Velocity Gradient in Porous Media

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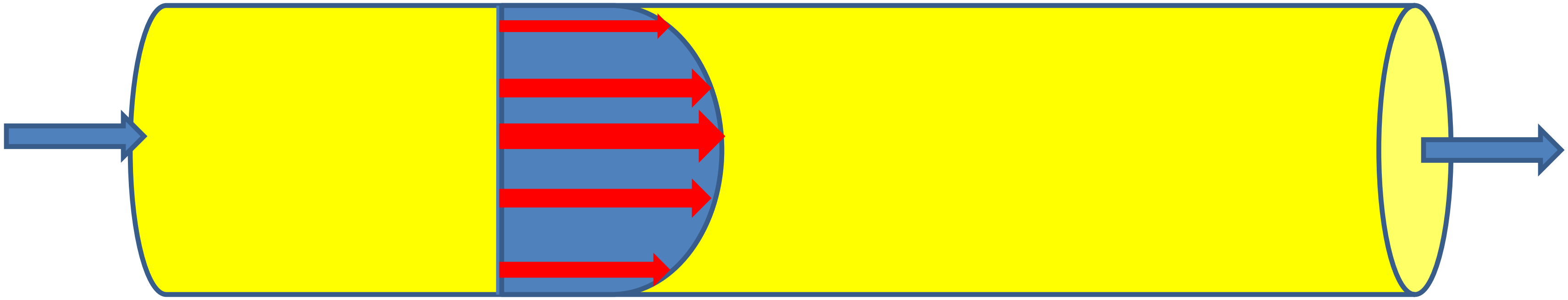
http://sites.google.com/site/drsaatci/home/class-notes

G in Pipes: Using pipes as Mixers and Flocculators



There is velocity gradient ($G=dv/dr$) in pipes causing flocculation.

Darcy Weisbach Eqn
HL in Pipes for Turbulent Flow

$$h = (\lambda\ L/D)\ V^2/(2g)$$

h_f is the head loss due to friction;
L is the length of the pipe;
D is the hydraulic diameter of the pipe (for a pipe of circular section, this equals the internal diameter of the pipe);
V is the average velocity of the fluid flow, equal to the volumetric flow rate per unit cross-sectional wetted area;
g is the local acceleration due to gravity;
f is a dimensionless coefficient called the Darcy friction factor. It can be found from a Moody diagram.

G in Pipes

Power = ρ g Q Δh

Pipe Volume= A L

ϕ = Power/Volume = ρ g (Q/A) (Δh/L)

From Darcy Weisbach's Eqn:

$(\Delta h/L) = \lambda / D \; V^2 / (2g)$

$\phi = \rho \; g \; (Q/A) \; \lambda / D \; V^2 / (2g)$

$\phi = \rho \; \lambda \; V^3 / 2 \; D$

$G = (\rho / \mu \lambda V^3 / 2 \; D)^{(1/2)}$

Note that G is not dependent on pipe length (L)

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$$tR = L / V$$

$$G * tR = L/V * (\rho / \mu \lambda V^3 / 2\, D)^{(1/2)}$$

G in Porous Media (Flocculation-Filter)

Sabri Ergun Equation (1952)

$$\frac{h}{L} = \frac{k_1 \mu}{\rho g} \frac{(1-\varepsilon)^2}{\varepsilon^3} \left(\frac{6}{\psi d_{eq}} \right)^2 v + \frac{k_2}{g} \frac{(1-\varepsilon)}{\varepsilon^3} \left(\frac{6}{\psi d_{eq}} \right) v^2$$

$h/L = K_1 \; V \; + \; K_2 \; V^2$

LAMINAR TURBULENT

Kozeny-Carman Eq'n

Kozeny-Carman Eqn

H/L = $[5\ (\mu / \rho)/g * (1-\in)^2 / \in^3 * (6/dp)^2]\ v$

Kozeny-Carman Eq'n

Volume in Porous Media= $\in$ A L

Power Loss in Porous Media= ρ g Q Δh

Power/Volume = ϕ= ρ g Q Δh / $\in$ A L

Insert Δh / L from Ergun or Kozeny Equation

Kozeny-Carman Eqn

H/L = [5 (μ / ρ)/g *(1-$\in$)^2 /$\in^3$ $*$(6/dp)^2] v

Velocity Gradient in Porous Media

$$G = 13.4 * (1-\varepsilon)/\varepsilon^2 * v/dp$$

$\varepsilon = 0.4$ for filter sand

v= approach velocity, m/s = Q/A_{filter}

d_p = Particle diameter, m

Graham's Eqn (1988)

$$G = 10.1 * (1-\varepsilon)/\varepsilon * v/d_p$$

can be compared with above drived Eq'n:

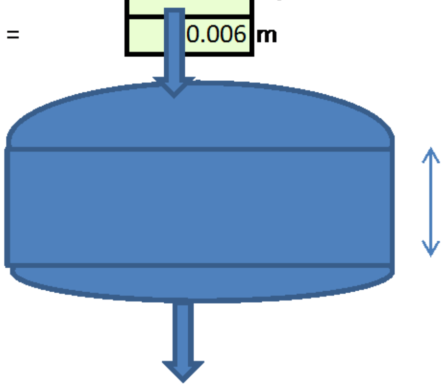
$$G = 13.4 * (1-\varepsilon)/\varepsilon^2 * v/d_p$$

[5 (μ/ρ)/g *(1-∈)^2/?^{3} *(6/dp)^2] v

	20	C
	1	m
	1.00E-03	kg/(m.s) Pa.s
	998.21286	kg/m3
	0.4	
	10	mm
	0.01	m
	20	m/h =Q/A
	0.00556	m/s
	180.0	s

= 0.006 m/m

H = 0.006 m



G= 13.4*$(1-\varepsilon)/\varepsilon^2$*v/dp

G= 27.91667 1/s

G*t= 5.03E+03

v-insterst

tf=

D=	3	m
L=	1	m
A=	7.07	m2

Kin Visc	1.004E-06	m2/s	
Dynam. Visc	0.00100221	kg/(m.s)	Pa.s
Density	998.212864	kg/m3	

Kozeny-Carman Eqn

$$H/L = \left[5\ (\mu/\rho)/g * (1-\in)^2/\in^3 * (6/dp)^2\right]\ v$$

T=	20	C	
L=	1	m	
μ	1.00E-03	kg/(m.s)	Pa.s
ρ	998.21286	kg/m3	
$\in$	0.4		
dp=	10	mm	
	0.01	m	
v=	20	m/h	=Q/A
	0.00556	m/s	
tR=	180.0	s	

η=	Kin Visc	1.004E-06	m2/s	
μ=	Dynam. Visc:	0.00100221	kg/(m.s)	Pa.s
ρ =	Density	998.212864	kg/m3	

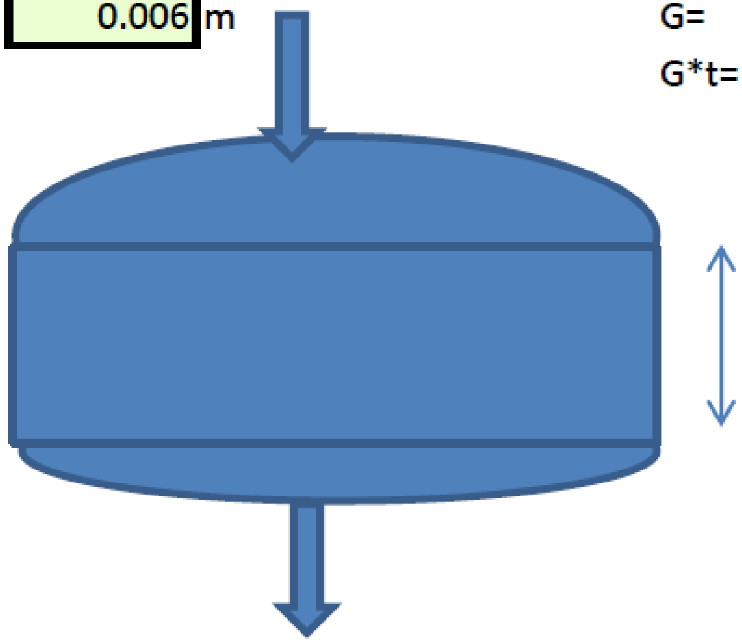
=	0.006	m/m
=	0.006	m

G= $13.4*(1-\varepsilon)/\varepsilon^2*v/dp$

G=	27.91667	1/s
G*t=	5.03E+03	

v-insterst

tf=



D=	3	m
L=	1	m
A=	7.07	m2

Graham's Eqn (1988)

G= $10.1*(1-\varepsilon)/\varepsilon$*v/dp

G=	21.04167	1/s
v/ε =	0.013889	m/s
$L\varepsilon/v$ =	72	sec
G*tf=	1515	

Basınçlı Filtreler

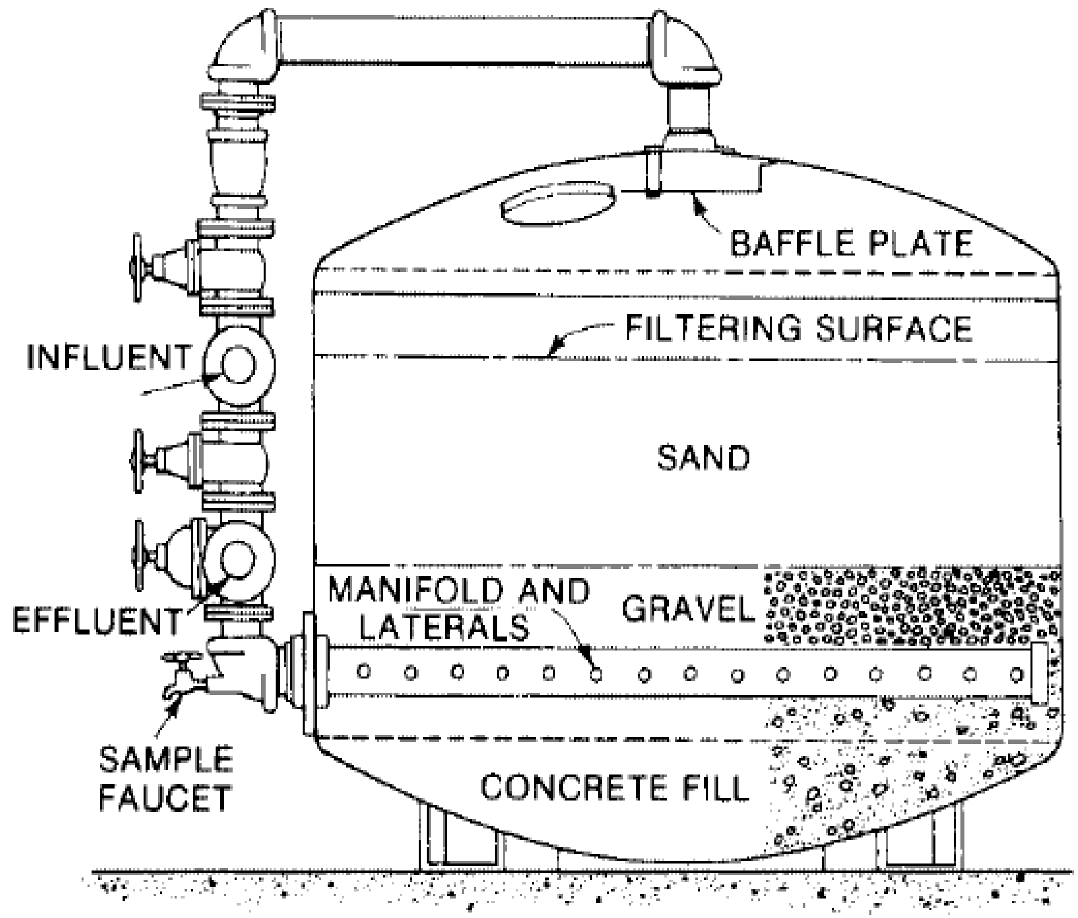
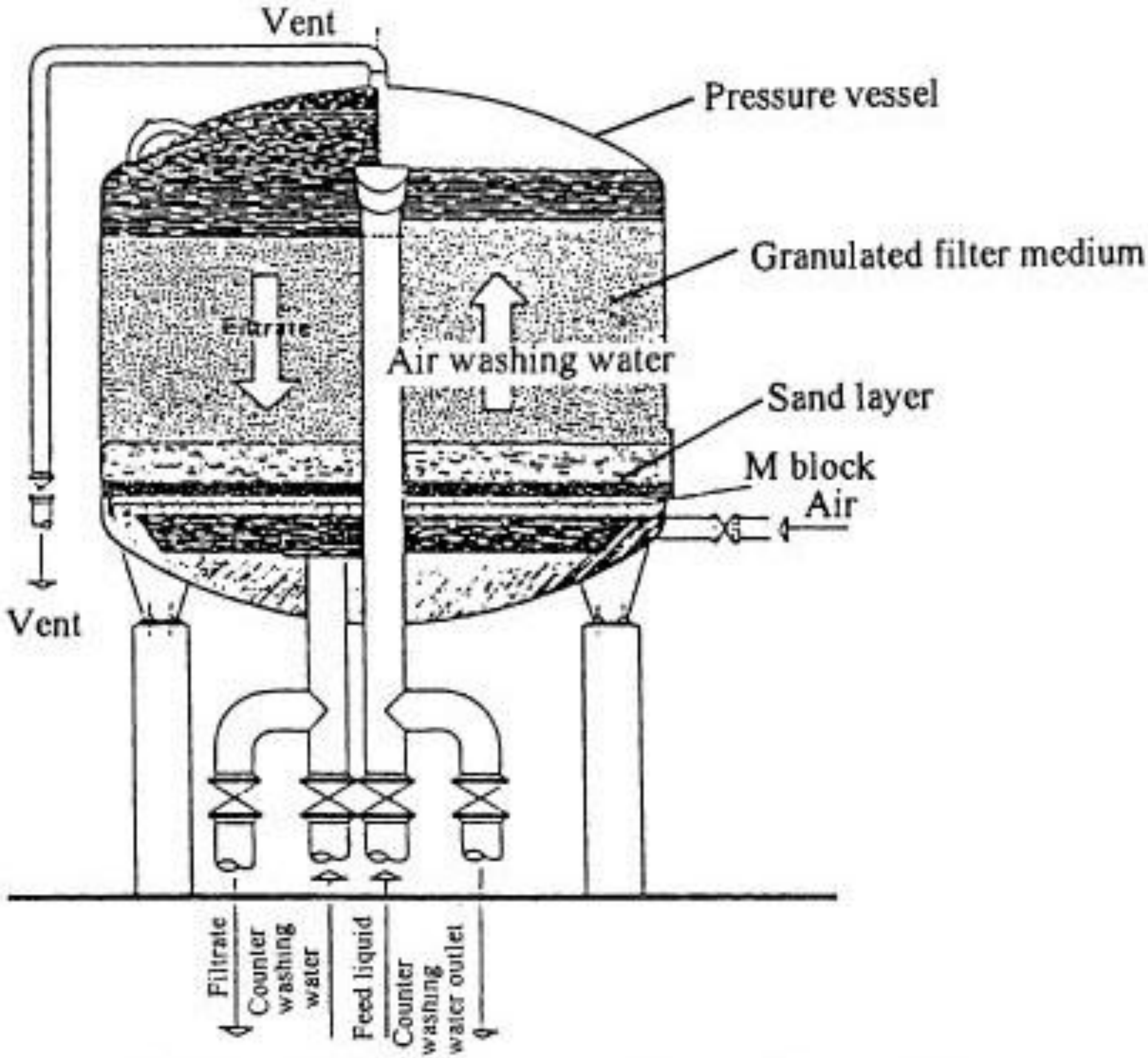


FIGURE 8.31 Cross section of typical pressure filter.


Vent
Pressure vessel
Granulated filter medium
Filtrate
Air washing water
Sand layer
M block
Air
Vent
Filtrate
Counter washing water
Feed liquid
Counter washing water outlet