Freude Number in Water Treatment

ASaatci

FREUDE NUMBER AND CRTITICAL DEPTH

$$E = \underbrace{\frac{P}{\wp} + z}_{y} + \frac{v^2}{2g}$$

$$E = y + \frac{v^2}{2g} = y + \frac{Q^2}{2gA^2}$$

For critical depth to occur Fr = $\frac{Q^2 B}{gA^3} = 1$

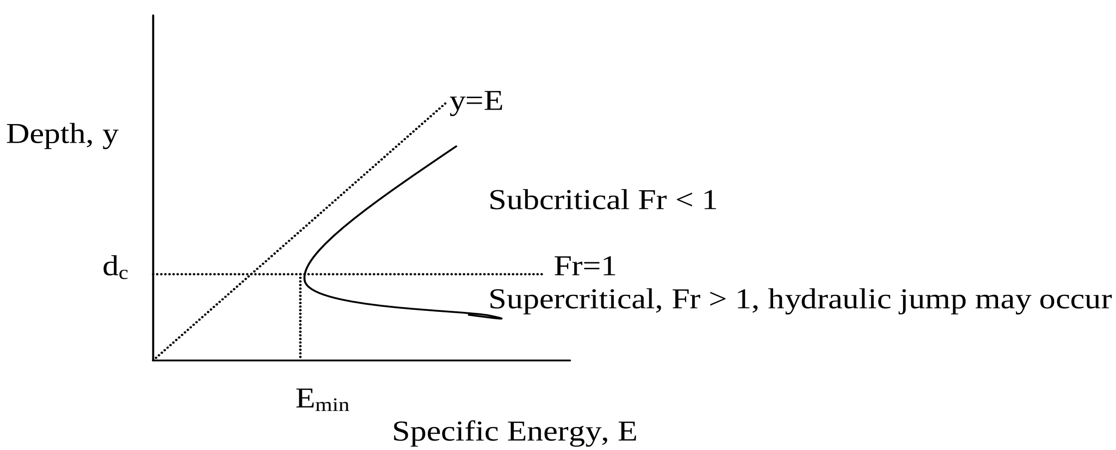
For rectangular channels

$$A = By$$

$\frac{Q^2 B}{gB^3 y^3} = 1$, from which

$$y_c = \left[\frac{Q^2}{B^2 g}\right]^{1/3}$$

At d_c Freude number = 1



FREUDE NUMBER

Ref: (p. 165 Degremont. Water Treatment Handbook), Freude Number Definition

Freude Number makes it possible to asses the stability of a circulation process when the flow is affected primarily by gravitation and the forces of inertia:

$$Fr = \frac{v^2}{gD_H} = \frac{v^2}{g(4R_H)}$$

D_H = equvalent hydraulic diameter = $4R_H$.

The more stable the circulation, the more uniform the velocity distribution over the whole section of the tank. Stable circulations have high Freude number

p. 582 (Bird) Blending of Miscible Fluids Freude Number Definition

$$Fr = {DN^2}/{g}$$

D = diameter of impeller
N = rate of rotation of impeller

P 108 (Bird)

$$Fr = \frac{v^2}{gD}$$

D = diameter of tube, (for flow around a sphere diameter of the sphere)

(p. 30 Huisman Sedimentation) Use of Freude Number in Sedimentation

The stability of the settling zone can be promoted by augmenting a ratio between inertial forces and gravity, expressed by the dimensionless Freude number:

$$Fr = \frac{v^2}{gR_H} = \frac{Inertialforces}{gravity}$$

In sedimentation tanks short circurting can be acoided if $Fr > 10^{-5}$.

In sedimentation tanks scour is commonly not a problem when

$$\mathrm{Re} = \frac{vR_H}{\nu} < 2000 \text{ and } Fr = \frac{v^2}{gR_H} > 10^{-5}.$$

Freude Number in Rectengular Sedimentation Tanks

$$v_0 = \frac{Q}{BH}, R_H = \frac{BH}{B+2H}$$

$$Fr = \frac{Q^2}{g}\frac{B+2H}{B^3H^3}$$

$$S_0 = surface\,loading = \frac{Q}{BL}$$

$$\boxed{Fr = \frac{S_0^2 L^2}{gH^3}\left(1+\frac{2H}{B}\right)}$$

Freude Number in Rectengular Sedimentation Tanks

Freude Number in Circular Sedimantation Tanks

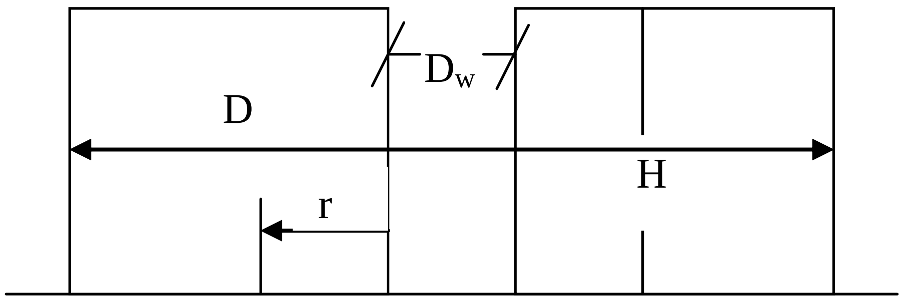


Fig 1. Circular horizontal flow tank (D_w 5 to 10 % of D)

$$R_H = \frac{2\pi r H}{2\pi r} = H$$

$$v = \frac{Q}{\pi D H}$$

$$v^2 = \frac{Q^2}{\pi^2 D^2 H^2}$$

$$Fr = \frac{Q^2}{g \pi^2 D^2 H^3}$$

For circular horizontal flow sedimentation tanks near the outer circumference.

$$Fr_{\min} = \frac{Q^2}{\pi^2 g D^2 H^3} = \frac{S_0^2 D^2}{16 g H^3},$$

and near the outer center:

$$Fr_{\max} = \frac{Q^2}{\pi^2 g} \frac{1}{D_w^2 H^3} = \frac{S_0^2 D^4}{16 g D_w^2 H^3}$$ in which D_w = 5 to 10% of D.

with normal tank depth of 3m

$Fr_{min} = 0.02 \times 10^{-9} D^2$
$Fr_{max} = 4 \times 10^{-9} D^2$

Freude number must be $> 10^{-5}$. For large tanks of diameter 50 m:

$Fr_{min} = (0.005)\, 10^{-5}$, $Fr_{max} = 10^{-5}$

Minimum Freude number can be less than 10^{-5} in large tanks.