Flocculation:

The coagulation process chemically modifies the colloidal particles so that the stabilizing forces are reduced. To insure that a maximum amount of turbidity is removed, mixing condition and energy input must be properly after rapid mixing, to allow the aggregation of destabilized particles. The coagulated water must be gently stirred to promote the growth of the folc.

Flocculation:

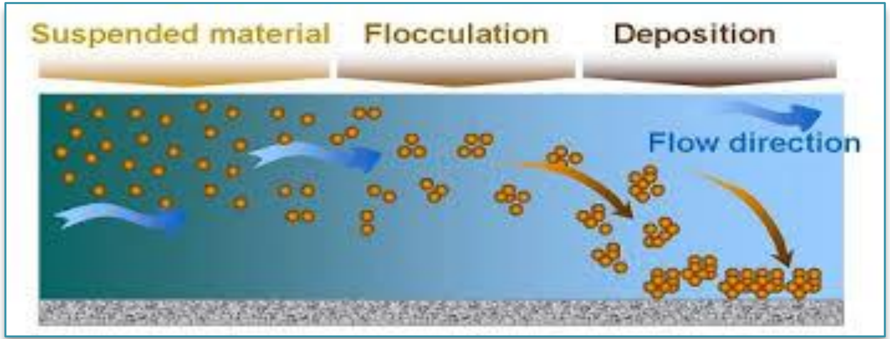
. This process is known as flocculation. Flocculation is an important in precipitation process. The precipitate initially forms into small particles that cannot readily be settled or filtered . In the flocculation process, the mixture is gently stirred to promote the growth of the floc to a size that can be removed by sedimentation and filtration. The typical floc size is in the range from 0.1 to 2.0 mm.

Flocculation :

a)**By using baffled channels or (static or hydraulic flocculate):**
in this type of flocculation the slow mixing is obtained by construction baffles the flocculation . there are tow type of baffles arrangement : slow mixing due to passing water below and above baffles , and slow mixing due to passing water around baffles .
b) **By using paddles : the slow mixing is obtained by using large paddles wheel mixer .The paddles are mounted either vertically or horizontally .The flocculation technique most commonly involves mechanical agitation with rotating paddle wheels o mounted turbines. Typical paddle flocculation are illustrate below .**

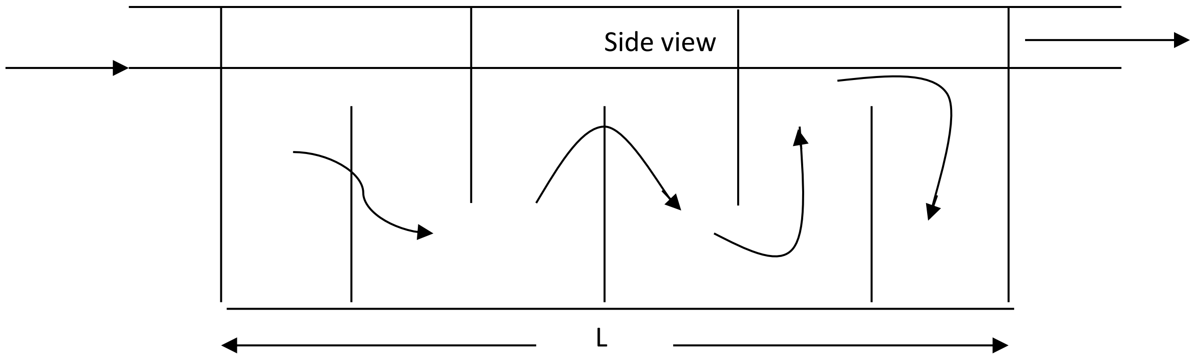
Flocculation:

Flocculation is a slow mixing process in which destabilized colloidal particles are brought into intimate contact in order to promote their agglomeration . The rate of agglomeration or flocculation is dependent upon the number of particles present, the relative volume which they occupy, and the velocity gradient (G) in the basin. The flocculation process may be done by:



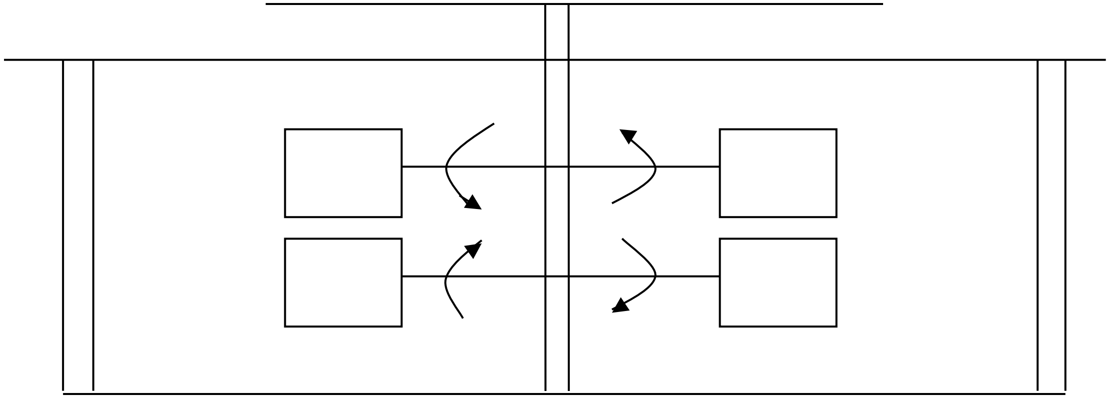
FLOCCULATION:

Coagulation Processes



Flocculation tank with vertical

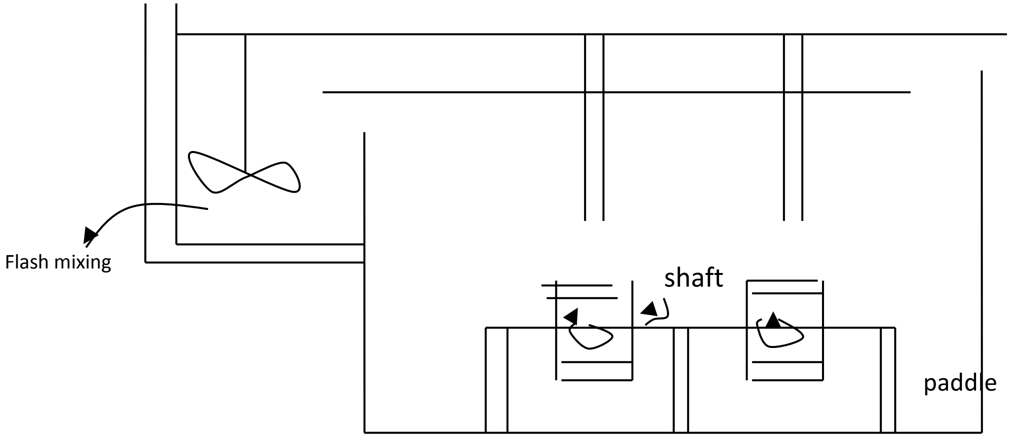
Coagulation Processes



In such system of flocculation the power input is a function of drag force and is equal to :

Ca

Coagulation Processes



Flocculation tank with paddles

وفي مثل هذه المنظومة تكون القدرة الداخلية دالة لقوة الجر للمحذاف ويعبر عنها

$$Fd = 1/2\ Cd\ .\ A\ \rho_w\ .\ v^2 = \frac{Cd\ .A\ .\rho_W.V^2}{2}$$

Ca

Coagulation Processes

Fd = drag force

Cd = drag coefficient

كثافة الماءV = (m/s)

ρ_w = kg/ m^3

(p = السرعة * القوة)

$$P = \frac{Cd\ .A.\rho_W.v^3}{2(vol)}$$

$G = (p/\mu.val\ .)^{1/2}$

$P = \mu.G^2$

gradient of velocity

Velocity grad. = dv /dy

G

$$\mu.G^2 = \frac{Cd\ .A\ .pW\ V3}{2.vol.}$$

Coagulation Processes

$$G = \sqrt{\frac{Cd\ .A.\rho_w.v^3}{2.\mu.vol.}}$$

Vp = linear velocity of paddle blades = $\frac{\pi.D.N}{60}$

Vd = differential velocity of paddle blades = 0.75 *vp

A= (15-20)% of the sectional area of the tanke.

V= (0.15-1) m/sec .

G = (35 -66) m/m.sec ($10 \leq G \leq 75$) 0r (25-65) (20-70)

G .t = ($10^4 - 10^5$) or($5*10^4 - 10*10^4$)

Ca

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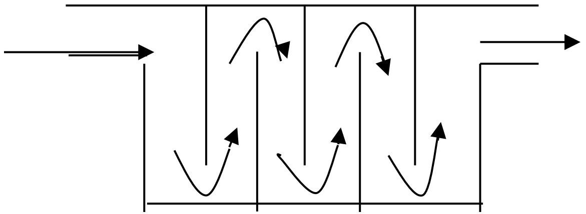
Baffled basins

$$P = \frac{.\rho_w.g.Q.h}{A.l}$$

$$P = \frac{\rho w\ .g\ ,r\ .A\ .h}{A.l} = \frac{r.\rho w.g.h}{l} = \frac{l.\rho w.g.h}{t.l}$$

$$P = \frac{\rho w.g.h}{t} = \mu.G^2 \quad G = \sqrt{\frac{\rho W.g.h}{\mu.t}\ (20-74)}$$



V: velocity of flow .
T: detention time.
Q :flow rate m^3/sec
L: length of the basin (m)
A: cross section area (m^2)
h:ahead loss (m)
p: power in put per unit volume
pw: density of fluid .
G =(20 – 74)
V= (0.15-1)m/sec
T= (15-40) min.
H= (0.3 -1) m.

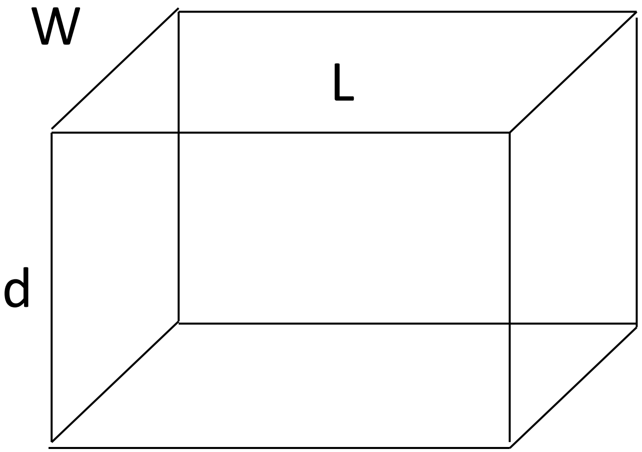
Limits of design for flocculation tank.

1-Speed of revolt ≥ 30-40 r.p.m
2-detention time (20-30) min
Depth (2-6) m = (1.5-2) the paddle diameter

Ex :
Design a flocculation tank to treat 0.1 m^3/sec

Sol. V= Q.t
Let t = 20 min . depth = 3 m
As *3 = 0.1 * 20 *60 =120
As = 120 /3 = 40 m^2
Use circular basin

$$40 = \frac{\pi . D^2}{4} \quad :. \; D = 7.14\,m$$



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Coagulation Processes

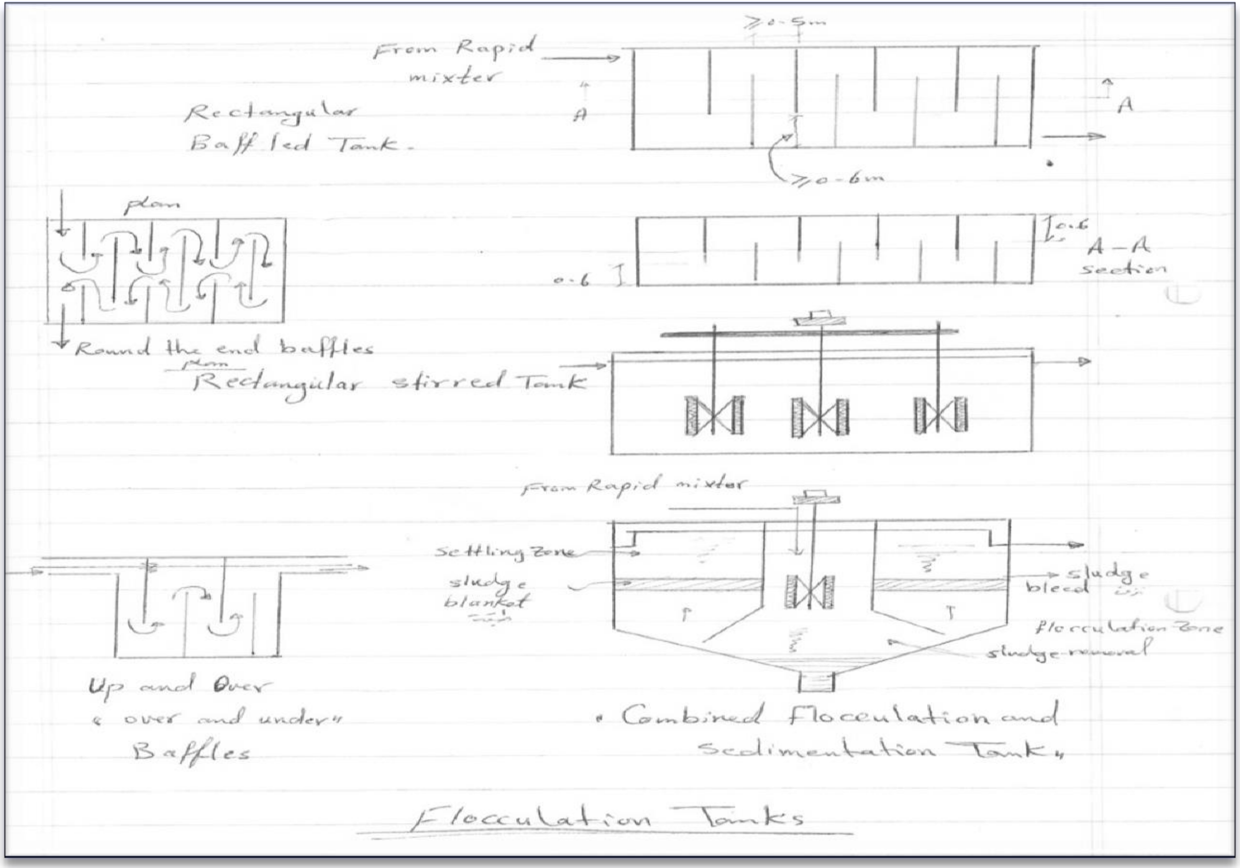
*combined flocculation and settling tank called a clariflocculator
**depth (2-3) m ,depth of setting tank = (0.6 -1.2) m more
Than the depth of flocculating tank.
*the clarifying zone in the clariflocculator is approximating (2.5 m)
**the detention time (2-6) hrs but it is may be as short as 40 min in a clariflocculator.

Ex :
Design a flash mixer and a clariflocculator for a plant of 4550 l/min
Sol :
Flash mix : assume t = 1 min
V = Q . t

$$VOL = \frac{1*4550}{1000} = 4.55\ M^3\ let\ d = 1.5\ m$$

As = 4.55/1.5 = 3 m^2
Use dimensions (1.5 * 2 * 1.5)

Coagulation Processes



Ca

Ex :

In a baffled basin the rate of flow of water is 12 m^3/ min the detention time is 40 min and the head loss is 1 m.

Calculate :-

1-the power input 2- the value of G and Gt.

$\mu = 1.004 * 10^{-2}$ gm /cm sec.

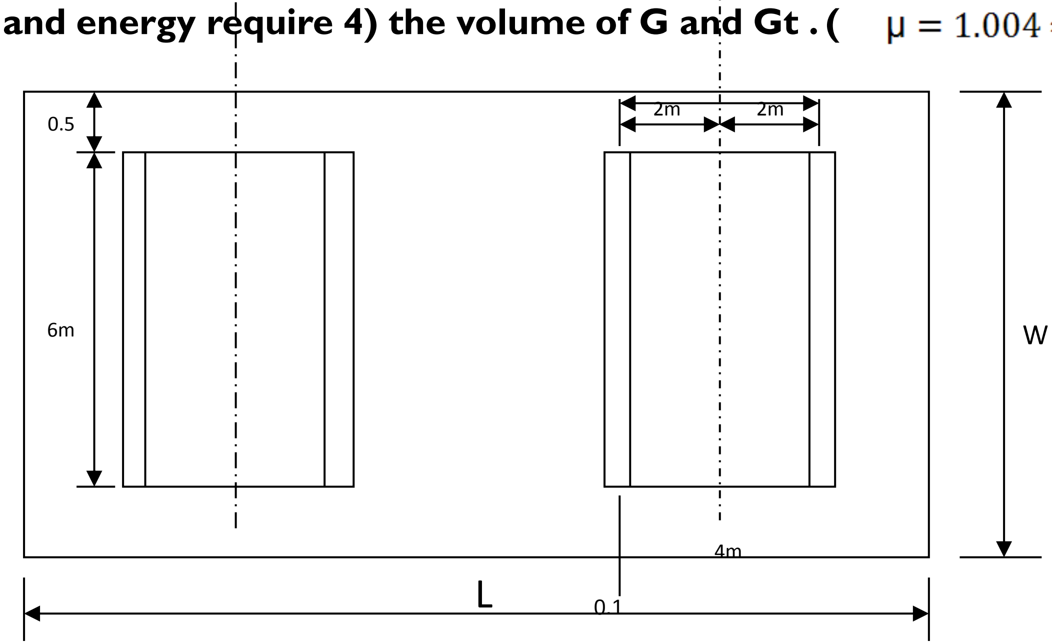
sol :

1)p= $\frac{\rho.g.h}{t} = \frac{1000*9.81*h}{40*60}$ $4.1\, watt/m^3.$

2) G = $\sqrt{\frac{p}{\mu}}$ $\sqrt{\frac{4.1}{\mu 1.004*10^{-3}}}$ = 64 $\frac{1}{5}$ $(20 - 74)$

G.t = 64 * 40 * 60 = 153600 = 15.36 * 10^4 (10^4 - 10^5)

Ex : **A flocculation tank is fitted with paddle impellers 6 m long mounted on two horizontal shafts perpendicular to the flow and rotating at a speed of 4 r.p.m , Each shaft is pitted with two paddles 20 cm wide fitted opposite each other , the center of the paddle is 2mfrom the center of the shaft . the rate of flow of water is 10.5 m^3/min and the detention time is (40 min) . the coefficient of drag is 1.4 the mean velocity of the water is one fourth the paddle velocity . calculate : 1) the rate of the paddle area and the cross section area of tank expressed as percentage . 2) the velocity differential for the paddles 3) the power and energy require 4) the volume of G and Gt . ($\mu = 1.004 * 10^{-2}$) g/cm . sec.**



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Sol.

Volume = Q.t =10.5 * 40 = 420 m^3

Depth = (1.5 – 2) diameter of paddle .

Let depth = 2 * (4) = 8 m

:. 420 As * 8 As = 52.5 m2

Let W = 6+1 = 7m :. 52.5 = 7 *l

:. L = 7.5 < (4 + 4 + 3 *0.5 + 0.4) = 99 m Net area

Let depth = 1.5 * (4) = 6m 420As * 6 :.As = 70 m2 = L * 7

:. L = 10 m ≥ 9.9 (o . k) :. Use tank of (L*W*d) (10 * 7 * 6) .

Paddle area rotating in the cross- section = 0.2 * 6 * 2 = 2.4 m2

Cross- section area of tank = W.d =-7 * 6 =42 m^2.

$:. \frac{2.4}{42}$ * 100 = 5.7 % < (15 – 25) % (o.k) .

The liner velocity of paddle blades = $\frac{\pi D N}{60}$ = $\frac{\pi * (4) * (4)}{60}$ = 0.837 m/sec

Velocity deferential for paddle = 0.75 * 0.837 = 0.63 m/sec.

Total power input $= \dfrac{cd.A.\rho.v^3}{2} = \dfrac{1.4\,(4.8)(1000)(0.63)^3}{2}$ = 840 watt = 0.84 k.watt

$$G = \sqrt{\frac{\rho}{\mu.vol.}} = \sqrt{\frac{840}{1.004 * 10^{-3} * 420}} = 44.6\ \frac{1}{sec}\quad (10 \le G \le 75)\ .o.k$$

Flocculation:

Paddle Flocculator

The power input to the water by horizontal paddles may be estimated as:

$$P = \frac{C_D A_P \rho v_P^3}{2}$$

where P = power imparted, W
C_D = coefficient of drag of paddle
A_P = cross-sectional area, m^2
v_P = relative velocity of paddles with respect to fluid, m/s

The velocity of the paddles may be estimated as

$$v_P = 2\pi k r n$$

where k = constant = 0.75
r = radius to centerline of paddle, m
n = rotational speed, rps

EXAMPLE:

A flocculation tank (L=18 m, W = 10m, D = 6mm) is designed with one rotating paddle of blades as shown in figure. Knowing that :

T = 20 min

Cd = 1.2

μ=1.307 x 10^{-3} kg/m.s

spead of paddle = 2 rpm

ρw = 1000 kg/m^3

Find:

Coagulation:

1- power input

2- G

Solution:

$$P = \frac{C_D\, A\, \rho\, v^3}{2}$$

Velocity differential of the paddle = 0.75 VP

$$vp1 = \frac{\pi d n}{60} = \frac{\pi\, x\, 3.6\, x\, 2}{60} = 0.377\ m/s$$

$$vd1 = 0.75\, x\, 0.377 = 0.283\ m/s$$

$$vp2 = \frac{\pi d n}{60} = \frac{\pi\, x\, 2\, x\, 2}{60} = 0.21\ m/s$$

$$vd2 = 0.75\, x\, 0.21 = 0.158\ m/s$$

$$A1 = 0.3\, x\, 8\, x\, 2 = 4.8\ m2$$

$$A2 = 0.2\, x\, 8\, x\, 2 = 3.2\ m2$$

$$P = \frac{1.2\, x\, 1000}{2}\ [4.8\ (0.283)^3 +\ 3.2(0.158)^3]$$

$$= 72.8\ N.m/s$$

$$G = \sqrt{P/\mu V} = \sqrt{\frac{72.8}{1.307\, x\, 10^{-3}\, x\, 18\, x\, 10\, x\, 6}} = 51.57 s^{-1}$$

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For listening