AIR POLLUTION

PROBLEMS (II)

Problem 6.- A medium-efficiency standard cyclone is to be used to clean up 1,000 $m^3 \cdot h^{-1}$ of gas at 50 °C carrying particles of density 1,200 $kg \cdot m^{-3}$. Assuming that the density and viscosity of the carrier gas are 1.25 $kg \cdot m^{-3}$ and $1.8 \cdot 10^{-5}$ $N \cdot s \cdot m^{-2}$, determine the diameter of the particles collected with a 50% efficiency. The inlet velocity cannot be higher than 10 $m \cdot s^{-1}$.

Problem 7.- Determine the efficiency based on mass (%) of a standard cyclone which is collecting particles with a diameter of 10 μm and a density of 800 $kg \cdot m^{-3}$. Use Lapple's approach for this evaluation and assume the following conditions:

- Main cylinder diameter 0,5 m
- Flow rate 4,0 $m^3 \cdot s^{-1}$
- Gas temperature 25 °C
- Gas viscosity at 25 °C 18.5 μPa s
- Gas density at 25 °C 1.2 $kg \cdot m^{-3}$

Problem 8.- A pulverized coal-fired steam power plant releases 150 m^3 of gases per kilogram of coal burning. The burning of a ton of coal entails the release of 5 kg of particles.

8.1. Calculate the concentration of particles in the exhaust gas (in $g \cdot m^{-3}$) considering that each day 5 tons of coal are burnt.

8.2. A plate-type electrostatic precipitator (ESP) is going to be installed in order to attract and collect these particles. The collecting plates of the selected model are 4 m long and 1.5 m tall in the direction of flow. A test on a similar ESP prototype indicated that the migration velocity of the particles emitted by this process is about 5 $m \cdot min^{-1}$. Calculate the number of collection plates required to achieve an overall collection efficiency of 99%.

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Problem 9.- A cast-iron manufacturing process releases 10 t of particles to the atmosphere per day. The average density of these particles is 2,300 kg·m^{-3}. The business owners and engineers of this factory are considering two systems to clean this particle-laden gas: an electrofilter and a high efficiency cyclone. The size range, typical size, feed distribution (% mass) and collection efficiency of the two collectors are set out in the table below.

Size particles (μm)	***0-10***	***10-20***	***20-44***	***> 44***
Typical size (μm)	5	15	32	≈ 50
Mass particles (%)	20	35	30	15
Efficiency electrofilter	90	97	99,5	100
Efficiency cyclone	55	78	90	99

9.1. Determine the global collection efficiency based on the mass (%) of these two collectors.

9.2. Calculate the mass (in kg) and number of PM_{10} particles that would be released daily if each of these collection systems were installed. Compare the results.

Problem 10.- The weight distribution by size ranges of the particulate matter carried by a gaseous effluent is given in the table below. A gas-particle separation device was tested: the results of the collection efficiency for different size ranges are detailed in the third column. The inlet gas flow rate is 0.3 m^3·s^{-1} and the PM loading is 18 g·m^{-3} under standard conditions for temperature and pressure.

10.1 Compute the global collection efficiency of this device (in %)

10.2 Calculate the mass of dust with a diameter < 20 μm (in %) in the emission.

Range diameter (μm)	***Mass (%)***	***Fractional efficiency (%)***
< 5	10	20
5 – 10	15	40
10 – 20	35	80
20 – 40	20	90
40 – 80	10	95
> 80	10	100

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