11.10.2022

$Q_1 = 223\ m^3/hr$

$Q_2 = 669\ m^3/hr$ $\qquad Q = 1,00,000$

no. of cyclone $= \dfrac{Q}{Q_1} = \dfrac{100,000}{223} = 448.$

min^m no. of cyclone.

scale-up is to be done.

S.F = scale-up factor $= \dfrac{d_2}{d_1} \ \dfrac{D_{c2}}{D_{c1}}$

$$\frac{d_2}{d_1} = \left[\left(\frac{D_{c2}}{D_{c1}}\right)^3 \left(\frac{Q_1}{Q_2}\right)\left(\frac{\Delta\rho_1}{\Delta\rho_2}\right) \times \left(\frac{\mu_2}{\mu_1}\right)\right]^{1/2}.$$

d_1 → mean diameter of particle separated at std cyclone design conditions at the choosen separation efficiency of high η or high throughput.

~~d_2 → m~~

d_2 → mean particle dia in the proposed design.

D_{C_2} → dia of cyclone proposed

D_{C_1} → dia of standard cyclone. (203 mm)

Q_1 → flow rate of gas in std cyclone ($223\ m^3/hr$)

Q_2 → flow rate of gas in proposed design (669 m

$\Delta\rho_1 = \rho_p - \rho_g = 2000\ kg/m^3$

$\Delta\rho_2 = (\rho_p - \rho_g)$ of proposed ~~design~~ particle of gas

μ_1 = viscosity of gas 0.18 mNs/m.

μ_2 = " " gas for proposed design

$DC_2 =$.

$=$ Area × ~~flowrate~~ velocity

min^m velocity 15 m/s

flow rate $= \frac{m^3}{sec}$

$Q_2 = b \times h \times V_s$. (proposed design)

$= f(D) \times f(D) \times V_s$

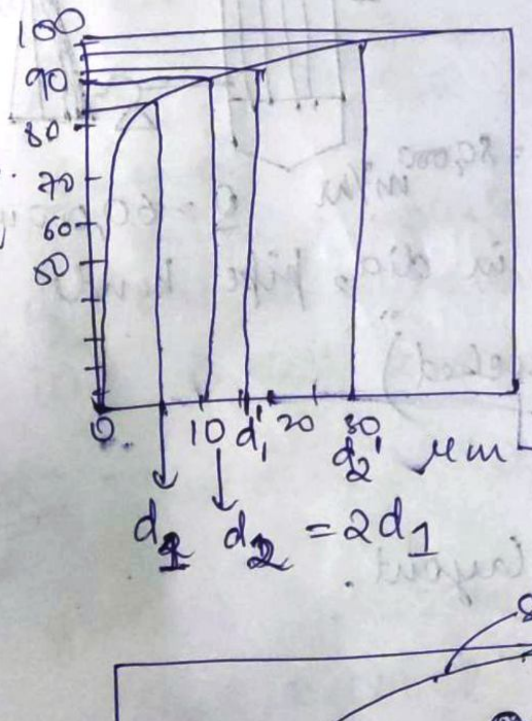
$\frac{d_2}{d_1} = 2.0$. $\therefore d_2 = 2$ times of d_1.

$d_1 = 5\,\mu m$; $d_2 = 10\,\mu m$

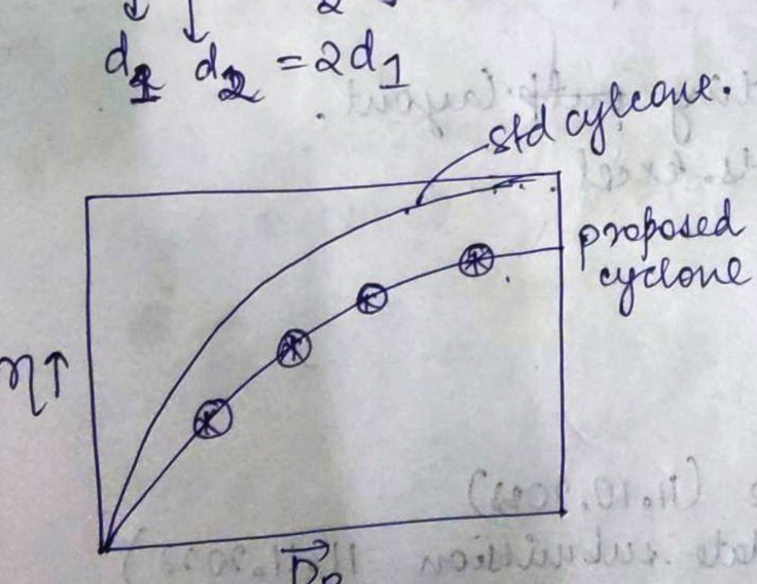
$d_1 = 15\,\mu m$; $d_2 = 30\,\mu m$

$\frac{dp_2}{dp_1} = 2.0$

draw secondary plot on graph



$d_1 \;\; d_2 = 2d_1$



if η ↓ increase no. of cyclones to achieve the η.

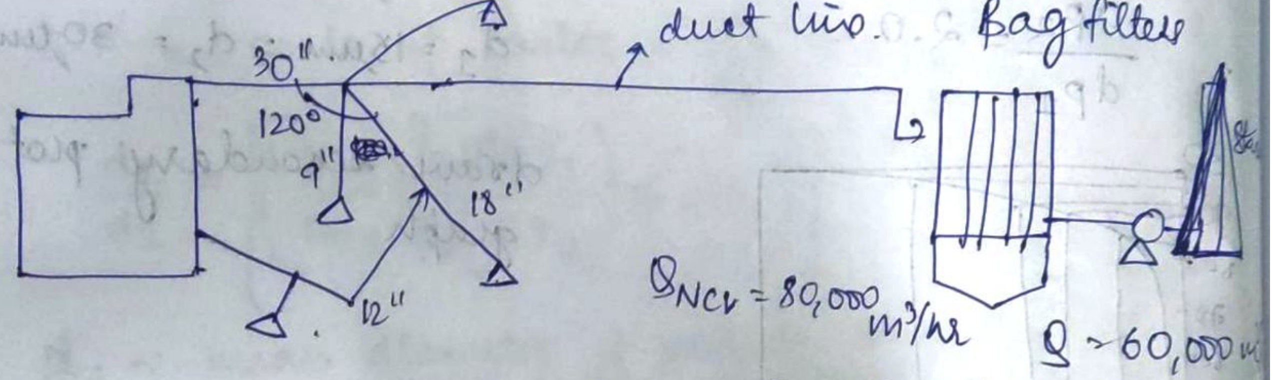
Standard condition are to be considered. (using standard Book of Chem. Engg).

8. Source approximation

$Q = 60{,}000\ m^3/hr$

Pressure losses :

Ducting Layout :-



pressure losses due to change in dia, pipe bends

ΣQ_n (Q of all hood. gas sucked)

n → no. of hoods → suction ~~sour~~ pt.

→ simply the ~~tav~~ ducting ~~outp~~ layout.

→ calculate in Ms. excel.

→ Design.

→ Adequate or not

→ Capacity required

(one month time (11.10.2022)

(Assignment date submission 11.11.2022)

Q. A conventional cyclone of dia. 500 mm is used to treat the flue gas containing cement dust particulate of 3.5 gm/m³ at 165°C and 1.0 atm. pressure. The inlet gas velocity is 17 m/s and no. of turns the gas complete in cyclone is 5.

Data: ρ_p – 2700 Kg/m³ and ρ_g – 1.04 Kg/m³ resp. viscosity of gas μ = 0.019 CP.

particle size distribution are as follows:

particle size (µm)	>50	50-40	40-30	30-20	20-15	15-10	10-5	<5
% wt.	19.5	10.0	7.5	15.0	21.0	15.0	9.5	2.5

Calculate:

i) cut size particle diameter

ii) Overall collection efficiency of cyclone.

iii) Outlet conc. of dust from cyclone.

Solⁿ cut dia = $d_{pc} = \left[\dfrac{9\,\mu\,(W)}{2\pi N v_i \cdot (\rho_p - \rho_g)}\right]^{1/2}$

given → $\rho_p = 2700$ Kg/m³ ; ρ_g – 1.04 Kg/m³

$\mu_g = 0.019$ CP $= 0.019 \times 10^{-3}$ $\frac{Kg}{mS}$.

$v_i = 17$ m/s $\quad D_C = 0.5$ m $= 500 \times 10^{-3} = 0.5$ m.

$n = 5$.

$$d_{pc} = \frac{9 \times 0.019 \times 10^{-3} \times 0.2 \times 0.5}{2 \times 3.14 \times 5 \times 17 \times (2700 - 1.04)}$$

$= \sqrt{5.934 \times 10^{-11}}$ $\quad 10^{-6}$.

$= \cancel{5.934 \times 10^{-5}}$ µm $= 7.703 \times 10^{-6}$ m

$=$ 7.703 µm

ii) Overall collection efficiency

$$\eta_i = \frac{\left(\frac{D_{p\,avg\,i}}{D_{pc}}\right)^2}{1 + \left(\frac{D_{p\,avg\,i}}{D_{pc}}\right)^2} \qquad d_{pc} = 7.703\,\mu m$$

overall efficiency $= \sum \eta_i$ wt%.

d_{p_i} =	>50	50-40	40-30	30-20	20-15	10-5	<5
$\overline{d_p}$	25	45	35	25	17.5	7.5	2.5

$d_{p\,avg} = 20\,\mu m$

$\eta_i = \eta_1 = 0.913 = 91.3\%$

$\eta_2 = 0.971 = 97\%$

$\eta_3 = 0.9538 = 95.38\%$

$\eta_4 = \cancel{0.7913} = \cancel{79.13\%}$ $0.9132 = 91.32\%$

$\eta_5 = 0.8376 = 83.76\%$

$\eta_6 = 0.724 = 72.4\%$

$\eta_7 = 0.513 = 51.3\%$

$\eta_8 = 0.0929 = \cancel{0.95}$ 9.529%

$\eta_{overall} = \sum$

$\_\_\_\_ \times \_\_\_\_\_\_\_\_ \times \_\_\_\_$

i) $D_{p,c} = \left[\dfrac{9\mu_f b}{2\pi N V_i (\rho_p - \rho_f)}\right]^{1/2}$

$1\,cP = 10^{-3}\,Pa\text{-}s = 1\,m$

given – $\mu_f = 0.019\,cP = 10^{-3} \times 0.019\,Pa\text{-}s$

$\rho_p = 2700\,kg/m^3$ $\quad N = 5$

$\rho_g = 1.04\,kg/m^3$. $\quad b = 0.2 D_c$

$v_i = 17\,m/s$ $\quad D_c \rightarrow$ cyclone dia $= 0.5$

$D_{p,c} = 3.445 \times 10^{-6}\,m$

$= \underline{3.445\,\mu m}$

ii) $\eta_i = \dfrac{\left(\dfrac{Dpavg_i}{Dpc}\right)^2}{1 + \left(\dfrac{Dpavg_i}{Dpc}\right)^2}$

① ~~Dpavg~~ $dpavg_1 = 25\,\mu m$

$\eta_1 = \dfrac{\cancel{3.445}\left(\dfrac{25}{3.445}\right)^2}{1+\left(\dfrac{25}{3.445}\right)^2} = 98.13\%$

② η_2 $\quad dpavg_2 = \dfrac{\left(\dfrac{45}{3.445}\right)^2}{1+\left(\dfrac{45}{3.445}\right)^2} = 99.41\%$

③ η_3 $\quad dpavg_3 = 35$

$\eta_3 = \dfrac{\left(\dfrac{35}{3.445}\right)^2}{1+\left(\dfrac{35}{3.445}\right)^2} = 99.04\%$

④ $dp_{avg4} = 25$

$$\eta_4 = \frac{\left(\frac{25}{3.445}\right)^2}{1+\left(\frac{25}{3.445}\right)^2} = 98.13\%$$

⑤ $dp_{avg5} = 17.5$

$$\eta_5 = \frac{\left(\frac{17.5}{3.445}\right)^2}{1+\left(\frac{17.5}{3.445}\right)^2} = 96.26\%$$

⑥ $dp_{avg6} = 12.5$

$$\eta_6 = \frac{\left(\frac{12.5}{3.445}\right)^2}{1+\left(\frac{12.5}{3.445}\right)^2} = 92.94\%$$

⑦ $dp_{avg7} = 7.5$

$$\eta_7 = \frac{\left(\frac{7.5}{3.445}\right)^2}{1+\left(\frac{7.5}{3.445}\right)^2} \rightarrow 82.57\%$$

⑧ $dp_{avg8} = 2.5$

$$\eta_8 = \frac{\left(\frac{2.5}{3.445}\right)^2}{1+\left(\frac{2.5}{3.445}\right)^2} = 34.49\%$$

Overall efficiency

$\eta_{overall} = \sum \eta_i \cdot wt\% \quad \sum \eta_i x_i$

$= 0.9813 \times 19.5 + 0.9941 \times 10 + 7.5 \times \cancel{99.04}\ 0.9904$

$+ \cancel{0.989}\ 0.9813 \times 15 + 21 \times 0.9626 + 15 \times 0.9294$

$+ 9.5 \times 0.82.57 + 0.3449 \times 2.5$

$\eta_{overall} = 94.08\%$

iii) $\eta = \dfrac{\text{mass of dust collected}}{\text{mass of dust inlet}}$

$\Rightarrow 0.9408 \times 3.5 \dfrac{gm}{m^3} =$ outlet mass conc. of dust.

$\Rightarrow 3.2928 \dfrac{gm}{m^3}$

$\eta = \dfrac{C_{inlet} - C_{out}}{C_{inlet}}$

$\eta = 0.9408 = \dfrac{\cancel{3.5}\ 3500 - C_{out}}{3500}$

2. Design a cyclone to remove solids from conc. gas stream. The particle size distribution of the stream is given below. The ρ_p = 2500 kg/m³ and the gas is essentially N_2 at 50°c. The stream volumetric flow rate is 4000m³/hr and the cyclone operates at 1atm pressure emission unit consideration gives 80% solids must be removed.

particle size (μm)	50	40	30	20	10	5	2
% by wt less than	90	86	80	70	45	25	10

Soln given = η

$Q = 4000 m^3/hr$ $\qquad P = 1 atm$

$\rho_p = 2500 Kg/m^3$ $\qquad \rho_f = 1.25 \; Kg/m^3$.

$\Delta\rho = \cancel{1.25 \; Kg/m^3}$ $\qquad \Delta\rho_2 = 2498.75$

$\mu_{f_2} =$ Pa-sec.

$\mu_{f_1} = 0.18$ Pa-sec.

$$\frac{d_2}{d_1} = \left[\left(\frac{Dc_2}{Dc_1}\right)^3 \left(\frac{Q_1}{Q_2}\right)\left(\frac{\Delta\rho_1}{\Delta\rho_2}\right)\left(\frac{\mu_2}{\mu_1}\right)\right]^{1/2} = 1.5, 2$$

$$\left(\frac{22.428}{11.214}\right) = \left[\left(\frac{Dc_2}{203}\right)^3 \left(\frac{223}{4000}\right)\left(\frac{2000}{2498.75}\right)\left(\frac{}{0.18}\right)\right]^{1/2}$$

$\cancel{Q_2 = b \times h \times V_s}$ for high efficiency

$\cancel{2000 = 0.2 Dc_2 \times 0.5 Dc_2 \times 15}$ $\qquad (V_s = 15)$

$\cancel{Dc_2 = 51.6 \; m}$

$dp_{2avg} = 22.428\ \mu m$

$\frac{dp_2}{dp_1} = 2 \Rightarrow dp_2 = 2 \times dp_1.$

$\Rightarrow dp_1 = \frac{dp_2}{2} = 11.214\ \mu m$

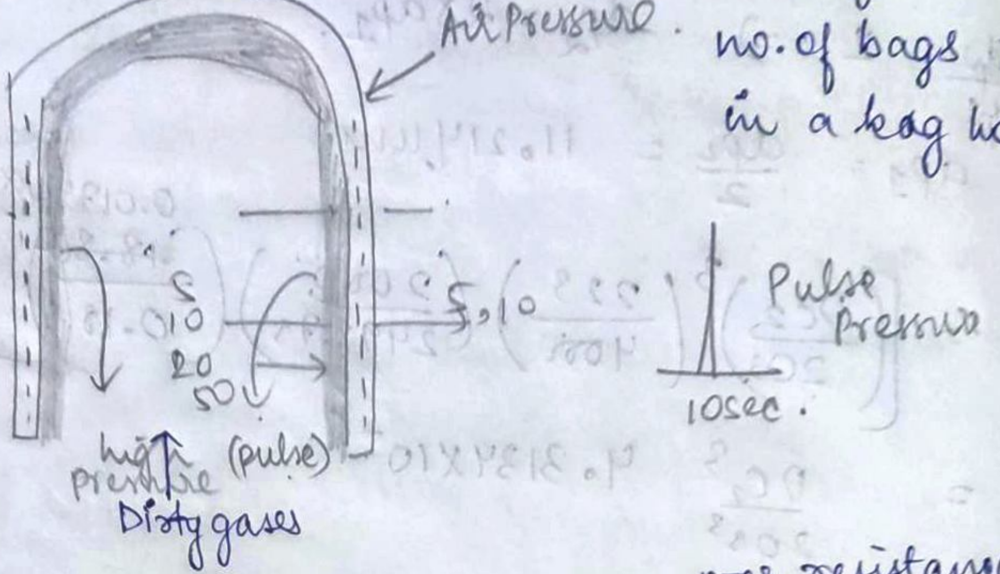
$$\Rightarrow 2 = \left[\left(\frac{Dc_2}{203}\right)^3 \left(\frac{223}{4000}\right)\left(\frac{2000}{2498.75}\right)\left(\frac{\overset{0.01744\times10^{-3}}{\cancel{18.80}}}{0.18}\right)\right]^{1/2}$$

$$\Rightarrow 4 = \frac{Dc_2^3}{203^3}\ 4.3134\times10^{-6}$$

$Dc = 19795\ mm$

18/10/2022 :

Bag Filters :-



, Length - 8 ft - 10

no. of bags present in a bag house.

max^{m} temp withstand is glass (280°C) → poor resistance to abrasion.

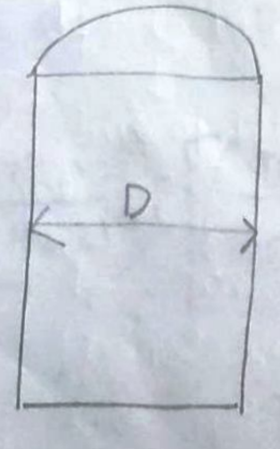
it is desired to maintain the pollutant gases to be at room temp to avoid spoilage of bag filters.

Cleaning

A. Reverse jet Bag filter

B. Pulse jet. Bag filter.

C. Mechanical shakers Bag Filters



Air to cloth ratio A/C) should be 1.2 to 2.5 in m/min for pulse jet Bag filter.

→ min^{m} no. of bags

→ collection η

(loss of K.E of gases due to long length of pipe of vaccum cleaner.)

calculation of Bag Filter Capacity:-

Bag filter capacity : $Q = 3600 \Sigma q = 3600 nq$

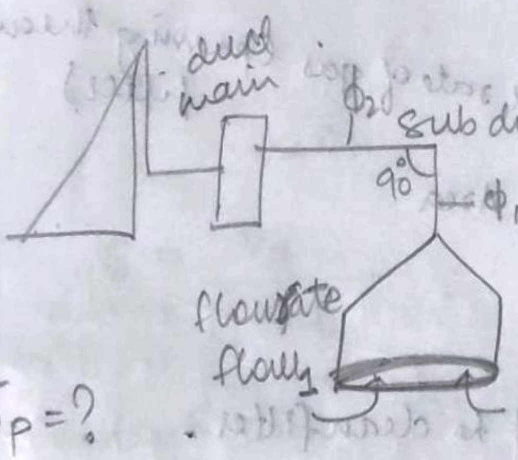
$n \rightarrow$ no. of hoods.

$Q \rightarrow$ Bag filter capacity

Calculation of A/C ratio:-

Based on recommended air to cloth ratio.

$$A = \frac{Q_{c,a}}{A/C \text{ ratio}}$$



velocity loss due to loss in K.E.

Pressure drop.

$\bar{D}_p = ?$

$u_t = ?$

particle captured velocity at $2.5 \times v_t$.

q_1 = flow$_1$ + additional flow needed to overcome all the losses in the du[ct]

$Q = q_1 + q_2 + \ldots \ldots q_n$.

$t = 0 \quad Q = Q_0 = Q_1$

$t = t \quad Q = Q.$

$Q_0 > Q$

$Q_1 = 5000 m^3/hr$

$Q_5 = 4700 m^3/hr.$

* high moisture and humidity resistance or else it results in choking of Bag filter.

Cleaning of Bag filter cannot be practiced replace is to be done.

$Q_0 = \frac{Q_1 + Q_L}{2}.$

↑ P ↑s flowrate & overcome the resistance and is ~~filtered~~ closed bag

1.) Constant Pressure (industrial use)

2.) Constant Capacity

Filter velocity = $\frac{Q_G}{A}$ → flow rate of gas (passing through filter); A → surface Area

Filtration :-

$t_T = t_f + t_c$

t_c → time required to clean filter.

t_f → time of filtration ~~required~~

t_T → total time

$t_c = 30$ mins approx (Mechanical Shaker)

$t_c = 10$ min approx (Pulse & Reverse Jet)

if data not provide $t_c = t_f$. (~~no~~ or no cleaning req)

$$\boxed{t_{min} = t_f + \underbrace{t_c}_{0}}$$

Constant Pressure -

$$t_f = \left(\frac{B}{2\Delta P}\right)V_G^2 + \left(\frac{C}{\Delta P}\right)V_G.$$

$V_G \rightarrow$ Vol of gases filtered for deposited dust of thickness dx.

If resistance of filter is negligible :

$$t_f = \left(\frac{B}{2\Delta P}\right)V_G^2$$

$$B = \left(\frac{\mu_G C}{\rho_B K}\right) \times \frac{1}{A^2} = \frac{K}{A^2}.$$

$C =$ Cunningham correction factor.

$\rho_B =$ Bulk density of filter cake.

$A \rightarrow$ Collection Area

$$t_f = K^* \times \frac{V_G^2}{A^2}.$$

$$\Rightarrow K^* = \frac{K}{2\Delta P}$$

$V_G = f(t)$.

$$Q = \frac{V_G}{t_f + t_c}$$

Constant rate filtration (Q = const)

$$\Delta P = BQ^2 t + CQ \quad \text{—— (1)}$$

at $t=0$ $\quad \Delta P = CQ$.

at $t=t$ $\quad \Delta P = \cdot f$ -- (1)

$$\Delta P = (BV_G + D)Q$$

$$Q = \frac{V_G}{t_c + t_f}$$

$\downarrow$

Q_{max}.

for Q_1 max calculate A/C ratio

$A_C = ?$

$N \times A_{G_i} = A_C$

ht of ~~felt~~ bag filter → 8 ft to 10 ft.

dia – 20-30 cm

when

L ↑

Q_1 Q_2 $\frac{K}{A}$ = major loss in main duct.

Pressure loss.

[a'-b] → total L, dia bends losses,

[a-b] " " dia bend losses

no. of

(Assignment)

→ calculated P in excel.

→ Auto-Cad

Q. An old bag filter ~~from~~ for a discontinued process ~~each~~ is to be utilized for constant Pressure filtration at 12.7 cm of H_2O the filter has 20 Bags of ·7432·240 each surface Area. cleaning time ~~is~~ determined is 45 min.

for a given pressure filtration equ.

$t = 674.82 V_G^2$

t → time (min)

V_G → Volume of gas m^3/cm^2.

Determine overall capacity of filtration at. same condition.

$$\boxed{\Delta P_{max} = 700 \text{ cm of } H_2O}$$

$$Q = \frac{V_G \times A_C}{t_c + t_f}$$

$$t_f = 674.82\, V_G^2$$

Q. A filter is operating at const rate on a optimum cycle the filtration equation is

$$V_G^2 = 2.62 \times 10^6 t \times P^{0.65}$$

P – cm of H_2O

$V_G \rightarrow m^3$ of gas filter $t \rightarrow$ time (min)

the filtering time is 45 mins & cleaning time is 0 min. Max^m allowable pressure = 10.16 cm H_2O column calculate ~~over~~ i) max^m overall capacity

ii) ~~If~~ it is necessary ~~the~~ to increase the capacity of bag filter it ~~have~~ been suggested that an additional unit bag filter identical to present one to be installed, both the filter should ~~work~~ operate on same ∴ which has high capacity max^m pressure at present. ~~The thire~~ the time required to clean both units is estimated as 2 mins What is the max^m % of increase in overall capacity by adopting this suggestion.

$$\frac{Q_2 - Q_1}{Q_1} \times 100.$$

25th Oct, 2022

ESP :

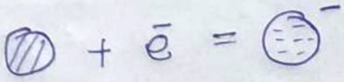
$\bar{D}_p$ = 0.1 to 20 μm.

electrical field = 60,000 to 90,000

Mechanism :-

1. Bombardment
2. Diffusional

ε = dielectric properties

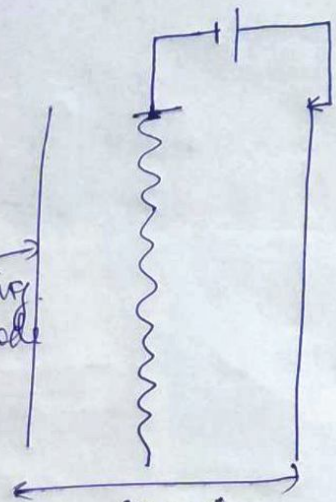


(-ve charged)

thin plate → discharging electrode.

collecting electrode

Discharging electrode.



spacing

$NH_3 + H_2O + SO_2 \rightarrow SO_3 \rightarrow (NH_4)_2SO_4$

1 mV is required for a.

1. Plate to Plate type ESP
2. Tube type - wire in - tube.

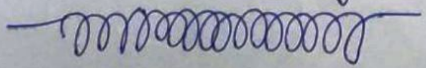
spacing → distance btw 2 ~~disch~~ collecting electrodes/plates

inlet duct → 24 ft. (ht)

Ash pond

n → discharging electrode
n+1 collecting "

discharging electrode.

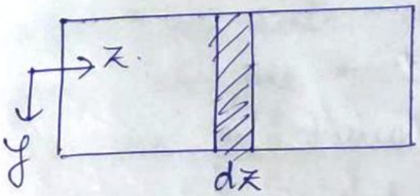


1.) velocity at which the gas is entering in ESP.

particle migration velocity → velocity at which the particle are being attracted towards the collecting plate (nearest).

ESP collection efficiency: (η)

L →



collecting surface Area.

Cross sectional Area = A.

Perimeter → P.

$v_p \to z$ gas velocity.

V_{PM} = Particle migration velocity.

Inlet = Outlet + dust collected on the surface.

in − out = collected.

$$A.V\,(\Delta C) = V_{PM} \times P \times dz \times C$$

$$m^2 \times \frac{m}{s} \times \frac{Kg}{m^3} = \frac{m}{sec} \times m \times m \times \frac{Kg}{m^3}$$

$$Kg/sec = Kg/sec$$

$$-\int_{C_0}^{C_L} \frac{dC}{C} = \frac{V_{PM}}{V} \times \frac{P}{A} \int_0^L dz$$

$$\frac{C_L}{C_0} = \exp\left[-\frac{V_{PM} \times PL}{VA}\right]$$

$$\eta = \frac{C_0 - C_L}{C_0} \times 100 = 1 - e^{-\frac{V_{PM} \times A_C}{Q}}$$

$V_{PM} \to 0.14$ to 0.18 m/s

$$\eta = \frac{C_{inlet} - C_{outlet}}{C_{inlet}} = 1 - \exp\left[-\frac{V_{PM} A_C}{Q}\right]$$

Ht → 5 m × 6 m

$$V_{PM} = \frac{q_L * E C}{3\pi\mu d_p}$$

C → Cunnigham Correction factor

d_p → particle dia in micron

μ → viscosity of gas

q_{Lt} → limiting charge.

E → electric flied.

$$q_{Lt} = q_{Lt/B} + q_{Lt/Diff}.$$

$$q_{Lt/b} = ne$$
$$= f(r_p, E)$$

valid only for $\epsilon = 2.5$

for $\epsilon \neq 2.5$

$$q_{Lt/B} = q_{Lt/b,\epsilon=2.5} * \frac{D_{\epsilon=2}}{D_{\epsilon=2.5}}.$$

$$D = 1 + \frac{2(\epsilon-1)}{(\epsilon+2)}.$$

$$q_{Lt/Diff} = ne = 2\times10^{8} r_p e$$

formation of Corona - (loss of

Ignition of spark is prevent in order to prevent formation Corona.

electronegative charge loss.

→ 20-30 cm spacing is required for plate to plate type of ESP.

$\boxed{\cancel{V_{PM} \propto \frac{E}{S}}}$ $\quad E = \frac{V}{S}$ Voltage supplied / spacing

Electric field

Q. It is required to remove the dust from an iron-ore fine separation unit the contaminated gas flows from the unit at the rate of 8.8 m³/s at 45°C. A bag filter is used to remove the dust particulate matter from separation plant. The gas filter velocity through the bag filter is 1.5 m/min. Determine the are req. to process such gas of if diameter of bag filter dia - 12 cm, length - 5m. How many bags will be required for the continuous carrying of the bags.

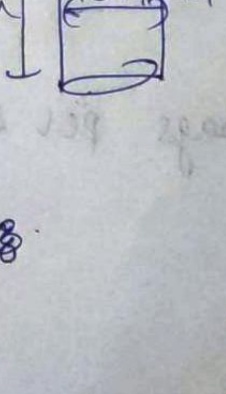
Soln Given = $Q = 8.8\ m^3/sec$, $T = 45°C$

$V_t = 1.5$

dia = 0.12 m $\quad L = 5m$

filter velocity $= \frac{Q_G}{A}$.

$Q = 3600$ mq.



$V_t \times A = 8.8$

$\frac{1.5}{60} \times A = 8.8 \quad \Rightarrow A = \frac{8.8 \times 60}{1.5} =$

Area of one bag = $\pi D L$

$= 3.14 \times 0.12 \times 5$

$=$

Q. A bag filter must ~~produce~~ process ~~15~~ 50 m^3/sec of waste gas the bag house has to be divided into 8 sections cloth Area so that one of the section be shut down for the cleaning or other maintaining works while other section working. set analysis indicate a 9.0 m/min will provide sufficient treatment. the bags are 25 cm in dia 7m length determine no. of bags & physical arrangements to ~~make~~ meet the above requirements.

Soln

$$A = \frac{Qc}{A/c\,ratio}$$

A/c ratio = 9.0 m/min

Qc → 15 m^3/sec

$$A = \frac{\cancel{150}}{\frac{\cancel{9.0}}{\cancel{60}}} = \cancel{\frac{15 \times 60}{9.0}} \quad \frac{\cancel{50} \times 60}{9.0} = \cancel{333}.33$$

$= \cancel{100\,m^2}$ $100\,m^2$

divided into 8 sections →

~~$\frac{100}{8} = 12.5\,m^2$ per section~~

⇒ Area of one bag = $3.14 \times 0.25 \times 7$

$= 5.495\,m^2$

⇒ no. of bags $= \frac{\cancel{333.33}\ 100}{5.495} =$ ~~60 plates~~ ~~18.19 ≈ 19 plates~~ 19 plates

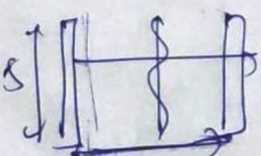
bags per section $= \frac{19 \text{ plates}}{8 \text{ sections}} = 2.375 \approx 3$ plates

$= \frac{19}{7} = 2.714 \approx 3$ plates.

Q. A wire in tube type ESP having total collecting to separate

Q. A horizontal parallel plate consists of 5 m ht 6 m width with 30 cm plate to plate spacing having collection efficiency of 94.4% for handling a contaminated gas of 180 m^3/min. ~~the~~

The gas enters the ESP at 450°C & inlet loading is 10 g/m^3 calculate i) bulk velocity of gas ii) outlet loading iii) particle migra velocity iv) find η for a gas flow rate of 250 m^3/min & v) find η of collection if spacing is changed to ~~at~~ 20 cm.



Soln i) $A_{c/s} \times V_{Bulk} =$

$A_C \Rightarrow 0.30 \times 5 = 1.5\,m^2$

$Q = 180\,m^3/min = 3\,m^3/sec$

$= C_{in} = 10\,g/m^3$

$$\eta = \frac{C_{in} - C_{out}}{C_{inlet}} = 94.4 = \cancel{1 - exp}\,[$$

$$0.944 = \frac{10 - C_{out}}{10}$$

$C_{out} = 0.06$

$$0.944 = 1 - exp\left[\frac{-V_{PM} \times A_C}{3}\right]$$ (with $A_C = 1.5$)

$$\Rightarrow exp\left[\frac{-V_{PM} \times 1.5}{\cancel{180}}\right] = 0.056$$

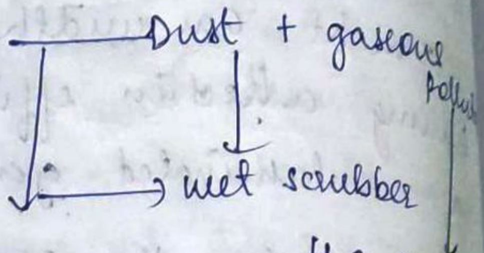
$$= \frac{-V_{PM} \times 1.5}{3\ \cancel{180}} = -2.88240$$

$V_{PM} = 5.7648$ m/s

1st November, 2022

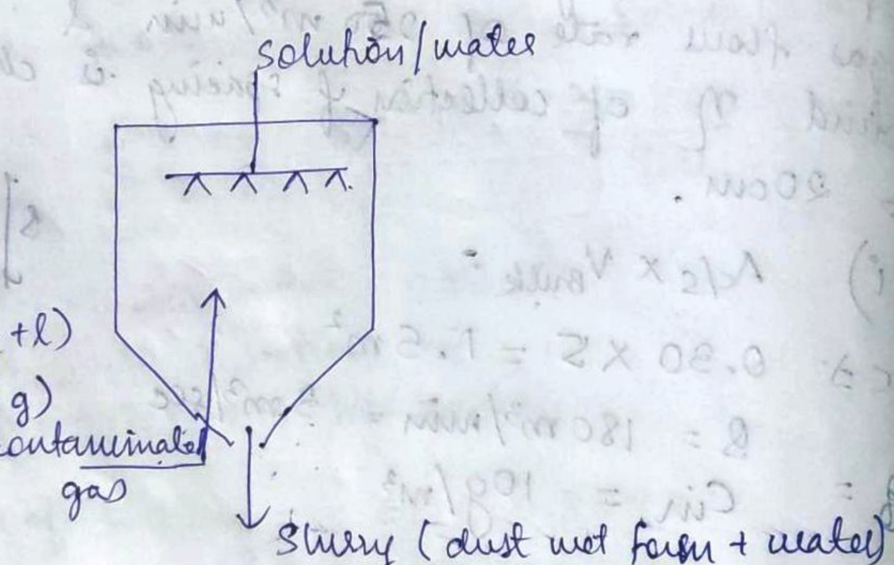
Wet collectors

- Spray tower
- Packed beds
- Bubble or plate tower
- Venturi scrubber.
- Cyclonic scrubber
-



H_2S, SO_2, NH_3
NO_x, H/C vapour

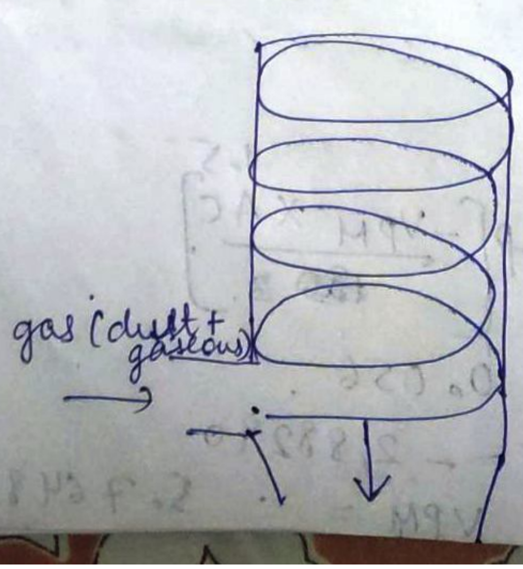
Spray tower:

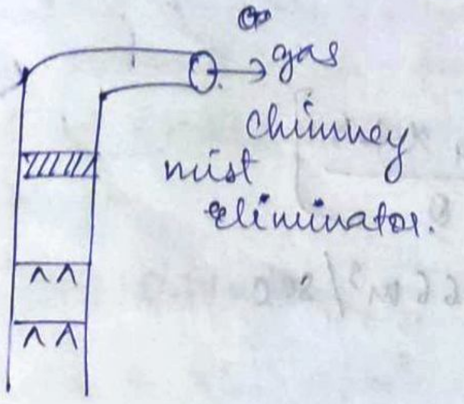


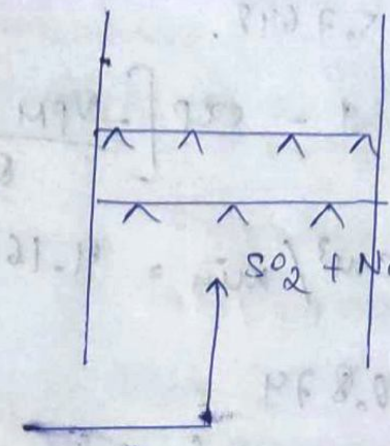
absorbers (g + l)
Adsorbers (s + g)

$\eta_{\text{spray tower}} < \eta_{\text{Packed Bed}}$

Cyclonic scrubber:







$SO_2 + NaOH \rightarrow Na_2HSO_3$.

1. Choked
2. Channeling.

Read design of Packed Bed tower
HETP; NTU.; Selection of solvent.

Assignment design Packed Bed tower.

$L \rightarrow$ vol^m flow rate m^3/hr.

g-l eq^m Henry's law constant
How many gas ~~absorption~~ absorbed

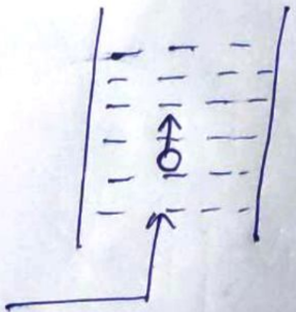
design mean dimension

$a \rightarrow$ interfacial area of contact (m^2/m^3).

$\uparrow a \; \eta \uparrow$.

$K_l a$

$K_l \rightarrow$ cannot be changed
$K_l \rightarrow$ system dependent.



overall mtc & rate depends on a.

Q. Using V_{PM} Calculate η or Q.

$V_{PM} = 5.7648$.

$\Rightarrow \eta = 1 - \exp\left[-\frac{V_{PM} \times 1.5}{Q}\right]$

$Q = 250\,m^3/min = 4.166\,m^3/sec$

$\eta = 0.874$
$= 87.4\%$

v) $A_c = 0.20 \times 5 = 1.0\,m^2$.

$\eta = 1 - \exp\left[\frac{-5.7648 \times 1}{Q}\right]$

$\eta = 0.853$
$= 85.3\%$

Q. As a recently hired engineer for an equipment vending company, you have been assigned the job of submitting a preliminary process design of an ESP to treat 120000 m^3/hr of a polluted gas laden with :

$V_{PM} = 0.14\ m/s$.

$C_{in} = 85.5\ g/m^3$

$C_{out} = 0.087\ g/m^3$

$V_{PM} = 0.14\ m/s$

~~Inlet x outlet loading 85.5 g/m³, 87 mg/m²~~

$Q = 120{,}000\ m^3/hr = 33.33\ m^3/sec$

$$\eta = 1 - \exp\left[\frac{-V_{PM} \times A_{c/s}}{Q}\right]$$

$$\eta = \frac{C_{in} - C_{out}}{C_{in}} \times 100 = \frac{85.5 - 0.087}{85.5} = 99.89\%$$

$$0.99{,}89 = 1 - \exp\left[\frac{-0.14 \times A_{c/s}}{33.33}\right]$$

$$+6.89036 = \frac{+0.14 \times A_{c/s}}{33.33}$$

Q. given :
$Q = 60000\ m^3/hr$; $T = 150°c$
$ht = 3m$; depth = 4m spacing = 25 cm.
$A_{c/s} = 0.25 \times 3 = 0.75m$
$C_{in} = 2.8 gm/Nm^3$
$C_{out} = 50\ mg/Nm^3 \Rightarrow 50 \times 10^{-3} g/Nm^3$

$$\eta = \frac{2.8 - (50 \times 10^{-3})}{2.8} = 0.98214$$

$$\Rightarrow 0.98214 = 1 - exp\left[\frac{-V_{PM} \times 0.75}{\frac{60,000}{3600}}\right]$$

$$\Rightarrow exp\left[\frac{-V_{PM} \times 0.75}{16.666}\right] = 1 - 0.98214$$

$$exp\left[\frac{-V_{PM} \times 0.75}{16.666}\right] = 0.01786$$

taking ln

$$= \frac{+V_{PM} \times 0.75}{16.666} = +4.02519.$$

$V_{PM} =$

Q. 4m - ht ; depth = 5m . spacing = 25 cm = 0.25 m
at T = 150°C & P = 1.05 Kg/cm²

$Q = 100\ m^3/hr = \frac{100}{3600} = 0.0277\ m^3/sec$

1 hr = 60 × 60 s

voltage = 66,000V = E

Dp (μ)	0.05	0.1	0.2	0.4	0.9	1.2	5.0
% wt	2	15	20	33	15	10	5

$$C = 1.0 + \frac{0.172}{dp}$$

a) $V_{PM} = \frac{q_L \times EC}{3\pi\mu\, dp}$

~~VPM~~

i)

ii)

iii)

iv)

v)

vi)