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Design of a Solid Bowl Centrifuge for Sludge Dewatering Formulas

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List of 33 Design of a Solid Bowl Centrifuge for Sludge Dewatering Formulas

Design of a Solid Bowl Centrifuge for Sludge Dewatering

Centrifugal Acceleration Force

1) Bowl Radius given Centrifugal Acceleration Force

$$\text{fx } R_b = \frac{32.2 \cdot G}{(2 \cdot \pi \cdot N)^2}$$

Open Calculator 

$$\text{ex } 3\text{ft} = \frac{32.2 \cdot 2000.779\text{lb*ft/s}^2}{(2 \cdot \pi \cdot 2.5\text{rev/s})^2}$$

2) Centrifugal Acceleration Force in Centrifuge

$$\text{fx } G = \frac{R_b \cdot (2 \cdot \pi \cdot N)^2}{32.2}$$

Open Calculator 

$$\text{ex } 2000.779\text{lb*ft/s}^2 = \frac{3\text{ft} \cdot (2 \cdot \pi \cdot 2.5\text{rev/s})^2}{32.2}$$



3) Rotational Speed of Centrifuge using Centrifugal Acceleration Force

[Open Calculator !\[\]\(4729e517bc6a7cd81c8025b9646574fb_img.jpg\)](#)

$$\text{fx } N = \sqrt{\frac{32.2 \cdot G}{(2 \cdot \pi)^2 \cdot R_b}}$$

$$\text{ex } 2.5 \text{ rev/s} = \sqrt{\frac{32.2 \cdot 2000.779 \text{ lb} \cdot \text{ft} / \text{s}^2}{(2 \cdot \pi)^2 \cdot 3 \text{ ft}}}$$

Percent Solids

4) Percent Cake Solids given Percent Solids Recovery

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$\text{fx } C_s = \frac{\%R \cdot F \cdot C_c}{\%R \cdot F + 100 \cdot C_c - 100 \cdot F}$$

$$\text{ex } 25.03684 = \frac{95.14 \cdot 5 \cdot 0.3}{95.14 \cdot 5 + 100 \cdot 0.3 - 100 \cdot 5}$$

5) Percent Centrate Solids given Percent Solids Recovery

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$\text{fx } C_c = (F \cdot C_s) \cdot \left(\frac{\%R - 100}{\%R \cdot F - 100 \cdot C_s} \right)$$

$$\text{ex } 0.300104 = (5 \cdot 25) \cdot \left(\frac{95.14 - 100}{95.14 \cdot 5 - 100 \cdot 25} \right)$$



6) Percent Feed Solids given Percent Solids Recovery 

$$fx \quad F = \frac{100 \cdot C_s \cdot C_c}{\%R \cdot C_c + 100 \cdot C_s - \%R \cdot C_s}$$

Open Calculator 

$$ex \quad 4.9986 = \frac{100 \cdot 25 \cdot 0.3}{95.14 \cdot 0.3 + 100 \cdot 25 - 95.14 \cdot 25}$$

7) Percent Solids Recovery to Determine Solids Capture 

$$fx \quad \%R = 100 \cdot \left(\frac{C_s}{F} \right) \cdot \left(\frac{F - C_c}{C_s - C_c} \right)$$

Open Calculator 

$$ex \quad 95.1417 = 100 \cdot \left(\frac{25}{5} \right) \cdot \left(\frac{5 - 0.3}{25 - 0.3} \right)$$

Polymer Feed Rate 8) Dry Sludge Feed given Polymer Feed Rate of Dry Polymer 

$$fx \quad S = \frac{2000 \cdot P}{D_p}$$

Open Calculator 

$$ex \quad 76.5\text{lb/h} = \frac{2000 \cdot 0.765\text{lb/h}}{20}$$



9) Percent Polymer Concentration given Polymer Feed Rate as Volumetric Flow Rate

$$\text{fx } \%P = \left(\frac{P}{8.34 \cdot P_v \cdot G_p} \right)$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$\text{ex } 0.650195 = \left(\frac{0.765\text{lb/h}}{8.34 \cdot 7.82\text{gal (UK)}/\text{hr} \cdot 1.8} \right)$$

10) Polymer Dosage when Polymer Feed Rate of Dry Polymer

$$\text{fx } D_p = \frac{2000 \cdot P}{S}$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$\text{ex } 20 = \frac{2000 \cdot 0.765\text{lb/h}}{76.5\text{lb/h}}$$

11) Polymer Feed Rate as Mass Flow Rate given Polymer Feed Rate as Volumetric Flow Rate

$$\text{fx } P = (P_v \cdot 8.34 \cdot G_p \cdot \%P)$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$\text{ex } 0.76477\text{lb/h} = (7.82\text{gal (UK)}/\text{hr} \cdot 8.34 \cdot 1.8 \cdot 0.65)$$

12) Polymer Feed Rate as Volumetric Flow Rate

$$\text{fx } P_v = \left(\frac{P}{8.34 \cdot G_p \cdot \%P} \right)$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80_img.jpg\)](#)

$$\text{ex } 7.82235\text{gal (UK)}/\text{hr} = \left(\frac{0.765\text{lb/h}}{8.34 \cdot 1.8 \cdot 0.65} \right)$$



13) Polymer Feed Rate of Dry Polymer

$$\text{fx } P = \frac{D_p \cdot S}{2000}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$\text{ex } 0.765\text{lb/h} = \frac{20 \cdot 76.5\text{lb/h}}{2000}$$

14) Specific Gravity of Polymer given Polymer Feed Rate as Volumetric Flow Rate

$$\text{fx } G_p = \left(\frac{P}{8.34 \cdot P_v \cdot \%P} \right)$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$\text{ex } 1.800541 = \left(\frac{0.765\text{lb/h}}{8.34 \cdot 7.82\text{gal (UK)}/\text{hr} \cdot 0.65} \right)$$

Sludge Volume and Feed Rate

15) Dewatered Sludge or Cake Discharge Rate

$$\text{fx } C_d = (S_f \cdot R)$$

[Open Calculator !\[\]\(104fbf564e2e5a8fbd84f31656d114c7_img.jpg\)](#)

$$\text{ex } 27\text{lb/h} = (45\text{lb/h} \cdot 0.6)$$

16) Digested Sludge using Sludge Feed Rate for Dewatering Facility

$$\text{fx } D_s = (S_v \cdot T)$$

[Open Calculator !\[\]\(21226b58c700e5231ab98d27101bac58_img.jpg\)](#)

$$\text{ex } 24\text{m}^3/\text{s} = (2.4\text{m}^3/\text{s} \cdot 10\text{s})$$




17) Operation Time given Sludge Feed Rate for Dewatering Facility 

$$fx \quad T = \left(\frac{D_s}{S_v} \right)$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5_img.jpg\)](#)


$$ex \quad 10s = \left(\frac{24m^3/s}{2.4m^3/s} \right)$$

18) Percent Reduction in Sludge Volume 

$$fx \quad \%V = \frac{V_i - V_o}{V_i}$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5_img.jpg\)](#)

$$ex \quad 0.214286 = \frac{28m^3 - 22m^3}{28m^3}$$

19) Sludge Feed Rate for Dewatering Facility 

$$fx \quad S_v = \left(\frac{D_s}{T} \right)$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2_img.jpg\)](#)

$$ex \quad 2.4m^3/s = \left(\frac{24m^3/s}{10s} \right)$$

20) Sludge Feed Rate using Dewatered Sludge Discharge Rate 

$$fx \quad S_f = \frac{C_d}{R}$$

[Open Calculator !\[\]\(06a315363e7801bba8c7489a6694af19_img.jpg\)](#)

$$ex \quad 45lb/h = \frac{27lb/h}{0.6}$$



21) Sludge Volume-in given Percent Reduction in Sludge Volume

$$\text{fx } V_i = \left(\frac{V_o}{1 - \%V} \right)$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$\text{ex } 27.98982\text{m}^3 = \left(\frac{22\text{m}^3}{1 - 0.214} \right)$$

22) Sludge Volume-out given Percent Reduction in Sludge Volume

$$\text{fx } V_o = V_i \cdot (1 - \%V)$$

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

$$\text{ex } 22.008\text{m}^3 = 28\text{m}^3 \cdot (1 - 0.214)$$

23) Solids Recovery given Dewatered Sludge Discharge Rate

$$\text{fx } R = \left(\frac{C_d}{S_f} \right)$$

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9_img.jpg\)](#)

$$\text{ex } 0.6 = \left(\frac{27\text{lb/h}}{45\text{lb/h}} \right)$$

Weight Flow Rate of Sludge Feed

24) Percent Solids given Weight Flow Rate of Sludge Feed

$$\text{fx } \%S = \frac{7.48 \cdot W_s}{V \cdot \rho_{\text{water}} \cdot G_s \cdot 60}$$

[Open Calculator !\[\]\(9db214d549b9aeebe72aa11d3a5c4b1a_img.jpg\)](#)

$$\text{ex } 0.449999 = \frac{7.48 \cdot 3153.36\text{lb/h}}{7\text{gal (US)}/\text{min} \cdot 62.4\text{lb}/\text{ft}^3 \cdot 2 \cdot 60}$$



25) Specific Gravity of Sludge using Weight Flow Rate

$$\text{fx } G_s = \frac{7.48 \cdot W_s}{V \cdot \rho_{\text{water}} \cdot \%S \cdot 60}$$

[Open Calculator !\[\]\(c3d993ca47bfe2a953c700506ce31fa0_img.jpg\)](#)

$$\text{ex } 1.999994 = \frac{7.48 \cdot 3153.36\text{lb/h}}{7\text{gal (US)/min} \cdot 62.4\text{lb/ft}^3 \cdot 0.45 \cdot 60}$$

26) Volume Flow Rate of Sludge Feed using Weight Flow Rate

$$\text{fx } V = \frac{7.48 \cdot W_s}{\rho_{\text{water}} \cdot G_s \cdot \%S \cdot 60}$$

[Open Calculator !\[\]\(17413706fd4997a1a4bdf85c6864eee1_img.jpg\)](#)

$$\text{ex } 6.99998\text{gal (US)/min} = \frac{7.48 \cdot 3153.36\text{lb/h}}{62.4\text{lb/ft}^3 \cdot 2 \cdot 0.45 \cdot 60}$$

27) Weight Flow Rate of Sludge Feed

$$\text{fx } W_s = \frac{V \cdot G_s \cdot \rho_{\text{water}} \cdot \%S \cdot 60}{7.48}$$

[Open Calculator !\[\]\(4b7a79268f6ba26c1471d4232fffa85a_img.jpg\)](#)

$$\text{ex } 3153.369\text{lb/h} = \frac{7\text{gal (US)/min} \cdot 2 \cdot 62.4\text{lb/ft}^3 \cdot 0.45 \cdot 60}{7.48}$$



Wet Cake

28) Cake Density using Volume of Wet Cake

$$fx \quad \rho_c = \left(\frac{W_r}{V_w} \right)$$

[Open Calculator !\[\]\(339a16584d5da0f0a3ca4e9ec17bf6a1_img.jpg\)](#)

$$ex \quad 4lb/ft^3 = \left(\frac{60lb/h}{15ft^3/hr} \right)$$

29) Dry Cake Rate using Wet Cake Discharge Rate

$$fx \quad D = (W \cdot C)$$

[Open Calculator !\[\]\(6059a5aa8b4ca7bb793408023d6c6e42_img.jpg\)](#)

$$ex \quad 29.997lb/h = (54.54lb/h \cdot 0.55)$$

30) Percent Cake Solids using Wet Cake Discharge Rate

$$fx \quad C = \left(\frac{D}{W} \right)$$

[Open Calculator !\[\]\(e3275251d0893157c3584e20c81dc3ba_img.jpg\)](#)

$$ex \quad 0.550055 = \left(\frac{30lb/h}{54.54lb/h} \right)$$

31) Volume of Wet Cake

$$fx \quad V_w = \left(\frac{W_r}{\rho_c} \right)$$

[Open Calculator !\[\]\(eabd9f9ababee93effadc3b380fe65fd_img.jpg\)](#)

$$ex \quad 15ft^3/hr = \left(\frac{60lb/h}{4lb/ft^3} \right)$$



32) Wet Cake Discharge Rate

[Open Calculator !\[\]\(4729e517bc6a7cd81c8025b9646574fb_img.jpg\)](#)

$$\text{fx } W = \left(\frac{D}{C} \right)$$

$$\text{ex } 54.545451\text{lb/h} = \left(\frac{30\text{lb/h}}{0.55} \right)$$

33) Wet Cake Rate using Volume of Wet Cake

[Open Calculator !\[\]\(e474458956c9a37fbf9586ddb60a7fa1_img.jpg\)](#)

$$\text{fx } W_r = (V_w \cdot \rho_c)$$

$$\text{ex } 60\text{lb/h} = (15\text{ft}^3/\text{hr} \cdot 4\text{lb}/\text{ft}^3)$$



Variables Used









- **%P** Percent Polymer Concentration
- **%R** Percent Solids Recovery
- **%S** Percent Solids
- **%V** Volume Reduction
- **C** Cake Solids in Decimal
- **C_c** Centrate Solids in Percent
- **C_d** Cake Discharge Rate (*Pound per Hour*)
- **C_s** Cake Solids in Percent
- **D** Dry Cake Rate (*Pound per Hour*)
- **D_p** Polymer Dosage
- **D_s** Digested Sludge (*Cubic Meter per Second*)
- **F** Feed Solids in Percent
- **G** Centrifugal Acceleration Force (*Pound Foot per Square Second*)
- **G_p** Specific Gravity of Polymer
- **G_s** Specific Gravity of Sludge
- **N** Rotational Speed of Centrifuge (*Revolution per Second*)
- **P** Polymer Feed Rate (*Pound per Hour*)
- **P_v** Volumetric Polymer Feed Rate (*Gallon (UK) per Hour*)
- **R** Solid Recovery in Decimal
- **R_b** Bowl Radius (*Foot*)
- **S** Dry Sludge Feed (*Pound per Hour*)
- **S_f** Sludge Feed Rate (*Pound per Hour*)



- **S_v** Volumetric Sludge Feed Rate (Cubic Meter per Second)
- **T** Operation Time (Second)
- **V** Volume Flow Rate of Sludge Feed (Gallon (US) per Min)
- **V_i** Sludge Volume in (Cubic Meter)
- **V_o** Sludge Volume Out (Cubic Meter)
- **V_w** Volume of Wet Cake (Cubic Foot per Hour)
- **W** Wet Cake Discharge (Pound per Hour)
- **W_r** Wet Cake Rate (Pound per Hour)
- **W_s** Weight Flow Rate of Sludge Feed (Pound per Hour)
- **ρ_c** Cake Density (Pound per Cubic Foot)
- **ρ_{water}** Water Density (Pound per Cubic Foot)









Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Function:** **sqrt**, sqrt(Number)
A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- **Measurement:** **Length** in Foot (ft)
Length Unit Conversion 
- **Measurement:** **Time** in Second (s)
Time Unit Conversion 
- **Measurement:** **Volume** in Cubic Meter (m³)
Volume Unit Conversion 
- **Measurement:** **Force** in Pound Foot per Square Second (lb*ft/s²)
Force Unit Conversion 
- **Measurement:** **Volumetric Flow Rate** in Gallon (UK) per Hour (gal (UK)/hr), Cubic Meter per Second (m³/s), Gallon (US) per Min (gal (US)/min), Cubic Foot per Hour (ft³/hr)
Volumetric Flow Rate Unit Conversion 
- **Measurement:** **Mass Flow Rate** in Pound per Hour (lb/h)
Mass Flow Rate Unit Conversion 
- **Measurement:** **Angular Velocity** in Revolution per Second (rev/s)
Angular Velocity Unit Conversion 
- **Measurement:** **Density** in Pound per Cubic Foot (lb/ft³)
Density Unit Conversion 



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