular edema.

A study by Saillenfait investigated the developmental toxicity of H_2S in rats. Rats were exposed 6 hrs/day on days 6 through 20 of gestation to 100 ppm hydrogen sulphide. No maternal toxicity or developmental defects were observed.

Hayden exposed gravid Sprague-Dawley rat dams continuously to 0, 20, 50, and 75 ppm H_2S from day 6 of gestation until day 21 postpartum. The animals demonstrated normal reproductive parameters until parturition when delivery time was extended in a dose dependent manner (with a maximum increase of 42 per cent at 75 ppm). Pups which were exposed in utero and neonatally to day 21 postpartum developed with a subtle decrease in time of ear detachment and hair development and with no other observed change in growth and development through day 21 postpartum.

The adverse effects reported in chronic animal studies occur at higher concentrations than effects seen in acute human exposures. For example, human irritation was reported at concentrations of 2.5–5 ppm for 15 minutes, yet no effects on laboratory animals were observed at concentrations up to 80 ppm for 90 days. This suggests either that humans are more sensitive to H_2S, or that the measurements in laboratory animals are too crude to detect subtle measures of irritation. However, the uncertainty factor and HEC attempt to account for these interspecies differences.

Data Strengths and Limitations for Development of the REL

Hydrogen sulphide is the leading chemical agent causing human fatalities following inhalation exposures. Although lower concentration acute exposures have been quantitatively studied with human volunteers, the dose-response relationship for human toxicity due to hydrogen sulphide exposure is not known. Thus, a major area of uncertainty is the lack of adequate long-term human exposure data. Subchronic (but not chronic) studies have been conducted with several animal species and strains, and these studies offer an adequate basis for quantitative risk assessment.

The strengths of the inhalation REL include the availability of controlled exposure inhalation studies in multiple species at multiple exposure concentrations, adequate histopathogical analysis, and the observation of a NOAEL.

Effects of Hydrogen Sulphide (H_2S) and Organic Sulphides

1. Mostly sulphides cause odour nuisance when present even in minute concentrations.
2. H_2S causes headache, nausea, collapse, coma and death even at 1–3 ppm.
3. H_2S at 5 ppm affects the digestive system destroying appetite.
4. An exposure to 150 ppm of H_2S gives rise to conjunctivitis and irritation of the mucos membrane.
5. H_2S gas rapidly passes through the alveolar membrane of lungs and penetrates blood. It causes death due to respiratory failure.
6. Even a short exposure, for 10–30 minutes at 500 ppm, of H_2S causes colic diarrhoea and bronchial pneumonia.
7. H_2S reacts with lead paints to form lead sulphide, thereby producing brown to black discolouration.

Contents at a Glance

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SECTION V