BAB 5

DETAIL ENGINEERING DESIGN (DED)

5.1 Saluran Pembawa

a. Kriteria Perencanaan

- Kecepatan Aliran (v) = 0,3 - 0,6 m/s (melalui barscreen)

(Sumber: Metcalf & Eddy 4th edition, hal 316)

- Freeboard = 5% - 30% H

(Sumber: Ven Te Chow. 1959. Open Channel Hydraulics, hal 159. New York, USA: Mc. Graw-Hill Book Company, Inc)

- Slope < 0,001 m/m

(Sumber: EPA-Storm Water Management Model User's Manual Version 5.0, pages 165)

- Koefisien Manning (n) = 0,013 (untuk bahan saluran beton)

b. Data Perencanaan

- Dibuat 1 saluran pembawa terbuka berbentuk persegi panjang
- Debit = 450 m^3/hari atau 0,0052 m^3/s dengan operasional 24 jam
- Jumlah saluran = 1 buah
- Bentuk saluran = Persegi
- Panjang saluran (L) = 2,5 m (direncanakan)
- Lebar saluran (B) = 2 x tinggi (2 x Hsaluran)
- Freeboard = 20% dari tinggi saluran
- Saluran dari beton (n) = 0,013

c. Perhitungan Unit Saluran Pembawa

1) Luas Permukaan Saluran (A)

$$A = \frac{Q}{v}$$

$$A = \frac{0{,}0052 \text{ m3/s}}{0{,}3\ m/s}$$

$A = 0{,}017\ m2 = 1{,}7\ cm2$

Sumber : Ven Te Chow, Ph.D., 1959,hlm.5)

2) Dimensi Saluran Pembawa

- Kedalaman Saluran

  Kedalaman (H) = $\frac{A}{B}$ berasal dari rumus lebar x tinggi penampang saluran (*cross*), dengan perencanaan lebar (B) = 2 x tinggi saluran (H), sehingga: (Chow,1959)

  A = H x 2H

  0,017 m^2 = $2H^2$

  H = $\sqrt{\frac{0{,}017\ m2}{2}}$

  H = 0,089 m

  Htotal = Hsaluran + *Freeboard*

  Htotal = Hsaluran + (20% x Hsaluran)

  Htotal = 0,089 m + (20% x 0,089 m)

  Htotal = 0,089 m + 0,017 m

  Htotal = **0,106 m = 10,6 cm**

- Lebar Saluran (B)

  Lebar Saluran (B) = 2 x H

  = 2 x 0,089 m

  Lebar Saluran (B) = **0,178 m = 17,8 cm**

3) Jari-Jari Hidrolis (saluran terbuka *rectangular*)

$$R = \frac{B\ x\ H}{B + (\ 2\ x\ H)}$$

(*Sumber : Chow, Ven Te, 1959, Open Channel Hydraulics, Mc. Graw-Hill Book Company, Inc. Hlm. 19*)

$$R = \frac{0{,}178\ m\ x\ 0{,}089\ m}{0{,}178\ m + (\ 2\ x\ 0{,}089 m)}$$

$R = 0{,}045\ m$

4) Cek Kecepatan (v)

$$v = \frac{Q}{A} = \frac{Q}{B\ x\ H}$$

$$v = \frac{0{,}0052\ m3/s}{0{,}178\ m\ x\ 0{,}089\ m} = 0{,}325\frac{m}{s}\ (\mathbf{memenuhi})$$

5) Slope dan *Headloss* Saluran

$$S = \left(\frac{n\ x\ v}{(R)^{2/3}}\right)^{\mathbf{2}}$$

$$S = \left(\frac{0{,}013\ x\ 0{,}325\ m/s}{(0{,}045)^{2/3}}\right)^{\mathbf{2}}$$

$$S = \left(\frac{0{,}004\ m/s}{0{,}13}\right)^{\mathbf{2}}$$

$$S = (0{,}031)^{\mathbf{2}}$$

$$S = 0{,}00096\frac{m}{m}\ (memenuhi)$$

6) Headloss Saluran (Hf)

= Slope x Panjang Saluran

= 0,00096 m/m x 3 m

= 0,00288 m

d. Nre Saluran Limbah Domestik

$$\text{Nre} = \frac{\rho\ x\ R\ x\ Vs}{\mu}$$

$$\text{Nre} = \frac{0{,}99568\frac{gr}{cm3}\ x\ 0{,}045\ m\ x\ 0{,}325\ m/s}{0{,}8004\ \text{centipoise}}$$

$$\text{Nre} = \frac{9{,}9568\frac{kg}{m3}\ x\ 0{,}045\ m\ x\ 0{,}325\ m/s}{0{,}8004\ \text{x}\ 10^{-3} kg.m/detik}$$

$$\text{Nre} = \frac{0{,}145}{0{,}0008004} = 181{,}2\ (\text{Nre} < 2100, \text{maka aliran laminar})$$

e. Resume Bangunan

- Luas Permukaan (A) = 0,017 m^2
- Kedalaman Saluran (H) = 0,089 m
- Kedalaman Total = 0,106 m
- Panjang Saluran (L) = 2,5 m
- Lebar Saluran (B) = 0,178 m
- Kecepatan Saluran (V) = 0,325 m/s

- Jari-jari hidrolis (R) = 0,045 m
- Slope Saluran (S) = 0,00096 m/m
- Headloss Saluran (Hf) = 0,00288 m
- Nre = 181,2 (aliran laminer)

5.2 Bar Screnn

a. Kriteria Perencanaan

- Menggunakan *bar screen* manual
- <u>Dimensi kisi:</u>

  Lebar kisi (d) = 5 – 15 mm = 0,005 – 0,015 m

  Kedalaman (h) = 25 – 38 mm = 0,025 – 0,038 m
- Jarak antar kisi (r) = 25 – 50 mm
- Slope saluran = 30° - 45°
- Kecepatan melalui *bar screen* (v) = 0,3 – 2,4 m/s
- Headloss Maksimum *Bar Screen* (Hf) = 150 mm
- Koef. saat non clogging (C) = 0,7
- Koef. saat clogging (Cc) = 0,6

(*Sumber : Metcalf & Eddy, 2003, Watewater Engineering Treatment & Reuse, Fourth Edition, hlm 316)*

- Faktor Kischmer (β) = 1,79 (circular)

  (*Sumber : Qasim, 2000)*
- V = 0,3 – 2,5 m/s
- K elbow 90° = 0,9

  (Sumber: Dake, J.M.K., Endang P. Tachyan dan Y.P. Pangaribuan, 1985. "Hidrolika Teknik Edisi II", Erlangga. Jakarta)
- K foot valve = 2,3

(Sumber: Practical Hydrolics for The Public Work Engineer, 1968)

b. Data Perencanaan

- Menggunakan *bar screen* manual dengan tipe *coarse screen* manual

- Debit (Q) = 0,0052 m^3/s dengan operasional 24 jam
- Kecepatan saluran (v) = 0,325 m/s
- Lebar saluran (Ws) = 0,178 m
- Lebar kisi (d) = 10 mm = 0,01 m (direncanakan)
- Jarak antar kisi (r) = 25 mm = 0,025 m (direncanakan)
- Kemiringan screen = 45°
- Gravitasi (g) = 9,81 m/ s^2
- Kedalaman saluran (H) = 0,089 m
- Headloss maksimum (Hf) = 150 mm = 0,15 m

c. Perhitungan Unit Bar Screen

1) Jumlah batang/kisi

   Ws = n.d + (n + 1) r

   0,178 m = n. 0,01 + (n + 1) 0,025 m

   0,178 m = 0,01 n + 0,025 n + 0,025 m

   0,203 m = 0,035 n

   n = 5,8

   n = **6 batang**

2) Lebar bukaan kisi (Wc)

   Wc = Ws – (n x d)

   Wc = 0,178 m – (6 x 0,01 m)

   Wc = 0,118 m = 11,8 cm

3) Tinggi *bar screen*

   Tinggi *bar screen* = Htotal

   Tinggi *bar screen* = Hsaluran + (20% x Hsaluran)

   Tinggi *bar screen* = 0,089 m + (20% x 0,089 m)

   Tinggi *bar screen* = 0,089 m + 0,018 m

   Tinggi *bar screen* = 0,11 m = 11 cm

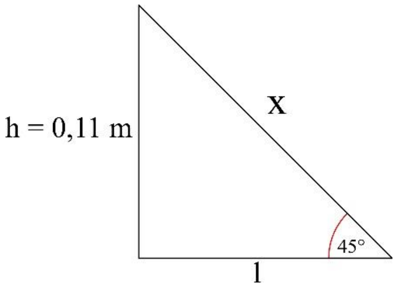
4) Dimensi *bar screen*

   - Panjang sisi miring *bar screen* (x)

Sin α $= \frac{h}{x}$

Sin 45° $= \frac{0,11}{x}$

X = 0,155 m = 15,56 cm



- Lebar *bar screen*

Cos α $= \frac{l}{x}$

Cos 45° $= \frac{l}{0,155}$

I = 0,11 m = 11 cm

5) Cek kecepatan setelah melalui kisi (Vi)

Vi $= \frac{Q}{Wc\ x\ H}$

Vi $= \frac{0,0052\ \ m3/s}{0,118\ m\ x\ 0,11\ m}$

Vi = 0,4 m/s

6) Kecepatan penggelontoran saat clogging 50%

Vc $= \frac{Q}{(50\%\ x\ Wc)\ x\ H}$

Vc $= \frac{0,0052\ m3/s}{(50\%\ x\ 0,118\ m)\ x\ 0,11\ m}$

Vc = 0,74 m/s

7) Headloss pada bar screen saat bersih

Hf $= \frac{1}{c}\ x\ \left(\frac{Vi^2 - V^2}{2\ x\ g}\right)$

Hf $= \frac{1}{0,7}\ x\ \left(\frac{0,4^2 - 0,325^2}{2\ x\ 9,81}\right)$

Hf = 0,004 m < 0,15 m (memenuhi)

8) Headloss saat clogging 50%

Hf $= \frac{1}{Cc}\ x\ \left(\frac{Vc^2 - Vi^2}{2\ x\ g}\right)$

Hf $= \frac{1}{0,6}\ x\ \left(\frac{0,74^2 - 0,4^2}{2\ x\ 9,81}\right)$

Hf = 0,03 m < 0,15 m (memenuhi)

d. Resume Bangunan

- Jumlah kisi = 6 batang
- Lebar kisi (d) = 0,01 m

- Lebar bukaan kisi (Wc) = 0,118 m
- Jarak antar kisi (r) = 25 mm = 0,025 m
- Panjang sisi miring (X) = 0,155 m
- Panjang bar screen (l) = 0,11 m
- Tinggi bar screen (H) = 0,089 m

5.3 Bak Penampung

a. Kriteria Perencanaan

- Waktu detensi = <2 jam
  (Metcalf & Eddy, 2003)
- Kedalaman (H) = 1,5 – 2 m
  (Metcalf & Eddy, 2003)
- Freeboard = 5 - 30%
  (Metcalf & Eddy, 2003)

b. Data Perencanaan

a) Debit (Q) = 0,0052 m^3/s dengan operasional 24 jam
b) Jumlah bak = 1
c) Waktu tinggal (td) = 1 jam = 3600 detik
d) Kedalaman bak (H) = 2 m
e) Freeboard = 20%
f) Panjang bak (P) = Lebar bak (L)
g) Bak penampung persegi
h) Kecepatan aliran (v) (0,3 – 0,6) = 0,4 m^3/detik

c. Perhitungan

a) Volume bak penampung

$V = Q \; x \; td$

$V = 0{,}0052 \; m^3/s \; x \; 3600 \; s$

$V = 18{,}7 \; m^3$

b) Dimensi bak penampung (P = L)

$V = P \; x \; L \; x \; H$

$$18{,}7\ m3 = L\ x\ L\ x\ 1{,}5\ m$$

$$18{,}7\ m3 = 1{,}5\ L^2\ m$$

$$L^2 = \frac{18{,}7\ m3}{1{,}5\ m}$$

$$\boldsymbol{L = 4\ m}\ ; \boldsymbol{P = 4\ m}$$

$Htotal =$ Kedalaman bak + *freeboard*

$$Htotal = 1{,}5\ m + (20\%\ x\ 1{,}5\ m)$$

$$Htotal = 1{,}8\ m = 2\ m$$

c) Luas bak penampung

$$A = \frac{V}{H}$$

$$A = \frac{18{,}7\ m3}{1{,}5\ m}$$

$$A = 13\ m2$$

d) Diameter *outlet*

$$A = \frac{Q}{v}$$

$$A = \frac{0{,}0052\ \text{m3/s}}{0{,}4\ m/s}$$

$$A = 0{,}01\ m2$$

$$A = \frac{1}{4}\ x\ 3{,}14\ x\ D^2$$

$$0{,}01\ m2 = \frac{1}{4}\ x\ 3{,}14\ x\ D^2$$

$$\boldsymbol{D = 0{,}114\ m}$$

Pipa pasaran = 0,125 m = 125 mm

e) Cek waktu detensi

$$td = \frac{V}{Q}$$

$$td = \frac{P\ x\ L\ x\ H}{Q}$$

$$td = \frac{4\ m\ \ x\ 4\ m\ \ x\ 2\ m}{0{,}0052\ m3/s}$$

$$td = 6153\ detik = 1{,}7\ jam$$

f) Cek kecepatan (Vcek) pipa outlet

$$Vcek = \frac{Q}{A}$$

$$Vcek = \frac{0,0052\ m3/s}{\frac{1}{4}\ x\ 3,14\ x\ (0,114\ m)^2}$$

$$Vcek = \frac{0,0052\ m3/s}{0,01\ m2}$$

$Vcek = 0,52 \frac{m}{s}$ (memenuhi kriteria v = $0,3 \frac{\mathrm{m}}{\mathrm{s}}$ sampai $0,6 \frac{m}{s}$)

g) Resume Bak Penampung

- Volume = $18,7\ m^3$
- Dimensi bak
  - P = 4 m
  - L = 4m
- H air = 1,5 m
- H total = 1,8 m
- Luas Bak penampung = 13 m^2
- Diameter pipa outlet = 0,144 m = pipa pasaran 0,125 m = 125 mm
- Cek td = 1,7 jam
- V cek = $0,52 \frac{m}{s}$ (memenuhi kriteria v = $0,3 \frac{\mathrm{m}}{\mathrm{s}}$ sampai $0,6 \frac{m}{s}$)

5.4 Grease Trap

a. Kriteria Perencanaan

- Kriteria Perencanaan = 2 – 6 m/jam
- Waktu tinggal = 5 – 20 menit

Sumber : Buku A IPLT. Dirjen Cipta Karya. tahun 2017. hal. 25

- Massa jenis minyak = 804 kg/m^3
- Massa Jenis air, T 30 = 995,68 kg/m^3 = 0,99568 g/cm^3

Sumber : Reynolds, Hal. 762

b. Data Perencanaan

- Debit (Q) = 0,0052 m^3/s
- Waktu detensi (dt) = 5 - 20 menit
- Konsentrasi minyak dan lemak = 1950 mg/l
- Kecepatan aliran (v) = 2 – 6 m/jam
- Asumsi tinggi area pendendapan (Hp) = 0,3 m
- Asumsi tinggi scum (Hs) = 0,2 m
- Freeboard (Fb) = 20%
- Viskositas dinamik minyak (u) = 0,62 poise
- Viskositas kinematis minyak (μ) = 0,00809 cm^2/s = 0,00000809 m^2/s
- Diameter butiran minyak (d) = 0,15 mm = 0,00015 m
- Waktu tinggal (td) = 15 menit = 900 s
- Kecepatan aliran (v) = 5 m/jam = 0,0014 m/s
- Persen removal = 95 %
- v penampang basah = 0,3 – 0,6 m/s
  Diasumsikan = 0,5 m/s

c. Perhitungan

- Perhitungan Bak

  Volume dibutuhkan (v) = Q x td

  Volume dibutuhkan (v) = 0,0052 m^3/s x 900 s

  Volume dibutuhkan (v) = 0,0052 m^3/s x 900 s

  Volume dibutuhkan (v) = 5 m^3

  Luas area (A) = Q / v

  Luas area (A) = 0,0052 m^3/s / 0,0014 m/s

  Luas area (A) = 4 m^2

- Perhitungan Dimensi

  Rasio P:L = 3:1

  $$L = \sqrt{\frac{A}{3}}$$

$L = \sqrt{\frac{4\ m2}{3}}$

$L = 1{,}14$ m

$P = 3L$

$P = 3(1{,}14\ m)$

$P = 3{,}42$ m

Luas area setelah perbandingan = P x L

Luas area setelah perbandingan = 3,42 m x 1,14 m

Luas area setelah perbandingan = 11 m^2

Panjang Kompartemen 1 = $\frac{2}{3}\ x$ P

Panjang Kompartemen 1 = $\frac{2}{3}\ x$ 3,42 m

Panjang Kompartemen 1 = 2,3 m

Panjang Kompartemen 2 = $\frac{1}{3}\ x$ P

Panjang Kompartemen 2 = $\frac{1}{3}\ x$ 3,42 m

Panjang Kompartemen 2 = 2 m

Check $v = \frac{Q}{A}$

Check $v = \frac{0{,}0052\ m3/s}{4m^2}$

Check $v = 0{,}001 \frac{m}{s} = 3{,}6 \frac{m}{jam} = 4 \frac{m}{jam}$ (memenuhi)

Kedalaman tangki (H air) = $\frac{V}{A}$

Kedalaman tangki (H air) = $\frac{5\ m^3}{4\ m^2}$

Kedalaman tangki (H air) = 1,3 m

Htotal = Hair + Hp + Hs + Fb

Htotal = 1,3 m + 0,3 m + 0,2 m + 0,3 m

Htotal = 2,1 m

$$\text{Jari} - \text{jari hidrolis (R)} = \frac{(\text{L x H})}{\text{L} + (2 \text{ x H})}$$

$$\text{Jari} - \text{jari hidrolis (R)} = \frac{(1{,}14 \text{ m x } 2{,}1 \text{ m})}{1{,}14 \text{ m } + (2 \text{ x } 2{,}1 \text{ m})}$$

$$\text{Jari} - \text{jari hidrolis (R)} = \frac{2{,}4 \text{ m}^2}{5{,}34 \text{ m}}$$

$$\text{Jari} - \text{jari hidrolis (R)} = 0{,}45 \text{ m}$$

$$\text{Kecepatan pengapungan (vp)} = \frac{g}{18\,\mu} \text{ d}^2(\rho\, air - \rho\, minyak)$$

Kecepatan pengapungan (vp)

$$= \frac{9{,}81}{18 \text{ (0,62 poise)}} (0{,}00015)^2 (995{,}68 \frac{\text{kg}}{\text{m}^3} - 804 \frac{\text{kg}}{\text{m}^3})$$

$$= \frac{0{,}00014}{11{,}16} = 0{,}000004 \frac{\text{m}}{\text{s}} = 0{,}0004 \frac{\text{cm}}{\text{s}}$$

$$\text{Cek Bilangan Reynolds (Nre)} = \frac{\rho\ x\ R\ x\ vp}{\mu}$$

$$\text{Cek Bilangan Reynolds (Nre)} = \frac{0{,}99568 \frac{g}{cm^3}\ x\ 0{,}45\ m\ x\ 0{,}0004 \frac{cm}{s}}{0{,}00809 \frac{cm^2}{s}}$$

$$\text{Cek Bilangan Reynolds (Nre)} = 0{,}022 \text{ (Laminer, Nre} < 800)$$

$$\text{Luas penampang pipa (A)} = \frac{\text{Q}}{\text{v penampang basah}}$$

$$\text{Luas penampang pipa (A)} = \frac{0{,}0052 \text{ m}^3/\text{s}}{0{,}5 \text{ m/s}}$$

$$\text{Luas penampang pipa (A)} = 0{,}01 \text{ m}^2$$

$$\text{Diameter pipa (D)} = \sqrt{\frac{4 \text{ x A}}{\pi}}$$

$$\text{Diameter pipa (D)} = \sqrt{\frac{4 \text{ x } 0{,}01 \text{ m}^2}{3{,}14}}$$

$$\text{Diameter pipa (D)} = 0{,}114 \text{ m} = 114 \text{ mm}$$

$$\text{Diameter pasaran} = 0{,}125 \text{ m} = 125 \text{ mm}$$

$$\text{Cek v}' = \frac{\text{Q}}{\text{A}}$$

$$\text{Cek } v' = \frac{0{,}0052 \text{ m}^3/\text{s}}{0{,}25 \text{ x } 3{,}14 \text{ x } 0{,}02 \text{ m}}$$

$\text{Cek } v' = 0{,}33 \text{ m/s}$

Slope dan *Headloss* Saluran

$$S = \left(\frac{\text{n x v}}{(\text{R})^{2/3}}\right)^{\mathbf{2}}$$

$$S = \left(\frac{0{,}013 \text{ x } 0{,}33 \text{ m/s}}{(0{,}45 \text{ m})^{2/3}}\right)^{\mathbf{2}}$$

$S = 0{,}0001$

Headloss Saluran (Hf)

= Slope x Panjang Saluran

= 0,0001 x 3,42 m

= 0,00034 m

- Dimensi Baffle

  $\text{Panjang baffle (L baffle)} = \text{W grease trap}$

  $\text{Panjang baffle (L baffle)} = 1{,}14 \text{ m}$

  $\text{Kedalaman baffle} = \text{htotal} - \text{hp}$

  $\text{Kedalaman baffle} = 2{,}1 \text{ m} - 0{,}3 \text{ m}$

  $\text{Kedalaman baffle} = 0{,}8 \text{ m}$

- Efisiensi penyisihan

  $\text{Debit (Q)} = 0{,}0052 \frac{\text{m}^3}{\text{s}} = 450 \ \frac{\text{m}^3}{\text{hari}} = \ 450.000 \frac{\text{l}}{\text{hari}}$

  $\text{Persen removal} = 95\%$

  $\text{Kadar} = \mathit{influent} \text{ x } 95 \ \%$

  $\text{Kadar} = 1950 \text{ mg/l x } 95 \ \%$

  $\text{Kadar} = 1.853 \text{ mg/l}$

  $\text{Minyak lemak teremoval} = \text{kadar x Q}$

  $\text{Minyak lemak teremoval} = 1.853 \frac{\text{mg}}{\text{l}} \text{x } 450.000 \text{ l/hari}$

  $\text{Minyak lemak teremoval} = 833.850.000 \frac{\text{mg}}{\text{hari}} = 833{,}85 \frac{\text{kg}}{\text{hari}}$

  $\text{Effluent minyak lemak} = \mathit{influent} - \text{kadar}$

$$\text{Effluent minyak lemak} = 1.950 \text{ mg/l} - 1.853 \text{ mg/l}$$

$$\text{Effluent minyak lemak} = 97 \text{ mg/l}$$

$$\text{Debit minyak lemak} = \frac{\text{minyak lemak teremoval}}{\rho \text{ minyak}}$$

$$\text{Debit minyak lemak} = \frac{833{,}85 \text{ kg/hari}}{804 \text{ kg/m}^3}$$

$$\text{Debit minyak lemak} = 1{,}04 \ \frac{\text{m}^3}{\text{hari}} = 0{,}000012 \ \frac{\text{m}^3}{\text{s}}$$

$$\text{Debit setelah minyak lemak} = \text{Q} - \text{Debit minyak lemak}$$

$$\text{Debit setelah minyak lemak} = 0{,}0052 \text{ m}^3/\text{s} - 0{,}000012 \text{ m}^3/\text{s}$$

$$\text{Debit setelah minyak lemak} = 0{,}0051 \text{ m}^3/\text{s}$$

- Dimensi bak penampung scum

$$\text{Td} = 5 \text{ hari}$$

$$\text{Volume} = \text{Q minyak x td}$$

$$\text{Volume} = 1{,}04 \text{ m}^3/\text{hari x } 5 \text{ hari}$$

$$\text{Volume} = 5{,}2 \text{ m}^3$$

$$\text{Lebar} = \frac{1}{2} \text{x P grease trap}$$

$$\text{Lebar} = \frac{1}{2} \text{ x } 4{,}3 \text{ m}$$

$$\text{Lebar} = 2 \text{ m}$$

$$\text{Tinggi} = \text{tinggi grease trap (L)} = 1{,}14 \text{ m}$$

$$\text{Panjang (W)} = \frac{\text{V}}{\text{L x H}}$$

$$\text{Panjang (W)} = \frac{5{,}2 \text{ m}^3}{2{,}15 \text{ m x } 1{,}14 \text{ m}}$$

$$\text{Panjang (W)} = 2 \text{ m}$$

- Dimensi outlet scum

$$\text{Luas Penampang (A)} = \frac{\text{Q}}{\text{v}}$$

$$\text{Luas Penampang (A)} = \frac{0{,}000012 \ \text{m}^3/\text{s}}{0{,}5 \text{ m/s}}$$

$$\text{Luas Penampang (A)} = 0{,}000024 \text{ m}^2$$

$$\text{Diameter pipa} = \sqrt{\frac{4 \text{ x A}}{\pi}}$$

$$\text{Diameter pipa} = \sqrt{\frac{4 \text{ x } 0{,}000024}{3{,}14}}$$

$\text{Diameter pipa} = 0{,}0055 \text{ m} = 55 \text{ mm}$

$\text{Diameter pipa pasaran (pvc)} = 0{,}125 \text{ m} = 125 \text{ mm}$

- Estimasi BOD

  Kualitas Effluent

  BOD pada air limbah = $1650\ mg/l$

  BOD yang disisihkan = BOD influent x persen removal

  BOD yang disisihkan = $1650\ mg/l$ x 75 %

  BOD yang disisihkan = $1238\ mg/l$

  $\text{BOD effluent} = \text{BOD influent} - \text{BOD disisihkan}$

  $$\text{BOD effluent} = 1650 \frac{\text{mg}}{\text{l}} - 1238 \frac{\text{mg}}{\text{l}}$$

  $\text{BOD effluent} = 412 \text{ mg/l}$

- Resume bangunan
  - Volume dibutuhkan (V) = 5 m^3
  - Luas Area (A) = 4 m^2
  - Perhitungan dimensi
    - L = 1,14 m
    - P = 3,42 m
    - Panjang Kompartemen 1 = 2,3 m
    - Panjang kompartemen 2 = 2 m
  - Check kecepatan (v) = $0{,}001 \text{m/s} = 3{,}6 \text{ m/jam} = 4 \text{ m/jam}$
  - Kedalaman tangki
    - H air = 1,3 m
    - H total = 2,1 m

- Kecepatan pengapungan (vp) = $0{,}000004\ m/s = 0{,}0004\ \mathrm{cm}/s$
- Nre = 0,022 (Laminer, Nre < 800)
- Luas penampang pipa = 0,01 m^2
- Diameter pipa = 0,114 m = 114 mm
- Diameter pipa pasaran = 0,125 m = 125 mm
- Cek v = 0,33 m/s
- Slope = 0,0001
- Headloss = 0,00034 m
- Dimensi baffle
  - Panjang = 1,14 m
  - Kedalaman = 0,8 m
- Efisiensi penyisihan = 95%
- Debit minyak lemak = $1{,}04\ \frac{\mathrm{m^3}}{\mathrm{hari}} = 0{,}000012\ \frac{\mathrm{m^3}}{\mathrm{s}}$
- Debit setelah minyak lemak = $0{,}0051\ \mathrm{m^3/s}$
- Diameter outlet scum
  - Luas penampang (A) = $0{,}000024\ \mathrm{m^2}$
  - Diameter pipa = $0{,}0055\ \mathrm{m} = 55\ \mathrm{mm}$
  - Diameter pipa pasaran = 12,5 cm = 125 mm
- Pompa menuju bak netralisasi

• Kriteria Perencanaan

- K *Elbow* 90° = 0,9

  (Sumber: Dake, J.M.K., Endang P. Tachyan dan Y.P. Pangaribuan, 1985. "Hidrolika Teknik Edisi II". Erlangga. Jakarta)
- K *increaser* = 0,25
- K *check valve* = 2,0

  (*Sumber: Pratical Hydrolics For The Public Work Engineer, 1968)*

- Data Perencanaan

-	*Elbow* 90° *suction*	= 1 buah ; k = 0,3
-	*Elbow* 90° *discharge*	= 1 buah ; k = 0,3
-	*Check valve*	= 1 buah
-	Q bak	= 0,0052 m^3/s
-	H suction	= 1,82 m
-	H discharge	= 0,5 m
-	H statis	= H suction + H discharge
		= 1,82 m + 0,5 m = 2,32 m
-	L *suction*	= 2,36 m
-	L *discharge*	= 3,39 m
-	Diameter pipa	= 5" = 125 mm (pasaran)
-	Kecepatan pipa (v)	= 0,5 m/s
-	Koefisien kekasaran (C)s	= 130

- Perhitungan

○ Perhitungan *Suction*

- *Headloss mayor*

$$Hf = \left(\frac{Q}{0{,}2785 \times C \times D^{2{,}63}}\right)^{1{,}85} \times L$$

$$Hf = \left(\frac{0{,}0052\ m^3/s}{0{,}2785 \times 130 \times 0{,}125^{2{,}63}}\right)^{1{,}85} \times 2{,}36\ m$$

Hf = 0,005 m

Headloss minor (elbow 90°)

$$Hf_{elbow} = n \times k \times \frac{v^2}{2g}$$

$$= 1 \times 0{,}9 \times \frac{0{,}5^2}{2 \times 9{,}81}$$

= 0,011 m

- *Headloss minor (increaser 90°)*

$$Hf_{increaser} = n \times k \times \frac{v^2}{2g}$$

$$= 1 \times 0{,}25 \times \frac{0{,}5^2}{2 \times 9{,}81}$$

= 0,003 m

ΣHf minor

Hf_{minor} = Hf minor elbow *90°* + Hf minor increaser

= 0,011 m + 0,003 m

= 0,014 m

- ΣHf *suction*

Hfs = Hf mayor + Hf minor

= 0,005 m + 0,014 m

= 0,019 m

- Perhitungan *Discharge*

- *Headloss mayor*

Hf $= \left(\frac{Q}{0,2785 \times C \times D^{2,63}}\right)^{1,85} \times L$

Hf $= \left(\frac{0,0052\ m^3/s}{0,2785 \times 130 \times 0,125^{2,63}}\right)^{1,85} \times 2,39\ m$

Hf = 0,004 m

- *Headloss minor*

Hf_{elbow} $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0,9 \times \frac{0,5^2}{2 \times 9,81}$

= 0,011 m

- *Headloss minor (check valve)*

$Hf_{chcek\ valve}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0,2 \times \frac{0,5^2}{2 \times 9,81}$

= 0,0025 m

- Headloss minor (increaser)

$Hf_{increaser}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0,25 \times \frac{0,5^2}{2 \times 9,81}$

= 0,003 m

ΣHf minor

Hf_{minor} = Elbow+Hf minor checek valve + Hf minor increaser

= 0,011 m + 0,0025 m + 0,003 m

= 0,016 m

- ΣHf *discharge*

  Hfd = Hf mayor + Hf minor

  = 0,004 m + 0,016 m

  = 0,02 m

○ Perhitungan *head* total (*head* pompa)

- *Head* total = *Head* statis + ΣHf *suction* + ΣHf *discharge*

  = 2,32 m + 0,019 m + 0,02 m

  = 2,35 m

○ Head statis < Head pompa = 2,32 < 2,35 m

Berdasarkan perencanaan debit (Q) = 18,75 m^3/jam dan head pump = 2,35 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa sentrifugal Grundfos tipe NKE 32-180/177 ASA1F1S3ESBQQEIWB dengan spesifikasi pompa sebagai berikut:

- Merk = Grundfos
- Tipe pompa = NKE 32-180/177 ASA1F1S3ESBQQEIWB
- Flow Rated = 21,77 m^3/h
- Rated Head = 19,95
- Diameter pipa suction = 50 DN
- Diameter pipa discharge = 32 DN

Gambar 5. 1 Pompa Grundfos NKE 32-180/177 ASA1F1S3ESBQQEIWB

a. Resume bangunan
   - Volume dibutuhkan (V) = 5 m^3
   - Luas Area (A) = 4 m^2
   - Perhitungan dimensi
     - L = 1,14 m
     - P = 3,42 m
     - Panjang Kompartemen 1 = 2,3 m
     - Panjang kompartemen 2 = 2 m
   - Check kecepatan (v) = $0{,}001 \text{m}/s = 3{,}6 \text{ m/jam} = 4 \text{ m/jam}$
   - Kedalaman tangki
     - H air = 1,3 m
     - H total = 2,1 m
   - Kecepatan pengapungan (vp) = $0{,}000004\ m/s = 0{,}0004 \text{ cm}/s$
   - Nre = 0,022 (Laminer, Nre < 800)
   - Luas penampang pipa = 0,01 m^2
   - Diameter pipa = 0,114 m = 114 mm
   - Diameter pipa pasaran = 0,125 m = 125 mm
   - Cek v = 0,33 m/s
   - Slope = 0,0001
   - Headloss = 0,00034 m

- Dimensi baffle
  - Panjang = 1,14 m
  - Kedalaman = 0,8 m
- Efisiensi penyisihan = 95%
- Debit minyak lemak = $0{,}052\ \frac{m^3}{hari} =$ $0{,}0000006\ \frac{m^3}{s}$
- Debit setelah minyak lemak = $0{,}005\ m^3/s$
- Diameter outlet scum
  - Luas penampang (A) = $0{,}0000012\ m^2$
  - Diameter pipa = $0{,}0012\ m = 12\ mm$
  - Diameter pipa pasaran = 12,5 cm = 125 mm
- Pompa menuju Bak Netralisasi

  Head statis < Head pompa = 2,32 < 2,35 m

  Berdasarkan perencanaan debit (Q) = 18,75 m^3/jam dan head pump = 2,35 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa sentrifugal Grundfos tipe NKE 32-180/177 ASA1F1S3ESBQQEIWB dengan spesifikasi pompa sebagai berikut:
  - Merk = Grundfos
  - Tipe pompa = NKE 32-180/177 ASA1F1S3ESBQQEIWB
  - Flow Rated = 21,77 m^3/h
  - Rated Head = 19,95
  - Diameter pipa suction = 50 DN
  - Diameter pipa discharge = 32 DN

5.5 Bak Netralisasi

a. Kriteria Perencanaan

- Waktu tinggal di dalam bak netralisasi (td) = 20-60 detik

  (*Sumber : Reynolds, Tom D. dan Richards c. 2003. Wastewater Engineering Treatment and Reuse 4th edition, hlm. 182*)

- Gradien kecepatan pengaduk (G) = 700 - 1500/detik
- Diameter *turbine* (Di) = 30 - 60% D/W
- Lebar *turbine* (Wi) = 1/6 – 1/10 D/W
- Lebar Baffle = 10% diameter tangki
- Kecepatan putaran *turbine* (n) = 10 – 150 rpm

  (*Sumber : Reynolds, Tom D. dan Richards c. 2003. Wastewater Engineering Treatment and Reuse 4th edition, hlm. 185*)
- Kedalaman bak (H) = 1 – 1,25 D/W

  (*Sumber : Reynolds, Tom D. dan Richards c. 2003. Wastewater Engineering Treatment and Reuse 4th edition, hlm. 184)*
- Kecepatan pipa outlet (v) = 1 – 2,5 m/s
- Bilangan Reynold (NRe) = >10.000

  (*Sumber : Reynolds, Tom D. dan Richards c. 2003. Wastewater Engineering Treatment and Reuse 4th edition, hlm. 187)*

b. Data Perencanaan Netralisasi

- Debit aliran (Q) = 0,005 m^3 /s = 450 m^3/hari
- Tangki pembubuh :

Menggunakan bahan kimia $Ca(OH)_2$ karena karakteristik air limbah yang bersifat asam dan efektivitas yang tinggi sehingga lebih efisien.

- pH air limbah = 5,29
- Menggunakan $Ca(OH)_2$
- Massa jenis $Ca(OH)_2$ = 2,21 kg/L
- Berat Molekul (Mr) = 74 g/mol
- Jumlah bak = 1 buah
- Kadar air dalam larutan = 80 %
- Kadar $Ca(OH)_2$ dalam larutan = 20 %
- Suhu air = 26˚C
- Viskositas absolut = 0,0008746 N.s/m^2
- Massa jenis air = 0,99681 gr/cm^3 = 996,81 kg/m^3
- Freeboard = 20 %
- Gradien kecepatan (G) = 700 – 1000/dt

(*Reynold, "Unit Operations and Processess In Environmental Engineering", Hlm. 180-188*)

- Lebar paddle impeller (Wi) = 0,1 diameter tangka
- Jenis impeller = Flat Paddle two blade
- Kecepatan putaran paddle (n) = 100 rpm = 1,67 rps
- Kt = 2,25

Sumber: Table 8.2 Reynold (Reynold & Richards, 1996) Uni Operation and Prcesses in Environmental Engineering, Second Edition, PWS Publishing Company, Halaman 188)

- Waktu
- Waktu detensi pembubuhan = 1 hari = 86400 detik
- Waktu detensi pembuatan larutan = 1 hari = 86400 detik
- Periode pembuatan larutan = 1 hari = 86400 detik

c. Perhitungan

<u>Bak Pelarut Penetralan $Ca(OH)_2$</u>

1) Dosis $Ca(OH)_2$

pOH $= -\log[OH^-]$

pOH $= -\log\left[\frac{gram}{v} \times \frac{1}{Mr}\right] \times b$

7 - 5 $= -\log\left[\frac{gram}{v} \times \frac{1}{74}\right] \times 2$

2 $= -\log\frac{Do}{37}$

10^{-2} $= \frac{gram}{37L}$

Do $= 10^{-2} \times 37$

Do = 0,37 g/L

= 0,00037 kg/L

2) Kebutuhan $Ca(OH)_2$

Kebutuhan $Ca(OH)_2$ $= Do \times Q$

$= 0{,}00037\ kg/L \times 0{,}005\ m3/s$

$= 0{,}00037\ kg/L \times 5\ L/s$

= 0,00185 kg/s

= 159,84 kg/hari

3) Volume $Ca(OH)_2$ $= \frac{\text{kebutuhan Ca(OH)2}}{\rho \text{ Ca(OH)2}} \times$

periode pembuatan larutan

$= \frac{0{,}00185 \text{ kg/s}}{2{,}12 \text{ kg/L}} \times 86400 \text{ s}$

= 75,39 L = 0,07539 m^3

4) Kebutuhan air untuk pelarutan

V air pelarut $= \frac{100\% - \text{kadar Ca(OH)2 dalam lar.}}{\text{Kadar Ca(OH)2dalam lar.}} \times \text{V Ca(OH)2}$

$= \frac{100\% - 20\%.}{20\%.} \times 0{,}07539 \text{ m3}$

= 0,30156 m^3

5) Volume larutan

Volume larutan $Ca(OH)_2$ $= \text{Volume Ca(OH)2} + \text{Volume air pelarut}$

$= 0{,}07539 \text{ m3} + 0{,}30156 \text{ m3}$

= 0,37695 m^3 = 376,95 L

6) Tinggi Air

H air $= \text{Htangki} - (20\% \times \text{Htangki})$

$= 1{,}17 \text{ m} - (20\% \times 1{,}17 \text{ m})$

= 0,94 m

7) Debit yang masuk ke tangki pembubuh

Q $= \frac{\text{volume tangki pembuatan larutan}}{\text{Td pembuatan larutan}}$

$= \frac{0{,}37695 \text{ m3}}{86400\ s}$

= 0,00000436 m^3/s

= 0,0043 L/s

= 15,48 L/jam

Berdasarkan Nilai htiung Volume larutan di Bak Pembubuh didapatkan sebesar 376,95 L. Sehingga disesuaikan untuk tangki yang akan digunakan yakni **Mpoin Tangki Air Wave (Toren) 400 W Hitam 400 L** , dengan spesifikasi sebagai berikut:

Gambar 5. 2 Mpoin Tangki Air Wave (Toren) 400 W Hitam 400 L
Sumber:

https://www.monotaro.id/items/s009241813.html?gclid=CjwKCAiA3aeqBhBzEiwAxFiOBtQpxtKzTN5X_KY44DUwqjXm1ayPhMwHx22D0itKRUM2HGBWdn0HIRoC_oEQAvD_BwE

Spesifikasi:

- Model Number = 400 W
- Volume (L) = 400
- Height (cm) = 117
- Diameter (cm) = 70

8) Suplai tenaga ke air

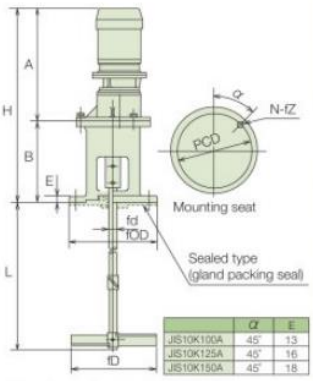
P $= G^2 \times \mu \times V$

$= (1000/s)^2 \times (0{,}8746 \times 10^{-3} N.s/m^2) \times 0{,}37695$ m3

= 329, 7 N.m/s

= 329, 7 watt = 0,3 kw

External Dimensions



* Can be made up to 0.75 kW1/20.
* Dimensions H and A vary slightly according to motor manufacturer.
* Paddle, 3-vane propeller and turbine impellers are also available.
* Agitators having a gear ratio other than the above are also available.

Specification Dimensions

Model	Motor/Gear Reducer Output kW	Motor/Gear Reducer Gear Ratio i	Revolution Speed (min^{-1}) 50Hz	Revolution Speed (min^{-1}) 60Hz	Agitation Shaft Standard length (L) mm	Agitation Shaft Dia. (Dia. D) mm	2-vane Paddle 2-stage Dia. (Dia. Di) mm	Main Body (H) mm	Main Body (A) mm	Main Body (B) mm	Mounting Flange Nominal dia. JIS-10K	Mounting Flange O.D. (OD) mm	Mounting Flange Pitch (PCD) mm	Hole (Z) mm	Hole (N) PCS	Max. Agitation Capacity Diluted Liquids L	Max. Agitation Capacity Medium Viscosity Liquid L	Approx. Weight W/ motor kg
M□T□ - 0.1A		1/10	150	180			200											18
		1/15	100	120			250											18
		1/20	75	90			300	410	241									18
		1/30	50	60			350											19
	0.1	1/50	30	36			500	—	—							700	300	20
M□T□ - 0.1		1/10	150	180			200											21
		1/15	100	120	1000	16	250			169	100A	210	175	19	4			21
		1/20	75	90			300	468	299									22
		1/30	50	60			350											22
		1/50	30	36			500	—	—									24
M□T□ - 0.2A		1/10	150	180			250											19
		1/15	100	120			300	451	282									19
		1/20	75	90			350											20
		1/30	50	60	1200	22	450	480	296	184	125A	250	210	23	4			27
	0.2	1/50	30	36			550									1300	600	29
M□T□ - 0.2		1/10	150	180			250											22
		1/15	100	120	1000	16	300	502	333	169	100A	210	175	19	4			22
		1/20	75	90			350											23
		1/30	50	60			450	531	347									30
		1/50	30	36			550											32
M□T□ - 0.4		1/10	150	180	1200	22	350			184	125A	250	210	23	4			33
		1/15	100	120			400	558	374									33
	0.4	1/20	75	90			450									2500	1200	33
		1/30	50	60			550	618	387									51
		1/50	30	36			650											53
M□T□ - 0.75		1/10	150	180	1500	32	400			231	150A	280	240	23	4			59
	0.75	1/15	100	120			500	644	413							5000	2500	60
		1/20	75	90			600											61

Gambar 5. 3 Katalog Daya Pengaduk Pembubuh Koagulan

Katalog Daya Pengaduk Bak Pembubuh Koagulasi Berdasarkan perhitungan daya pengadukan yang dibutuhkan, maka digunakan pengaduk dengan spesifikasi berikut:

- Merk = TACMINA
- Model = MT – 0,4
- Power = 0,4 kW
- Di = 350 mm = 0,35 m
- Panjang poros pengadukan (L) = 184 mm = 0,184 m

9) Diameter impeller

Cek Di $= \frac{Di}{Dtangki}$

$= \frac{0,35 \text{ m}}{0,7 \text{ m}} \times 100\%$

= 0,5 m = 50 % (memenuhi (50% - 80 % dari diameter tangki)

10) Jarak Impeller dari dasar

Jarak $= 0,5 \times Di$

$= 0,5 \times 0,35$ m

= 0,175 m

11) Lebar Paddle Impeller

Wi $= \frac{1}{10} \times$ Dtangki

$= \frac{1}{10} \times 0{,}7$ m

= 0,07 m

12) Cek bilangan Reynold

NRe $= \frac{(\mathrm{Di})^2 \times n \times \rho}{\mu}$

$= \frac{(0{,}5\ \mathrm{m})^2 \times 1{,}67 \times 996{,}81\ kg^3/m}{0{,}8746 \times 10^{-3}\ \mathrm{N.s/m^2}}$

= 475838,3 ⟶ NRe > 10.000 (memenuhi) (Aliran Turbulen)

<u>Perhitungan *Dosing Pump*</u>

Berdasarkan perhitungan diatas, diperoleh debit tangki koagulan sebesar 15,48 L/jam sehingga spesifikasi *dosing pump* yang akan digunakan yaitu:

Merk = Grundfoss

Tipe = **DMH 15,5-200D B-SS/T/SS-X-E2C2C2XEMAG**

Debit Maksimal = 15,5 L/jam

Gambar 5. 4 Dosing Pump Netralisasi

<u>Tangki Netralisasi</u>

1) Volume tangki netralisasi

V, tangki = Q x Td

= 0,005 m^3/s x 60 s

= 0,3 m^3

V total $= V \text{ limbah} + V \text{ pembubuh}$

$= 0{,}3 \text{ m}^3 + 0{,}37695 \text{ m}^3$

$= 0{,}67695 \text{ m}^3$

$= 676{,}95 \text{ L}$

2) Tinggi Air

H air $= H \text{ tangki} - (20\% \times H \text{ tangka})$

$= 1{,}29 \text{ m} - (20\% \times 1{,}29 \text{ m})$

$= 1{,}03 \text{ m}$

3) Debit Netralisasi

Q $= \frac{\text{v limbah total}}{\text{Td}}$

$= \frac{0{,}67695 \text{ m}^3}{60 \text{ s}}$

$= 0{,}0113 \text{ m}^3/\text{s}$

$= 11{,}3 \text{ L/s}$

Berdasarkan perhitungan, volume bak netralisasi sejumlah 676,95 L. Selanjutnya, digunakan tangki netralisasi yang telah disesuaikan dengan spesifikasi berikut, yang dibuat sesuai dengan bahan yang tersedia di pasaran:

Gambar 5. 5 Tangki TDA-700LT PU 700

Sumber: https://www.mitra10.com/profil-tangki-air-water-tank-tda-700-liter-pu?srsltid=AfmBOooaSSd97lyGYn9kmAkwscZNdVqN9I-C6TuK_mLD0_L3u7GDwSEZe6Y

Spesifikasi Tangki:

- Merk = TDA-700LT PU 700
- Volume = 700 L
- Diameter = 91 cm
- Tinggi = 129 cm

4) Suplai tenaga ke air

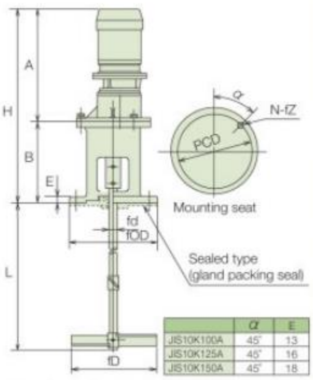
$P = G^2 \times \mu \times V$

$= (1000/s)^2 \times (0{,}8746 \times 10^{-3} N.s/m^2) \times 0{,}67695\ m^3$

= 592,06 N.m/s = 592,06 watt

= 0,59 kw = 0,6 kw

External Dimensions



* Can be made up to 0.75 kW1/20.
* Dimensions H and A vary slightly according to motor manufacturer.
* Paddle, 3-vane propeller and turbine impellers are also available.
* Agitators having a gear ratio other than the above are also available.

Specification Dimensions

Model	Motor/Gear Reducer Output kW	Gear Ratio i	Revolution Speed (min⁻¹) 50Hz	60Hz	Agitation Shaft Standard length (L) mm	Dia. (Dia. D) mm	2-vane Paddle 2-stage Dia. (Dia. D) mm	Main Body (H) mm	(A) mm	(B) mm	Mounting Flange Nominal dia. JIS-10K	O.D. (OD) mm	Pitch (PCD) mm	Hole (Z) mm	(N) PCS	Max. Agitation Capacity Diluted Liquids L	Medium Viscosity Liquid L	Approx. Weight W/ motor kg
M□T□ - 0.1A		1/10	150	180			200											18
		1/15	100	120			250											18
		1/20	75	90			300	410	241									18
		1/30	50	60			350											19
	0.1	1/50	30	36			500									700	300	20
M□T□ - 0.1		1/10	150	180			200											21
		1/15	100	120	1000	16	250			169	100A	210	175	19	4			21
		1/20	75	90			300	468	299									22
		1/30	50	60			350											22
		1/50	30	36			500											24
M□T□ - 0.2A		1/10	150	180			250											19
		1/15	100	120			300	451	282									19
		1/20	75	90			350											20
		1/30	50	60	1200	22	450	480	296	184	125A	250	210	23	4			27
	0.2	1/50	30	36			550									1300	600	29
M□T□ - 0.2		1/10	150	180			250											22
		1/15	100	120	1000	16	300	502	333	169	100A	210	175	19	4			22
		1/20	75	90			350											23
		1/30	50	60			450	531	347									30
		1/50	30	36			550											32
M□T□ - 0.4		1/10	150	180	1200	22	350			184	125A	250	210	23	4			33
		1/15	100	120			400	558	374									33
	0.4	1/20	75	90			450									2500	1200	33
		1/30	50	60			550	618	387									51
		1/50	30	36			650											53
M□T□ - 0.75		1/10	150	180	1500	32	400			231	150A	280	240	23	4			59
	0.75	1/15	100	120			500	644	413							5000	2500	60
		1/20	75	90			600											61

Gambar 5. 6 Katalog Daya Pengaduk Netralisasi

Katalog Daya Pengaduk Bak Netralisasi Berdasarkan perhitungan daya pengadukan yang dibutuhkan, maka digunakan pengaduk dengan spesifikasi berikut:

- Merk = TACMINA
- Model = MT – 0,75
- Power = 0,75 kW

- Di = 500 mm = 0,5 m
- Panjang poros pengadukan (L) = 231 mm = 0,231 m

5) Diameter impeller

Cek Di $= \frac{\text{Di}}{\text{Dtangki}}$

$= \frac{0{,}5\ \text{m}}{0{,}91\ m} \times 100\%$

= 50 % (memenuhi (50 - 80% dari diameter tangki))

6) Jarak Impeller dari dalam

Jarak $= 0{,}5 \times \text{Di}$

$= 0{,}5 \times 0{,}5\ \text{m}$

= 0,25 m

7) Lebar Paddle Impeller

Wi $= \frac{1}{10} \times \text{Dtangki}$

$= \frac{1}{10} \times 0{,}91\ \text{m}$

= 0,091 m

8) Cek bilangan NRe

NRe $= \frac{(\text{Di})^2 \times n \times \rho}{\mu}$

$= \frac{(0{,}5\ \text{m})^2 \times 1{,}67 \times 996{,}81\ kg^3/m}{0{,}8746 \times 10^{-3}\ \text{N.s/m}^2}$

= 475838,3 ⟶ NRe > 10.000 (memenuhi) (Aliran Turbulen)

Perhitungan Outlet

1) Luas penampang pipa

A $= \frac{\text{Q}}{\text{V}}$

$= \frac{0{,}0113\ \text{m3/s}}{0{,}5\ \text{m/s}}$

$= 0{,}0226\ \text{m}^2$

2) Diameter outlet pipa

d $= \sqrt{\frac{4 \times \text{A}}{\pi}}$

$= \sqrt{\frac{4 \times 0{,}0226 m^2}{3{,}14}}$

= 0,17 m = 170 mm = 200 mm (pasaran)

3) Cek kecepatan pipa

$V = \frac{Q}{A}$

$= \frac{0{,}0113\ m3/s}{0{,}0226\ m^2}$

= 0,5 m/s ⟶ 1 < V < 2,5 m/s (memenuhi)

d. Resume Bangunan

Bak Pelarut Penetralan $Ca(OH)_2$

- Dosis $Ca(OH)_2$ = 0,00037 kg/L
- Kebutuhan $Ca(OH)_2$ = 0,00185 kg/s
- Volume $Ca(OH)_2$ = 75,39 L
- Kebutuhan air untuk larutan = 0,30156 m^3
- Volume larutan = 376,95 L
- Tinggi air = 0,94 m
- Debit = 15,48 L/jam
- Jenis Tangki
  - Merk : Mpoin Tangki Air Wave (Toren) 400 W Hitam 400 L
  - Model Number : 400 W
  - Volume (L) :400
  - Height (cm) : 117
  - Diameter (cm) : 70
- Suplai tenaga ke air (P) = 329, 7 watt = 0,3 kw
- Jenis Impeller
  - Merk : TACMINA
  - Model : MT – 04
  - Power : 0,4 kW
  - Di : 350 mm = 0,35 m
  - Panjang poros pengadukan : 184 mm = 0,184 m

- Cek Di = 50 % (memenuhi (50% - 80 % dari diameter tangki)
- Jarak impeller dari dasar = 0,175 m
- Lebar Paddle Impeller = 0,07 m
- Nre = 475838,3 ⟶ NRe > 10.000 (memenuhi)

Bak Netralisasi

- Volume tangki = 0,3 m^3
- V total = 0,67695 m^3 = 676,95 L
- H air = 1,03 m
- Debit = 0,0113 m^3/s = 11,3 L/s
- Jenis Tangki
- Merk : TDA-700LT PU 700
- Volume : 700 L
- Diameter : 91 cm
- Tinggi :129 cm
- Suplai tenaga = 0,6 Kw
- Jenis Impeller
- Merk : TACMINA
- Model : MT – 0,75
- Power : 0,75 kW
- Di : 500 mm = 0,5 m
- Panjang poros pengadukan : 231 mm = 0,231 m
- Cek Di = 50 % (memenuhi (50 - 80% dari diameter tangki))
- Jarak impeller dari dalam = 0,25 m
- Lebar Paddle = 0,091 m

Nre = 475838,3 ⟶ NRe > 10.000 (memenuhi)

- Pipa Outlet

- Luas penampang pipa = 0,0226 m^2
- D = 170 mm = 200 mm (pasaran)
- Cek V = 1 < V < 2,5 m/s (memenuhi)

5.6 DAF (Dissolved Air Flotation)

A. Bak Pembubuh Koagulan

a. **Kriteria Perencanaan**

- Gradien Kecepatan (G) = 700 – 1000/s
  (Sumber: Reynolds, Tom D. dan Paul A. Richards. 1996. Unit Operations and Processes in Environmental Engineering 2nd edition, hal 182. Boston: PWS Publishing Company)
- Tinggi Bak (H) = 1 – 1.25 Lebar Bak
- Jarak Impeller Dari Dasar = 30 – 50% Diameter Impeller
  (Sumber: Reynolds, Tom D. dan Paul A. Richards. 1996. Unit Operations and Processes in Environmental Engineering 2nd edition, hal 184. Boston: PWS Publishing Company)
- Waktu detensi = 20 – 60 s
  (*Sumber: Reynolds, Tom D. dan Paul A. Richards. 1996. Unit Operations and Processes in Environmental Engineering 2nd edition, hal 182. Boston: PWS Publishing Company*)
- Lebar Impeller = 1/6 – 1/10 m
  (Sumber: Reynolds, Tom D. dan Paul A. Richards. 1996. Unit Operations and Processes in Environmental Engineering 2nd edition, hal 184. Boston: PWS Publishing Company)
- Nre = >10.000 Turbulen
- Kecepatan Turbin Impeller = 20 - 150 rpm
  (Sumber: Reynolds, Tom D. dan Paul A. Richards. 2003. Wastewater engineering treatment and reuse 4th edition, hal 185)
- Koefisien pipa jenis *Cast Iron Pipe* (C) = 130
  (Sumber: Soufyan dan Morimura, Perancangan dan Pemeliharaan Sistem Plambing, halaman 71)

- Koefisien headloss untuk aksesoris pipa (K):
- *Elbow 90˚* = 0,75
- *Gate valve* = 0,19
- *Check valve* = 2,50
- *Tee* = 0,50

  (Sumber: Kawamura, Integrated Design and Operation of Water Treatment Facilities, Jilid 2, hlm. 638)
- Kadar PAC = 30%
- ρ PAC = 1,23 kg/L
- Massa Jenis Air (ρ), T (28°C) = 0.9963 g/cm^3 = 996.3 kg/m^3
- Viskositas Absolut (μ) T (28°C) = 0.8363 x 10^{-3} N.s/m^2

  (Sumber: Reynolds, Tom D. dan Paul A. Richards. 1996. Unit Operations and Processes in Environmental Engineering 2nd edition, hal 175-762. Boston: PWS Publishing Company)
- Menggunaka jenis impeller *Three Bladed Propeller*

b. Data Perencanaan

- Koagulan yang digunakan = PAC (Poly Alumunium Chloride)
- Tangki yang digunakan = 1 buah
- Debit = 0,005 m^3/s = 432 m^3/hari = 432.000 L/hari
- Dosis koagulan = 30 mg/L
- Berat jenis koagulan (ρ PAC) = 1,23 Kg/L
- Periode Pelarutan PAC (td) = 1 hari
- Gradien Kecepatan (G) = 900/s
- Kecepatan Putaran Propeller (n) = 150 rpm = 2,5 rps
- Kadar PAC / Konsentrasi = 25 %
- Massa Jenis PAC = 1,23 Kg/L
- Massa Jenis air = 996 kg/m^3
- Konstanta Pengaduk = 0,32 (untuk aliran turbulen)

c. Perhitungan

<u>BAK PEMBUBUH KOAGULAN</u>

a) Kebutuhan Koagulan Harian

Kebutuhan PAC = dosis x Q air limbah

= 30 mg/l x 432.000 l/hari

= 12.960.000 mg/hari

= 12,96 kg/hari

b) Kebutuhan Koagulan (Kadar 25%)

Koagulan $= \frac{100\%}{\text{Kadar PAC}} \times \text{kebutuhan PAC}$

$= \frac{100\%}{25\%} \times 12{,}96 \text{ kg/hari}$

= 51,84 kg/hari

c) Debit PAC

Debit PAC $= \frac{\text{massa \% PAC}}{\rho \text{ PAC}}$

$= \frac{51{,}84 \text{ kg/hari}}{1{,}23 \text{ kg/L}}$

= 42,2 liter/hari = 0,0422 m^3/hari

d) Kebutuhan air untuk PAC (25%)

Kebutuhan pelarut $= \frac{100\% - 25\%}{\%\text{pelarut}} \times \text{Debit PAC}$

$= \frac{100\% - 25\%}{25\%} \times 0{,}0422 \text{ m3/hari}$

= 0,13 m^3/hari

e) Debit Bak

Debit total = Debit PAC + Debit pelarut

= 0,0422 m^3/hari + 0,13 m^3/hari

= 0,172 m^3/hari

f) Volume PAC (V1)

V = Q x Td pelarutan

= 0,0422 m^3/hari x 1 hari

= 0,0422 m^3

= 42,2 L

g) Volume pelarut (V2)

V = Q x Td pelarutan

= 0,13 m^3/hari x 1 hari

= 0,13 m^3

= 130 L

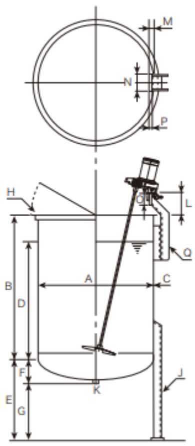
h) Volume Total = Volume PAC + Volume air pelarut

= 42,2 L + 130 L

= 172,2 L = 0,172 m^3

i) Dimensi bak pembubuh

Specification of optional tanks



Model	Available capacity	Maximum capacity	Tank dimension (mm)										Weight (kg)	
	ℓ	ℓ	A	B	C	D	E	F	G	H(SUS)	J(SS)	K	Tank	Lid*
ZTF-100	100	130	500	600	3	450	450	134	316	L25×25×3	3-L50×50×6	1/2 B Socket	43	3
ZTF-150	150	182	550	700	3	562	450	144	306	L30×30×3	3-L50×50×6	1/2 B Socket	51	4
ZTF-200	200	260	650	700	3	520	450	163	287	L30×30×3	3-L50×50×6	1/2 B Socket	60	5.5
ZTF-300	300	361	700	850	3	692	500	173	327	L40×40×3	4-L50×50×6	1/2 B Socket	77	6.5
ZTF-400	400	478	800	850	3	695	500	192	308	L40×40×3	4-L50×50×6	1/2 B Socket	88	8
ZTF-500	500	600	850	950	3	770	500	202	298	L40×40×3	4-L65×65×6	1/2 B Socket	106	9
ZTF-800	800	963	1000	1100	3	900	550	240	310	L40×40×5	4-[100×50×5	1B Socket	155	12
ZTF-1000	1000	1177	1100	1100	3	910	550	260	290	L40×40×5	4-[100×50×5	1B Socket	170	19
ZTF-1500	1500	1721	1250	1245	4	1065	600	290	310	L40×40×5	4-[100×50×5	1B Socket	260	24
ZTF-2000	2000	2275	1300	1550	4	1345	600	298	302	L50×50×6	4-[125×65×6	1B Socket	335	26
ZTF-2000S	2000	2273	1400	1300	4	1125	600	318	282	L50×50×6	4-[125×65×6	1B Socket	325	30
ZTF-2500	2500	3073	1500	1550	4	1230	700	370	330	L50×50×6	4-[125×65×6	1B JIS 10KF	400	34
ZTF-3000	3000	3603	1500	1850	4	1510	700	370	330	L50×50×6	4-[125×65×6	1B JIS 10KF	448	34
ZTF-3000S	3000	3521	1600	1550	4	1290	750	400	350	L50×50×6	4-[125×65×6	1B JIS 10KF	422	38
ZTF-3500	3500	4125	1600	1850	4	1540	700	400	300	L50×50×6	4-[150×75×9	1B JIS 10KF	524	38
ZTF-3500S	3500	4004	1700	1550	4	1330	800	430	370	L50×50×6	4-[150×75×9	1B JIS 10KF	514	43
ZTF-4000	4000	4685	1700	1850	4	1550	800	430	370	L65×65×6	4-[150×75×9	1 1/2 B JIS 10KF	575	45
ZTF-4000S	4000	4520	1800	1500	4	1345	800	450	350	L65×65×6	4-[150×75×9	1 1/2 B JIS 10KF	550	50
ZTF-4500	4500	5285	1800	1850	5	1542	800	450	350	L65×65×6	4-[200×90×8	1 1/2 B JIS 10KF	750	50
ZTF-5000	5000	5924	1900	1850	5	1530	900	500	400	L65×65×6	4-[200×90×8	2B JIS 10KF	800	56

* The lids have a thickness of 1.5t for A dimension up to 1000, and 2.0t for A dimension above that.

* Jacket type is also available.

Gambar 5. 7 Dimensi Bak Pembubuh

Berdasarkan perhitungan Volume total sebesar 172,2 L diperoleh spesifikasi tangki pembubuhan koagulan sesuai katalog di atas sebagai berikut:

- Merk = Satake Mixer Tanks
- Model Tangki = ZTF-150
- Kapasitas = 150 L
- Kapasitas Max. = 182 L
- Diameter tangki = 550 mm = 0,55 m
- Kedalaman bak = 700 mm + 144 mm = 844 mm = 0,844 m
- Kedalaman air = 520 mm + 144 mm = 664 mm = 0,664 m

j) Daya Pengadukan (P)

P $= G^2 \times \mu \times V$

$= (700/s)^2 \times (0{,}8363 \times 10^{-3} N.s/m^2) \times$ 0,172 m3

= 70,48 N.m/s

= 70,48 watt

= 0,07 kw = 0,1 kW

Standard specification

Model	Frame number	Motor: Power (kW)	Motor: Number of poles (P)	Motor: Phase and voltage (V)	Impeller: Frequency (Hz)	Impeller: Revolution (min^{-1})	Impeller: Diameter (mm)	Impeller: Stage	Shaft length (mm)
A720-0.065A	1	0.065	4	Single-phase 100	50 60	300 360	150	1	600
A720-0.1A		0.1	4	Single-phase 100	50 60	300 360	220	1	800
A720-0.1B		0.1	4	Three-phase 200	50 60	300 360	220	1	800
A720-0.2A	2	0.2	4	Single-phase 100	50 60	300 360	270	1	1000
A720-0.2B		0.2	4	Three-phase 200	50 60	300 360	270	1	1000
A720-0.4B	3	0.4	4	Three-phase 200	50 60	300 360	310	1	1250
A725-0.4B	4	0.4	6	Three-phase 200	50 60	200 240	350	1	1500
A720-0.75B		0.75	4	Three-phase 200	50 60	300 360	350	1	1500
A725-0.75B	5	0.75	6	Three-phase 200	50 60	200 240	400	1	2000
A720-1.5B		1.5	4	Three-phase 200	50 60	300 360	400	1	2000

* The standard materials for the shaft and the impeller are SUS304 or SUS316.
* The A720 and A725 are the replacement for the A520.

Gambar 5. 8 Pengaduk Bak Pembubuh

Berdasarkan perhitungan daya diatas, didapatkan spesifikasi impeller yang akan digunakan sebagai berikut:

- Merek/Model = Satake / A720-0,1B
- Power = 0,1 kW
- Diameter = 220 mm = 0,22 m

k) Jarak impeller dengan dasar

Hi = 50 % x Di

= 50% x 0,22 m

$= 0,11$ m

l) Lebar Impeller

Wi $= \frac{Di}{8}$

$= \frac{0,22}{8}$

$= 0,0275$ m

Cek Wi $= \frac{Wi}{Di}$

$= \frac{0,03 \text{ m}}{0,22 \text{ m}}$

$= 0,13$ (memenuhi syarat)

m) Cek bilangan Reynold

NRe $= \frac{(Di)^2 \times n \times \rho}{\mu}$

$= \frac{(0,22)^2 \times 2,5 \times 996 kg^3/m}{0,8363 \times 10^{-3} \text{N.s/m}^2}$

$= 144106,1 \longrightarrow$ NRe > 10.000 (memenuhi) (Turbulen)

n) Debit bak pembubuh

Q Bak Pembubuh $= \frac{\text{V tangki}}{\text{Td}}$

$= \frac{172,2 \text{ L}}{1 \text{ hari}}$

$= 172,2$ L/hari $= 0,172$ m^3/hari $= 1 \times 10^{-6}$ m^3/s

$= 7,17$ L/jam

PIPA KOAGULASI

Perhitungan Outlet:

a) Luas penampang pipa

A $= \frac{Q}{V}$

$= \frac{1 \times 10^{-6} \text{ m}^3/s}{0,5 \text{ m/s}}$

$= 2 \times 10^{-6}$ m^2

b) Diameter outlet pipa

$$d = \sqrt{\frac{4 \times A}{\pi}}$$

$$= \sqrt{\frac{4 \times 2 \times 10^{-6}\ m^2}{3,14}}$$

= 0,0016 m = 1,6 mm = diameter pasaran (pipa akrilik 2 mm)

c) Dosing Pump

Berdasarkan perhitungan diatas, diperoleh debit tangki koagulan sebesar 7,17 L/jam sehingga spesifikasi *dosing pump* yang akan digunakan yaitu:

Merk = Grundfoss

Tipe = **DMH 7,5-200D B-SS/V/SS-X-E2C2C2XEMAG**

Debit Maksimal = 7,5 L/jam

Gambar 5. 9 Dosing Pump Netralisasi

RESUME BANGUNAN BAK PEMBUBUH

- Kebutuhan PAC = 12,96 kg/hari
- Periode pelarutan = 1 hari
- Kebutuhan koagulan (kadar 25%) = 51,84 kg/hari
- Debit PAC = 42,2 liter/hari
- Debit bak total = 0,172 m^3/hari
- Volume total = 172,2 L
- Dimensi bak
    - Merk Satake Mixer Tank model ZT Series/ZTF-150

- Diameter : 0,55 m
- Kedalaman bak : 0,844 m
- Kedalaman air : 0,664 m

- Daya pengadukan : 0,1 kW
- Impeller yang akan digunakan
  - Merek/Model : Satake/ A720-0,1B
  - Power : 0,1 kW
  - Diameter : 220 mm = 0,22 m
- Cek Nre : 144106,1 (Memenuhi > 10.000 turbulen)
- Debit bak pembubuh : 0,172 m^3/hari
- Diameter pipa outlet ke daf = 0,0016 m = 16 mm
- Dossing pump:
  - Merk = Grundfoss
  - Tipe = **DMH 7,5-200D B-SS/V/SS-X-E2C2C2XEMAG**
  - Debit Maksimal = 7,5 L/jam

<u>BAK FLOTASI</u>

a. Kriteria Perencanaan

- Waktu detensi (Td) [1] = 20 – 30 menit
- Tekanan udara (P) [2] = 275 – 350 kPa
- Rasio udara per padatan (A/S) [3] = 0,005 – 0,06
- Fraksi kelarutan udara (f) [4] = 0,5
- Tekanan atm [4] = 101,35
- Surface Loading Rate (SLR) [4] = 8 – 160 lt/m2.min
- Rasio resirkulasi terhadap influent (R/Q) [4] = 15 – 120 %
- Kelarutan udara (sa) = 30 [4] = 15,7˚C
- Freeboard [5] = 5 – 30 %

Sumber:

[1]Industri Water Pollution Control, Eckenfelder Halaman 112

[2]Metcalf & Eddy, Waste Water Treatment Plant, Halaman 420

[3]Metcalf & Eddy, Waste Water Treatment Plant, Halaman 422

[4]Metcalf & Eddy, Waste Water Treatment Plant, Halaman 423

[5]Ven Te Chow, 1990, Open Channel Hydraulics, Halaman 159

b. Data Perencanaan

- Jumlah bak flotasi = 1 buah
- Debit air limbah (Q) = 450 m3/ hari
  = 0,005 m3/s
- Waktu detensi (Td) = 25 menit
  = 1500 s
- Rasio udara per padatan (A/S) = 0,01
- Freeboard (Fb) = 20 %
- Surface Loading Rate (SLR) = 50 liter/m2.menit

c. Perhitungan

a) Tekanan udara (ρ) = 2,98 atm = 301,874 kPa

b) Debit yang mengalir ke flotasi = 0,005 m3/s
= 300 liter/menit

c) Volume bak flotasi (V) = $(\text{Q air limbah} + \text{Q pembubuh}) \times \text{td}$

= $0{,}00500032\ \text{m3/s} \times 1500\ \text{s}$

= 7,5 m^3

d) Luas permukaan bak flotasi (A) = $\frac{Q}{SLR}$

= $\frac{0{,}005\ \text{m3/s}}{50\ \text{liter/m2.menit}}$

= $\frac{300\ \text{liter/menit}}{50\ \text{liter/m2.menit}}$

= 6 m^2

- A = $P \times L$
  = $2L \times L$
- L = $\sqrt{\frac{A}{2}}$

$= \sqrt{\frac{6\ m2}{2}}$

= 1,732

- P = $2 \times L$

  = $2 \times 1{,}732 = 3{,}464$ m

- Tinggi bak flotasi (Hair) = $\frac{V}{P \times L}$

  = $\frac{7{,}5\ m3}{3{,}464\ m \times 1{,}732\ m}$

  = 1,250 m

- Htotal = Hair + Freeboard

  = 1,250 m + (20% x 1,250 m)

  = 1,5 m

- SLR cek = $\frac{Q}{A}$

  = $\frac{300\ liter/menit}{3{,}464\ m \times 1{,}732\ m}$

  = 50 liter/m2.menit (memenuhi)

- Jari-jari hidrolis (R) = $\frac{L \times H}{L+(2 \times H)}$

  = $\frac{1{,}732 \times 2}{1{,}732+(2 \times 2)}$

  = 0,6 m

- Volume cek = $P \times L \times H$

  = 3,464 m × 1,732 m × 1,5 m

  = 8 m^3 (memenuhi)

- Kecepatan cek = $\frac{Q}{v}$

  = $\frac{0{,}005\ m3/s}{8\ m}$

  = 0,0006 m/s

Resume Bangunan

- Panjang bak = 3,464 m
- Lebar bak = 1,732 m
- Htotal = 1,5 m
- Volume = 8 m^3

- Kecepatan cek = 0,0006 m/s

Buffle dan Gutter

a. Kriteria Perencanaan

- Kecepatan pipa outlet (v) = 0,3 – 2,5 m/s

  Sumber: Morimura.1993
- Cd = 0,62

b. Data Perencanaan

- Panjang baffle (P) = lebar bak flotasi = 1,732 m
- Jarak baffle terhadap gutter = 1 m
- Kecepatan aliran gutter = 0,03 m/s
- Panjang gutter = lebar bak flotasi = 1,732 m
- Lebar gutter (B) = 1 m
- Waktu detensi = 20 s
- Kecepatan pipa outlet (v) = 0,5 m/s

c. Perhitungan baffle dan gutter

a) H baffle (kedalaman baffle) $= \frac{3}{4} \times \text{H total bak flotasi}$

$= \frac{3}{4} \times 1{,}5 \text{ m}$

= 1,13 m

b) Debit Effluent = Q total – Q TSS disisihkan

= 0,005 m3/s - 0,0000012 m3/s

= 0,005 m^3/s

c) Volume gutter $= Q \times td$

$= 0{,}005 \text{ m3/s} \times 20 \text{ s}$

= 0,1 m^3

d) Luas permukaan gutter (A) $= \frac{\text{Q debit effluent}}{\text{kecepatan aliran gutter (v)}}$

$= \frac{0{,}005 \text{ m3/s}}{0{,}03 \text{ m/s}}$

= 0,167 m^2

e) H air gutter $= \frac{\text{Luas permukaan gutter (A)}}{\text{Panjang gutter}}$

$= \frac{0,167\ m2}{1,732\ m}$

$= 0,1$ m

f) H gutter total $= Hair + (\ 20\%\ \times Hair)$

$= 0,1\ m + (\ 20\%\ \times 0,1\ m)$

= 0,12 m

g) Tinggi air di atas gutter

Q (debit effluent) = $\frac{2}{3} \times \text{lebar gutter (B)} \times Cd \times \sqrt{2g} \times H^{2/3}$

0,005 m^3/s = $\frac{2}{3} \times 0,5\ m \times 0,62 \times \sqrt{2 \times 9,81\ m/s} \times H^{2/3}$

$H^{2/3}$ = 0,005

H = 0,0004 m

d. Perhitungan pipa outlet

a) Luas Penampang (A) $= \frac{Q}{V}$

$= \frac{0,005\ m^3/s}{0,5\ m/s}$

$= 0,01\ m^2$

b) Diameter outlet pipa

d $= \sqrt{\frac{4 \times A}{\pi}}$

$= \sqrt{\frac{4\ \times 0,01 m^2}{3,14}}$

= 0,11 m = 110 mm = 125 mm (pasaran)

c) Cek kecepatan pipa

V $= \frac{Q}{A}$

$= \frac{0,005\ m^3/s}{\frac{1}{4} \times \pi \times (0,11)^2}$

= 1 m/s ⟶ 1 < V < 2,5 m/s (memenuhi)

e. Resume Bangunan

- Volume gutter = 0,1 m^3
- H buffle = 1,13 m
- H gutter = 0,1 m
- H gutter total = 0,12 m
- Diameter pipa outlet = 0,125 m = 125 mm
- Cek kecepatan = 1 m/s

<u>Penyisihan TSS</u>

a. Kriteria Perencanaan

- Persentase penyisihan TSS = 65% - 95%

  Sumber: Syed R. Qasim. 1999. WWTP Planning Design
- Massa jenis air T = 30˚C = 995,68 kg/m3

  Sumber: Reynolds.1995.Halaman 762

b. Data Perencanaan

- Debit air limbah (Q) = 0,005 m3/s = 300 liter/menit

  = 150 m3/hari
- Influent TSS = 335 mg/l
- Berat air yang disisihkan = 3% (asumsi)
- Massa jenis solid (ps) = $Ss \times \rho$

  $= 1{,}4 \times 995{,}68 \text{ kg/m3}$

  = 1393,95 kg/m3
- Massa jenis sludge (psg) = $Sg \times \rho$

  $= 1{,}02 \times 995{,}68 \text{ kg/m3}$

  = 1015,59 kg/m3

c. Perhitungan

a) Konsentrasi TSS yang disisihkan = $\% \text{ removal} \times \text{inffluent TSS}$

$= 95\% \times 335 \text{ mg/l}$

= 318,25 mg/l

b) TSS effluent = TSS influent – TSS disisihkan

= 335 mg/l – 318,25 mg/l

= 16,75 mg/l

c) W TSS disisihkan = TSS disisihkan x Q limbah

= 318,25 mg/l x 300 liter/menit

= 95475 mg/menit

= 137,5 kg/hari

d) Q TSS disisihkan $= \frac{\text{WTSS disisihkan}}{\rho \text{ solid}}$

$= \frac{137{,}5 \text{ kg/hari}}{1393{,}95 \text{ kg/m3}}$

= 0,1m3/hari = 0,0000012 m3/s

e) Berat air teremoval (W air) $= \frac{100\% - 3\%}{3\%} \times$ WTSS tersisihkan

$= \frac{100\% - 3\%}{3\%} \times 137{,}5$ kg/hari

= 4445,83 kg/hari

f) Volume air (Vair) $= \frac{\text{W air}}{\rho \text{ air}}$

$= \frac{4445{,}83 \text{ kg/hari}}{995{,}68 \text{ kg/m3}}$

= 4,46 m3/hari

g) V TSS $= \frac{\text{W TSS disisihkan}}{\rho \text{ solid}}$

$= \frac{137{,}5 \text{ kg/hari}}{1393{,}95 \text{ kg/m3}}$

= 0,01 m3/hari

h) Volume sludge (V Sludge) = V TSS + V air

= 0,01 m3/hari + 4,46 m3/hari

= 4,47 m3/hari

i) Berat Sludge (W Sludge) = V sludge $\times$ ρ sludge

$= 4{,}47\ \text{m3/hari} \times 1015{,}59\ \text{kg/m3}$

= 4539,68 kg/hari

j) Debit sludge (Q sludge) $= \frac{\text{W sludge}}{\rho\ \text{sludge}}$

$= \frac{4539{,}68\ \text{kg/hari}}{1015{,}59\ \text{kg/m3}}$

= 4,47 m3/hari

d. Resume Perhitungan Effluent TSS

- TSS effluent = 16,75 mg/l
- W TSS disisihkan = 137,5 kg/hari
- Volume air = 4,46 m3/hari
- Berat air yang teremoval = 4445,83 kg/hari
- Berat sludge = 4539,68 kg/hari
- Debit sludge = 4,47 m3/hari

<u>Penyisihan Minyak Lemak dan Bak Penampung</u>

a. Kriteria Perencanaan

- Konsentrasi minyak mengambang (K) = 3 – 7 %
  (*sumber: Metcalf & Eddy, WWTP. Hal.423*)
- Persentase penyisihan minyak lemak = 65 – 98 %
  (*sumber: Syed R. Qasim. 1999. Hal 159*)
- Massa jenis minyak = 820 – 850 kg/m3

b. Data Perencanaan

- Debit (Q) = 0,005 m^3/s = 432000 L/hari
- Influent minyak lemak = 97,5 mg/L
- % removal = 98 %
- Massa jenis minyak = 820 kg/m^3
- Td bak penampung = 10 hari
- Panjang bak penampung = 1 m

c. Perhitungan Bak

Minyak lemak disisihkan = % removal x Influent

= 98 % x 97,5 mg/L

	= 95,66 mg/L
Minyak lemak effluent	= influent – minyak lemak disisihkan
	= 97,5 mg/L – 95,66 mg/L
	= 1,8 mg/L = 2 mg/L
W minyak lemak tersisih	= minyak lemak disisihkan x Q limbah
	= 95,66 mg/L x 432000 L/hari
	= 41325120 mg/hari = 41,32 kg/hari
Q minyak lemak tersisih	$= \frac{\text{W minyak lemak tersisihkan}}{\rho \text{ minyak}}$
	$= \frac{41{,}32 \text{ kg/hari}}{820 \text{ kg/m3}}$
	= 0,05 m3/hari = 0,0000005 m3/s
Q effluent	= Q influent limbah – Q minyak lemak disisihkan
	= 0,005 m^3/s - 0,0000005 m^3/s
	= 0,005 m^3/s
Volume bak penampung	= Qminyak lemak x td
	= 0,05 m3/hari x 10 hari
	= 0,5 m^3
Dimensi bak penampung	
Panjang bak penampung	= l m
H minyak	= 0,4 m
Lebar bak penampung	$= \frac{V}{h \times L}$
	$= \frac{0{,}5 \text{ m3}}{0{,}5\, m \times 1\, m}$
	= 1 m
H total	= H minyak + freeboard
	= 0,4 m + (20% x 0,4 m)
	= 0,5 m
Luas permukaan (A)	= Q/v
	= 0,0000005 m^3/s / 0,5 m/s

= 0,000001 m2

Dimensi pipa outlet = $\sqrt{\frac{4 \times\ 0{,}000001\ \mathrm{m2}}{3{,}14}}$

= 0,001 m = 0,1 cm

Diameter pipa pasaran = 12,5 cm = 125 mm

d. Resume Bangunan

- Panjang bak penampung = 1 m
- Lebar bak penampung = 1 m
- Tinggi total = 0,5 m
- Diamter pipa outlet = pipa pasaran = 12,5 cm = 125 mm

<u>Penyisihan BOD dan COD</u>

a. Data perencanaan

- Debit air limbah (Q) = 0,005 m3/s = 300 liter/menit
  = 150 m3/hari
- Influent COD = 5200 mg/l
- Influent BOD = 1650 mg/l
- Persentase penyisihan COD = 70 %
- Persentase Penyisihan BOD = 60 %

- **Perhitungan**

a) BOD yang disisihkan = BOD influent $\times$ persen removal
= 1650 mg/l $\times$ 70 %
= 1155 mg/l

b) BOD effluent = BOD influent $-$ BOD disisihkan
= 1650 mg/l $-$ 1155 mg/l
= 495 mg/l

c) COD yang disisihkan = COD influent $\times$ persen removal
= 5200 mg/l $\times$ 60 %
= 3120 mg/l

d) COD effluent = COD influent $-$ COD disisihkan
= 5200 mg/l $-$ 3120 mg/l
= 2080 mg/l

e) W BOD disisihkan = BOD disisihkan $\times$ Qlimbah

= 1155 mg/l $\times$ 300 liter/menit

= 346500 mg/menit = 498,96 kg/hari

f) W COD disisihkan = COD disisihkan $\times$ Qlimbah

= 3120 mg/l $\times$ 300 liter/menit

= 936.000 mg/menit = 1347,84 kg/hari

Blower

a. Kriteria Perencanaan

- Berat aliran udara (w) [1] = 1,2 kg/m3
- Konstanta gas universal untuk udara (R) [2] = 8,314 J/mole.K
- Temperatur absolut inlet (T1) [1] = 20 °C
- Tekanan absolut outlet (P2) [1] = 25 lb/in^2
- Tekanan absolut inlet (P1) [1] = 14,7 lb/in^2
- n [2] = 0,283
- Faktor konversi ft/lb/s ke hp [2] = 550
- Efisiensi (E) [2] = 0,7 – 0,9
- Jumlah O_2 di udara = 21 %
- Efisiensi diffuser [3] = 4 – 8 %

Sumber:

[1]*Metcalf & Eddy, halaman 440*

[2]*Metcalf & Eddy, halaman 441*

[3]*Masduqi, Ali, dan Abdu F. Assomadi. 2016. Operasi & Proses Pengolahan Air Edisi Kedua. Pahe 296. Surabaya: ITS Press*

a. Data Perencanaan

- Jumlah TSS tersisihkan = 137,5 kg/hari
- Jumlah BOD tersisihkan = 498,96 kg/hari
- Jumlah COD tersisihkan = 1347,84 kg/hari
- Faktor desain = 2
- Berat aliran udara (w) = 1,2 kg/m^3

- Konstanta gas universal untuk udara (R) = 53,3 ft/lb/lb air
- Temperatur absolut inlet (T1) = 16˚R
- Tekanan absolut inlet (P1) = 14,7 lb/in^2
- Tekanan absolut outlet (P2) = 25 lb/in^2
- n untuk single centrifugal blower = 0,283
- Faktor konversi ft/lb/s ke hp = 550
- Efisiensi diffuser O_2 (E) = 8%

b. Data Perencanaan

a) Kebutuhan teroritis = TSS tersisihkan = 137,5 kg/hari

= BOD tersisihkan = 498,96 kg/hari

= COD tersisihkan = 1347,84 kg/hari

= 137,5 kg/hari + 498,96 kg/hari + 1347,84 kg/hari

= 1984,3 kg/hari

b) Kebutuhan O_2 teoritis = $\text{Kebutuhan teoritis} \times \text{faktor desain}$

$= 1984{,}3\ \text{kg/hari} \times 2$

= 3968,6 kg/hari

c) Kebutuhan O_2 aktual = $\frac{\text{Kebutuhan O2 teoritis}}{\text{Berat standar udara} \times \text{O2 dalam udara}}$

$= \frac{3968{,}6\ \text{kg/hari}}{1{,}2\ \text{kg/m3} \times 21\ \%}$

= 15748,4 m^3/hari

= 10,9 m^3/menit = 11 m^3/menit

Dari perhitungan blower diatas, diperoleh spesifik blower yang akan digunakan pada unit bangunan ini sebagai berikut:

Gambar 5. 10 Blower DAF

Sumber: Terjual JUAL Roots Blower : "Tai-Yih Sun", made in Taiwan | KASKUS

Kriteria:

Merk = ROOTS Blower Tai Yih Sun

Tipe = Pressure Blower

Kapasitas = 0,1 – 250 m^3/menit

Tekanan = 0 – 8000 mmaq

c. Data Perencanaan

- Kebutuhan O_2 teoritis = 3968,6 kg/hari
- Kebutuhan O_2 aktual = 11 m^3/menit

Diffuser

1. Kriteria Perencanaan

- Diameter plate disk/diffuser = 8 inch = 0,2032 m
- Area pelayanan = 0,25 – 1 m^2/pcs
- Diffuser model = HLBQ-215 fine bubble

Gambar 5. 11 HLBQ-215 fine bubble

Sumber: https://www.google.com/search?q=HLBQ-215+fine+bubble&rlz=1C1GCEA_enID934ID934&tbm=isch&source=lnms&sa=X&ved=0ahUKEwjx1-W-jvT7AhX0Q3wKHeokAZQQ_AUIpQcoAQ&biw=1536&bih=714&dpr=1.25#imgrc=xn27_eWdO_Si6M

b. Kriteria Perencanaan

- Diameter plate disk/diffuser = 8 inch = 0,2032 m
- Area pelayanan = 1 m^2/pcs
- Jarak antar plate disk = 1 m
- Diameter pipa manifold = 0,75 inch = 0,02 m
- Panjang bak flotasi = 3,464 m
- Lebar bak flotasi = 1,732 m

c. Perhitungan

a) Luas tiap plate dish (A) $= \frac{1}{4} \times 3{,}14 \times D^2$

$= \frac{1}{4} \times 3{,}14 \times (0{,}2032\ \text{m})^2$

$= 0{,}032\ m^2$

b) Jumlah plate yang dibutuhkan = Luas Bak Flotasi ÷ Area Pelayanan

$= 6\ \text{m2} \div 1\ \text{m2/pcs}$

= 6 buah

c) Jumlah disk vertikal = sejajar dengan bak flotasi = 2 buah

d) Jumlah disk horizontal = sejajar panjang bak flotasi = 3 buah

<u>ZONA LUMPUR ATAU ZONA SLUDGE</u>

1. Kriteria perencanaan

- Massa jenis air 30˚C = 995,68 kg/m^3
  Sumber: Reynolds.1995.Hal.762
- Specific sludge (Ss) = 1,02
  Sumber: Metcalf and Eddy 4th edition, hal.1456
- Bentuk zona sludge = limas terpancung

b. Data perencanaan

- Debit = 0,005 m3/s = 150 m3/hari
- Persen removal TSS = 95%
- Kadar TSS dalam air = 335 mg/l
- Kadar kepadatan lumpur = 5 %
- Bentuk Bak Atas = Rectangular
- Bentuk Bak Bawah = Limas Terpancung
- Periode pengurasan (tp) = 1 hari
- Panjang zona lumpur = 1 m
- Lebar zona lumpur = 1,7 m
- Kedalaman bak = 0,5 m

c. Perhitungan

a) TSS teremoval = $\% \text{ teremoval} \times \text{Kadar TSS}$

$= 95\ \% \times 335\ \text{mg/l}$

= 318,25 mg/l

= 0,32 kg/m^3

b) Berat Lumpur (Ws) = $\text{Q limbah} \times \text{TSS teremoval}$

$= 0{,}005\ \text{m3/s} \times 0{,}32\ \text{kg/m3}$

= 0,0016 kg/s

= 138,24 kg/hari

c) Berat air (Ww) $= \frac{\text{Kadar air dalam lumpur}}{\text{Kadar padatan dalam lumpur}} \times \text{Ws}$

$= \frac{95\%}{5\%} \times 138{,}24\ \text{kg/hari}$

= 2626,56 kg/hari

d) Berat jenis lumpur (ρs) = $(\text{Berat Jenis Ss} \times 5\%) + (\text{Berat jenis air} \times 95\%)$

$= (1{,}02\ \text{kg/m3} \times 5\%) + (995{,}68\ \text{kg/m3} \times 95\%)$

= 945,947 kg/m^3

e) Volume lumpur $= \frac{Ws+Ww}{\rho s} \times tp$

$= \frac{138,24 \text{ kg/hari} + 2626,56 \text{ kg/hari}}{945,947 \text{ kg/m3}} \times$

1 hari

$= 2,9 \text{ m}^3$

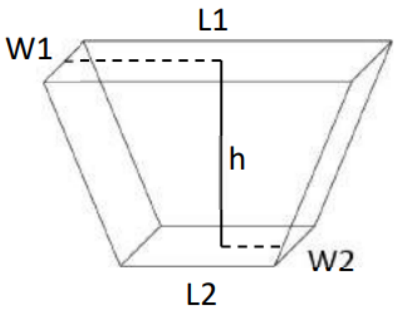
f) Dimensi Zona Lumpur Atas

Luas permukaan atas zona lumpur (A) $= P \times L$

$= 1 \text{ m} \times 1,7 \text{ m}$

$= 1,7 \text{ m}^2$

g) Dimensi Zona Lumpur Bawah (Limas Terpancung)



Gambar 5. 12 Dimensi Zona Lumpur

Luas permukaan atas zona lumpur (A) $= L1 \times W1$

$= 1,7 \text{ m} \times 1 \text{ m}$

$= 1,7 \text{ m}^2$

Luas permukaan bawah zona lumpur (A') $= L2 \times W2$

$= 0,5 \text{ m} \times 1\text{m}$

$= 0,5 \text{ m}^2$

V limas terpancung $= \frac{1}{3} \text{ x H x } (A + \sqrt{AA'} + A')$

$2,9 \text{ m}^3$ $= \frac{1}{3} \text{ x H x } (1,7 + \sqrt{1,7\, m2 \times 0,5\, m2}$

+ 0,52)

$2,9 \text{ m}^3$ $= \frac{1}{3} \text{ x H x } 3,1 \text{ m}^2$

H = 2 m

d. Dimensi pipa pengurasan

1. Data perencanaan pipa pengurasan

- Kecepatan pipa pengurasan = 1 m/s

- Volume lumpur = 0,146 m^3
- Waktu pengurasan = 60 menit = 300 s

b. Perhitungan pipa pengurasan

a) Debit pipa penguras (Qp) $= \frac{\text{volume lumpur}}{\text{waktu pengurasan}}$

$= \frac{3\ m3}{300\ s}$

= 0,01 m^3/s

b) Luas penampang pipa pengurasan (A) $= \frac{Qp}{v}$

$= \frac{0{,}01\ m3/s}{1\ m/s}$

= 0,01 m^2

c) Diameter pipa pengurasan $= \sqrt{\frac{4 \times A}{\pi}}$

$= \sqrt{\frac{4 \times 0{,}01\ m2}{3{,}14}}$

= 0,1 m = 100 mm

d) Diameter pasaran = 100 mm

e) Cek kecepetan $= \frac{Qp}{A}$

$= \frac{0{,}01\ m3/s}{0{,}25 \times 3{,}14 \times (0{,}1\ m)^2}$

= 1 m/s

5.7 Activated Sludge

<u>Bak Activated Sludge</u>

1. Kriteria Perencanaan

a. Umur lumpur (θc) = 4 – 10 hari

b. F/M ratio = 0,2 – 0,5 kg BOD/kg MLVSS.d

Sumber : Reynolds, Tom D. dan Paul A. Richards. 1996. Unit Operations and Processes in Environmental Engineering 2nd edition,hal 429)

c. Hydraulic detention time (HDT) = 6 – 8 jam

Sumber: Marcos Von Sperling, Activated Sludge and Aerobic Biofilm Reactor, hal 6)

d. VSS/SS ratio = 0,7 – 0,85

Sumber: Marcos Von Sperling, Activated Sludge and Aerobic Biofilm Reactor, hal 21)

- Particulate BOD = 0,45 – 0,65 mgBOD5/mgTSS

  Sumber: Marcos Von Sperling, Activated Sludge and Aerobic Biofilm Reactor, hal 29)

- Yield Coefficient (Y) = 0,5 – 0,7 gr VSS/gr BOD5 removed
- Endogenous Respiration Coefficient (Kd) = 0,06 – 0,10 gr VSS/gr VSS.d

  Sumber: Marcos Von Sperling, Activated Sludge and Aerobic Biofilm Reator, hal 20)

- Standard oxygenation efficiency = 1,8 kg O2/Kw.jam

  Sumber: Marcos Von Sperling, Activated Sludge and Aerobic *Biofilm Reactor, hal 66*)

- Ketinggian bak aerasi (H) = 3 – 5,6 m

  Sumber: Metcalf & Eddy, Waste Water Engineering Treatment & Reuse, 4th Edition, hal 687)

- Konsentrasi MLVSS (Xv) = 1500 -3500 mg/L
- Konsentrasi MLSS (X) = 2000 – 4000 mg/L
- Ratio resirkulasi lumpur (Qr/Q) = 0,6 – 1
- Biodegradable Fraction of VSS (fb) = 0,55 – 0,77
- Effluent soluble BOD = 5 – 20 mg/L

  Sumber: Marcos Von Sperling Activated Sludge and Aerobic Biofilm Reactor, hal 69)

- Kebutuhan O_2 = 0,8 – 0,94 kg O2/kg BOD removed

  Sumber: Marcos Von Sperling, Activated Suldge and Aerobic Biofilm Reactor, hal 205)

b. Data Perancanaan

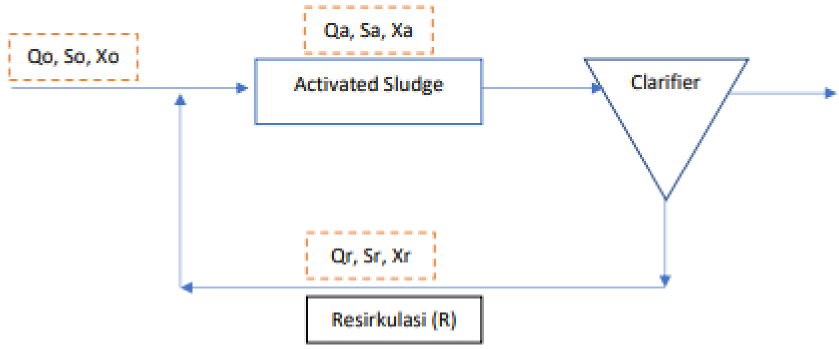
- Jumlah unit = 1 unit

- Debit (Q) = 0,005 m^3/s
- Umur lumpur = 5 hari
- VSS/SS ratio = 0,8
- Konsentrasi MLVSS (Xa) = 2500 mg VSS/L = 2,5 kg/m^3
- Konsentrasi MLSS (X) = 3500 mg/L
- Y = 0,6 gr VSS/gr VSS.d
- Kd = 0,06 gr VSS/gr VSS.d
- Suhu = 28°
- Rasio Resirkulasi (R) = 0,6
- Standard oxygenation efficiency = 1,8 kg O2/kW.jam
- Biodegradable fraction of VSS (fb) = 0,7
- Effluent soluble BOD = 5 mg/L
- Ketinggian bak aerasi (H) = 3 m
- Freeboard = 20 %
- Bentuk Bak AS = rectangular
- Kedalaman bak = 2 m
- Data influent dan persen removal yang dierncanakan pada bak Activated Sludge:

Tabel 5. 1 Influent dan Persen Removal Bak Activated Sludge

No	Parameter	Influent (mg/L)	% Removal
1.	BOD	31	95%
2.	COD	2080	90%
3.	Ammonia	75	95%
4.	Fenol	0,005	96%

c. Perhitungan



Keterangan :

Qo = Debit influent

Qa = Debit di dalam reaktor

Qr = Debit resirkulasi

So = Konsentrasi organik (BOD influent)

Sa = Konsentrasi organik (BOD di dalam reaktor)

Sr = Konsentrasi organik (BOD effluent)

Xa = Konsentrasi mikroorganisme dalam reaktor (MLVSS)

Xr = Konsentrasi mikroorganisme pada lumpur yang disirkulasikan (MLSS)

<u>REMOVAL</u>

a) BOD $= \text{BOD influent} - (\%\text{removal} \times \text{BOD influent})$

$= 31 \text{ mg/l} - (95\% \times 31 \text{ mg/l})$

$= 1{,}55 \text{ mg/l} = 0{,}0015 \text{ kg/m}^3$

b) COD =

Persen Removal COD $= \frac{\text{COD Influent} - \text{COD effluent}}{\text{COD Influent}} \times 100$

$= \frac{2080 - 104}{2080} \times 100$

= 95%

= 2080 – (95% x 2080)

= 104 mg/l = 0,104 kg/m3

c) Ammonia $= \text{Ammonia influent} - (\%\text{removal} \times \text{Ammonia influent})$

$= 75 \text{ mg/l} - (95\% \times 75 \text{ mg/l})$

= 3,75 mg/l

d) Koefisien kineti pada suhu 28˚C

- Koefisien endogeneous (kd)

  Kd = $Kd20 \times \theta^{(T-20)}$

  = $0{,}06 \times 1{,}04^{(28-20)}$

  = 0,082 hari

- Koefisien batas pertumbuhan

  Y = $Y20 \times \theta^{(T-20)}$

  = $0{,}6 \times 1{,}04^{(28-20)}$

  = 0,821 VSS/mg.COD

e) BOD yang teremoval

BOD yang teremoval = BOD influent × % removal

= 31 mg/l × 95%

= 29,45 mg/l

= 0,029 kg/m^3

f) COD yang teremoval = COD influent x % removal

= 2080 x 95%

= 1976 mg/l

=1,97 kg/m^3

g) Ammonia yang teremoval

Ammonia = Ammonia influent × % removal

= 75 mg/l × 90 %

= 67,5 mg/l

= 0,067 kg/m^3

h) Rasio resirkulasi

R $= \frac{\text{MLVSS Activated Sludge}}{\text{MLVSS Clarifier} - \text{MLVSS Activated Sludge}}$

$= \frac{2500 \text{ mg/l}}{8000 \text{ mg/l} - 2500 \text{ mg/l}}$

= 0,45

i) Debit resirkulasi (Qr)

Qr = debit influent x R

= $0{,}005 \text{ m3/s} \times 0{,}6$

$= 0{,}003\ m^3/s$

j) Debit yang masuk ke dalam bak Activated Sludge (Qin)

Qa $= \text{Debit influent} + \text{Debit resirkulasi}$

$= 0{,}005\ m3/s + 0{,}003\ m3/s$

$= 0{,}008\ m^3/s = 28{,}8\ m^3/jam = 691{,}2\ m^3/hari$

k) Konsentrasi BOD dalam bak Activated Sludge

$$Ca = \frac{(\text{BOD influent} \times \text{Debit influent}) + (\text{Debit resirkulasi} \times \text{BOD REMOVAL})}{(\text{Debit influent} + \text{Debit resirkulai})}$$

$$= \frac{(31\ mg/l \times 0{,}005\ m3/s) + (0{,}003\ m3/s \times 1{,}55\ mg/l)}{(0{,}005\ m3/s + 0{,}003\ m3/s)}$$

$= 19{,}95\ mg/l = 0{,}019\ kg/m^3$

l) Konsentrasi COD dalam bak Activated Sludge

$$Ca = \frac{(\text{COD influent} \times \text{Debit influent}) + (\text{Debit resirkulasi} \times \text{COD REMOVAL})}{(\text{Debit influent} + \text{Debit resirkulai})}$$

$$= \frac{(2080\ mg/l \times 0{,}005\ m3/s) + (0{,}003\ m3/s \times 104\ mg/l)}{(0{,}005\ m3/s + 0{,}003\ m3/s)}$$

$= 1339 mg/l = 1{,}3\ kg/m^3$

m) Volume bak Activated Sludge

$$V = \frac{(Y \times \text{umur sludge} \times Qa) \times (Ca - \text{COD REMOVAL})}{Xa\ (1 + Kd \times \text{umur sludge})}$$

$$= \frac{(0{,}821 \frac{mg\ VSS}{mg\ COD} \times 5\ hari \times 691{,}2 \frac{m3}{hari}) \times \left(1{,}3 \frac{kg}{m3} - 0{,}104 \frac{kg}{m3}\right)}{2{,}5\ kg/m3 \times (1 + 0{,}082/hari \times 5\ hari)}$$

$= 962\ m^3$

n) Cek waktu detensi bak Activated Sludge

$$Td = \frac{V}{Qa}$$

$$= \frac{962\ m3}{28{,}8\ m3/jam}$$

$= 33$ jam

o) Dimensi bak Activated Sludge

V $= L \times B \times H\ (L = 2B)$

$962\ m^3$ $= 2B \times B \times 4\ m$

B^2 $= 962\ m3 \div 8$

B $= \sqrt{120{,}2\ m} = 11\ m$

L = 2B = 2×11 m = 22 m

Htot = H + (freeboard $\times$ H)

= 4 m + (20% $\times$ 4 m)

= 4,8 m = 5 m

p) Jari – jari hidrolis

R $= \frac{B \times H}{B + 2H}$

$= \frac{11 \text{ m} \times 5 \text{ m}}{11 \text{ m} + (2 \times 5 \text{ m})}$

= 2,6 m

q) Kuantitas lumpur yang dihasilkan setiap hari (γ_{obs})

γ_{obs} $= \frac{Y}{1 + kd \times \text{umur sludge}}$

$= \frac{0{,}821 \text{ VSS/mg.COD}}{1 + 0{,}082 \text{ hari} \times 5 \text{ hari}}$

= 0,58

r) Konsentrasi resirkulasi SS (lumpur)

Xr $= \frac{\text{MLVSS} \times (1+R)}{R}$

$= \frac{2500 \text{ mg/l} \times (1+0{,}51 \text{ m})}{0{,}51 \text{ m}}$

= 7401,9 mg/l

s) Penyisihan beban BOD (BOD *load removal*)

Sr = Debit influent $\times$ (BOD influent $-$

BOD yang teremoval)

= 5 l/s $\times$ (31 mg/l $-$ 29,45 mg/l)

= 7,75 mg/s

= 0,67 kg/hari

t) Lumpur aktif yang harus dibuang

Pxv = γ obs $\times$ Sr

= 0,55 $\times$ 0,67 kg/hari

= 0,36 kg VSS/hari

u) Produksi Lumpur

Px (MLVSS) = γ obs $\times$ Qa $\times$ (Ca $-$ BOD effluent)

$= 0{,}55 \times\ 0{,}008\ \mathrm{m3/s}\ \times (0{,}019\ \mathrm{kg/m3} - 0{,}0015\ \mathrm{kg/m3})$

= 0,000077 kg/s

= 6,65 kg/hari

Px (MLSS) $= \frac{\text{Px (MLVSS)}}{\text{VSS / SS}}$

$= \frac{6{,}65\ \text{kg/hari}}{0{,}833}$

= 7,98 kg VSS/hari

= 0,00009 kg VSS/s

v) Debit lumpur yang dibuang (Qex)

Jika dibuang melalui bioreactor

Qex $= \frac{\text{volume bak AS}}{\text{umut sludge}}$

$= \frac{14{,}08\ \text{m3}}{5\ \text{hari}}$

= 2,81 m^3/hari

w) Kontrol rasio F/M

F/M $= \frac{\text{Qa} \times \text{Ca}}{\text{V} \times \text{Konsentrasi MLVSS}}$

$= \frac{691{,}2\ \text{m3/hari} \times 19{,}95\ \text{mg/l}}{14{,}08\ \text{m3} \times 2500\ \text{mg/l}}$

= 0,39 / hari (memenuhi 0,2 – 0,6 / hari)

x) Kebutuhan O_2 total

- Keb. O_2 BOD $= \frac{1{,}46\ \text{Qa (Co} - \text{Cr)}}{\text{f}} - (1{,}42\ \times \text{Px})$

  $= \frac{1{,}46 \times 0{,}008\ \text{m3/s} \times (0{,}029\ \text{kg/m3} - 0{,}0015\ \text{kg/m3})}{0{,}68} - (1{,}42\ \times 0{,}000077\ \text{kg/s})$

  = 0,00036 kg O_2/s

  = 1,29 kg O_2/jam

  = 30,96 kg O_2/hari

- Keb. O_2 COD $= \frac{1{,}46\ \text{Qa (Co} - \text{Cr)}}{\text{f}} - (1{,}42\ \times \text{Px})$

  $= \frac{1{,}46 \times 0{,}008\ \text{m3/s} \times (2{,}08\ \text{kg/m3} - 0{,}104\ \text{kg/m3})}{0{,}68} - (1{,}42\ \times 0{,}000077\ \text{kg/s})$

= 0,033 kg O_2/s

= 118,8 kg O_2/jam

= 2851,2 kg O_2/hari

- Jumlah kebutuhan oksigen NH3 (Ammonia)

  $NH_3 + 2O_2 \longrightarrow HNO_3 + H_2O$

  Dengan reaksi kimia tersebut didapatkan kebutuhan oksigen guna mendegradasi kadar ammonia adalah 0,09 kmol O_2/jam = 90 mol/jam

  Kebutuhan oksigen = 90 mol O_2/jam x 32 gram/mol

  = 2880 gram O_2/jam

  = 2,880 kg O_2/jam

  = 0,0008 kg O_2/s

  Oleh karena itu, jika mendegradasi 1 mg/l NH_3 membutuhkan 0,0008 kg O_2/s maka jumlah kebutuhan oksigennya sebagai berikut:

  = NH_3 yang teremoval x kebuthan oksigen x volume air dalam reaktor dalam satu siklus

  = 0,067 kg/m^3 x 0,0008 kg O_2/s x 14,08 m^3

  = 0,00075 kg O_2/s

  = 2,7 kg O_2/jam

  = 64,8 kg O_2/hari

- Kebutuhan O2 total

  $= \text{Keb. O2 BOD} + \text{Keb. O2 NH3} + \text{Keb. O2 COD}$

  $= 30{,}96 \text{ kg} \frac{\text{O2}}{\text{hari}} + 64{,}8 \text{ kg} \frac{\text{O2}}{\text{hari}} + 2851{,}2 \text{ kg O2/hari}$

  = 2946 kg O2/hari

Pada unit *Activated Sludge* ini direncanakan untuk penggunaan diffuser dengan spesifikasi sebagai berikut:

Model	HLBQ170	HLBQ215	HLBQ260	HLBQ350
Picture				
Bubble Type	Coarse bubble	Fine bubble	Fine bubble	Fine bubble
Size	6 inch	8 inch	9 inch	12 inch
Bubble Size	4-5mm	1-2mm	1-2mm	1-2mm
MOC (Material of construction)	EPDM/Silicon/PTFE membrane ABS carrier plate	EPDM/Silicon/PTFE membrane Strengthened PP+GF (Glass Fiber) carrier plate	EPDM/Silicon/PTFE membrane Strengthened PP+GF (Glass Fiber) carrier plate	EPDM/Silicon/PTFE membrane ABS carrier plate
Connector	3/4" NPT male thread	3/4" NPT male thread	3/4" NPT male thread	3/4" NPT male thread
Design Flow	1-5m³/h	1.5-2.5m³/h	3-4m³/h	5-6m³/h
Flow Range	6-9m³/h	1-6m³/h	1-8m³/h	1-12m³/h
SOTE (Standard Oxygen Transfer Efficiency)	≥10 % (6M Submerged)	≥38 % (6M Submerged)	≥38 % (6M Submerged)	≥38 % (6M Submerged)
SOTR (Standard Oxygen Transfer Rate)	≥0.21kg O_2/h	≥0.31kg O_2/h	≥0.42kg O_2/h	≥0.75kg O_2/h
SAE (Standard Aeration Efficiency)	≥7.5kg O_2/kW.h	≥8.9kg O_2/kW.h	≥8.9kg O_2/kW.h	≥8.9kg O_2/kW.h
Headloss	2000-3000Pa	2000-4500Pa	2000-4300Pa	2000-4200Pa
Service Area	0.5-0.8m²/pcs	0.2-0.64m²/pcs	0.25-1.0m²/pcs	0.4-1.5m²/pcs
Service Life	> 5 years	> 5 years	> 5 years	> 5 years

Gambar 5. 13 Katalog Diffuser Pada Unit Activated Sludge

Spesifikasi :

- Merk = Aquamart, HBLQ Fine Bubble Disk Diffuser
- Model = HLBQ 170
- Bubble Type = Coarse bubble
- Diameter = 6 inch = 0,15 m
- Efisiensi transfer O_2 = 10%
- A service / Aliran design = 5 m^3/jam

y) Volume udara yang dibutuhkan

Efisiensi transfer O2 untuk aerasi = 10% (berdasarkan katalog)

Presentase O2 di udara = 21 %

Safety factor = 2

Massa jenis udara (ρ) = 1,2 kg/m^3

- Kebutuhan udara tertentu

Keb. Udara teoritis $= \frac{\text{Keb.O2 total}}{\rho \text{ udara} \times \%\text{O2}}$

$= \frac{2946 \text{ kg O2/hari}}{1{,}2 \text{ kg/m3} \times 21\ \%}$

= 11690 kg/hari

= 0,13 kg/s

- Kebutuhan udara design

Keb. Udara aktual $= \frac{\text{Keb.O2 teoritis}}{\text{efisiensi transfer O2}}$

$= \frac{11690 \text{ kg/hari}}{10\%}$

= 116900 kg/hari

= 1,35 kg/s

= 4860 kg/jam

- Debit kebutuhan udara

Debit udara $= \frac{\text{keb.udara aktual}}{\text{densitas udara}}$

$= \frac{4860 \text{ kg/jam}}{1{,}2 \text{ kg/m3}}$

= 4050 m^3/jam

- Transfer O_2 di lapangan

N $= \text{No} \times \left[\frac{\beta \times Cw - C1}{9{,}17}\right] \times$

$1{,}024^{T-20} \times \alpha$

Dengan:

N = Kg O2/Kw.jam transfer di bawah kondisi lapangan

No =Kg O2/Kw.jam transfer di bahawa kondisi standart (nilai No = 1,5)

β = rasio konsentrasi kelarutan oksigen dalam air limbah terhadap air terdistilasi (umumnya limbah = 0,95)

Cw = Konsentrasi O2 jenuh = 8,16 mg/liter

C1 = Konsentrasi O2 operasi = 2 mg/liter

T = temperatur (˚C)

α = Faktor koreksi O2 transfer = 0,8 – 0,85

Maka:

N $= 1{,}5 \times \left[\frac{0{,}95 \times 8{,}16 - 2}{9{,}17}\right] \times 1{,}024^{28-20} \times 0{,}8$

= 2,2 kgO2/kw.jam

= 52,8 kgO2/kw.hari

z) Daya Blower (P)

P $= \frac{F \times R \times T1}{C \times n \times E}\left[\left(\frac{P2}{P1}\right)^{n} - 1\right]$

Dimana:

P = Daya Blower (Kw)

F = Berat aliran udara (kg/s)

C = 1 koefisien SI

R = Konstanta gas universal untuk udara 0,288 (SI)

T1 = Temperatur absolut inlet (˚R)

K = 28˚C + 273,15 = 301,15 K

P1 = Tekanan absolut inlet, dengan range single stage *centrifugal Blower* 1 atm dan digunakan pada perencanaan yakni sebesar 1 atm

P2 = Tekanan absolut inlet, dengan range single stage *centrifugal Blower* 1 atm dan digunakan pada perencanaan yakni sebesar 1,05 atm

n = 0,283 untuk udara

E = Efisiensi (0,7 – 0,9) digunakan pada perencanaan 0,8

Sumber: (Reynold & Richards, 1996) Unit Operation and Processes in Environmental Engineering, Second Edition. PWS Publishing Company. Halaman 509

Maka:

P $= \frac{1{,}35\frac{kg}{s} \times 0{,}288 \times 301{,}15}{1 \times 0{,}283 \times 0{,}8}\left[\left(\frac{1{,}05 kPa}{1 kPa}\right)^{0{,}283} - 1\right]$

= 7,1 kW

Berdasarkan perhitungan tenaga di atas untuk blower diperoleh klasifikasi sebagai berikut:

Hz	Type	Motor				Bore		Max. Continuous Duty Point				Maximum Discharge		Noise	L x W x H	Weight
								Discharge		Suction						
		HP	kW	PH	V	inch	mm	mmAq	m³/min	mmAq	m³/min	mmAq	m³/min	dB(A)	mm	kG
50	BS-0212	1/4	0.2	1	220	1	25	450	0.14	450	0.09	500	0.76	52	220x200x215	7
	BS-0512	1/2	0.37	1	220	1-1/4	32	1000	0.13	800	0.02	1100	1.4	61	253x250x250	12
	BS-0532			3	220~440											
	BS-112	1	0.75	1	220	1-1/2	40	1400	0.15	1200	0.1	1500	2.3	68	290x290x310	17
	BS-132			3	220~440											
	BS-212	2	1.5	1	220	2	50	2250	0.14	1750	0.38	2250	3.5	75	340x340x350	27
	BS-232			3	220~440											
	BS-332	3	2.2	3	220~440	2	50	2750	0.25	2250	0.37	3000	5.5	75	345x390x425	35
	BS-532	5	3.7	3	220~440	2	50	3000	0.13	2250	0.37	3000	5.5	75	385x390x425	36
	BS-732	7-1/2	5.5	3	220~440	2-1/2	65	1500	5.64	1750	3.72	3450	9	76	490x470x505	76
	BS-1032	10	7.5	3	220~440	2-1/2	65	2750	3.51	2500	1.66	3450	9	76	490x470x505	76
	BS-1532	15	11	3	220~440	4	100	1800	19.14	2200	6.38	3600	14	82	730x550x575	123
60	BS-0212	1/4	0.2	1	220	1	25	650	0.07	600	0.06	700	0.9	55	220x200x215	7
	BS-0512	1/2	0.37	1	220	1-1/4	32	1200	0.14	1100	0.02	1400	1.5	63	253x250x250	12
	BS-0532			3	220~440											
	BS-112	1	0.75	1	220	1-1/2	40	1600	0.43	1600	0.12	2050	2.7	69	290x290x310	17
	BS-132			3	220~440											
	BS-212	2	1.5	1	220	2	50	2000	0.64	1750	1.01	3000	4	78	340x340x350	27
	BS-232			3	220~440											
	BS-332	3	2.2	3	220~440	2	50	2250	2.4	2000	2.09	4000	6	80	345x390x425	35
	BS-532	5	3.7	3	220~440	2	50	2500	2.36	2250	1.54	4000	6	80	385x390x425	36
	BS-732	7-1/2	5.5	3	220~440	2-1/2	65	2250	6.67	2550	4.74	4750	10.5	86	490x470x505	76
	BS-1032	10	7.5	3	220~440	2-1/2	65	3000	4.89	3250	17.33	4750	10.5	86	490x470x505	76
	BS-1532	15	11	3	220~440	4	100	2200	9.65	2600	8.63	4800	17	87	730x550x575	123

Gambar 5. 14 Katalog Blower *Activated Sludge*

Sumber: https://www.showfou.com/product-detail/ring-blower-bs/

Berdasarkan katalog blower diatas didapatkan spesifikasi sebagai berikut:

- Merk = Showfou
- Type = BS-1032, 50 Hz
- Max discharge = 9 m^3/min
- Daya = 7,5 kW

aa) Luas tiap plate disk

A Disk $= \frac{1}{4} \times \pi \times D^2$

$= \frac{1}{4} \times 3{,}14 \times (0{,}15 \text{ m})^2$

$= 0{,}017 \text{ m}^2$

bb) Jumlah disk yang dibutuhkan

N Disk $= \frac{\text{Debit kebutuhan udara}}{\text{A service}}$

$= \frac{4050 \text{ m3/jam}}{5 \text{ m3/jam}}$

= 810 buah

Jumlah disk vertikal (lebar) = 40 buah

Jumlah disk horizontal (panjang) = 22 buah

Diameter pipa manifold direncanakan = 0,75 inch = 0,02 m

cc) Jarak antar disk

- Jarak horizontal antar disk (sh)

  Perencanaan = 0,5 m

- Jarak vertikal antar disk (sv)

  Perencanaan = 0,5 m

dd) Pipa outlet

- A $= \frac{\text{Debit air (Qa)}}{\text{Kecepatan aliran (v)}}$

  $= \frac{0{,}008\ m3/s}{0{,}5\ m/s}$

  $= 0{,}016\ m^2$

- Diameter pipa (D)

  D $= \sqrt{\frac{4 \times A}{\pi}}$

  $= \sqrt{\frac{4 \times 0{,}016\ m2}{3{,}14}}$

  = 0,142 m = 142 mm

  = diameter pasaran = 0,15 m = 150 mm

- Cek kecepetan (v cek) pipa outlet

  v cek $= \frac{Qa}{A}$

  $= \frac{0{,}008\ m3/s}{\frac{1}{4} \times 3{,}14 \times (0{,}15\ m)^2}$

  = 0,45 m/s = 0,5 m/s (memenuhi)

ee) Pompa Resirkulasi

- Kriteria Perencanaan

- K *Elbow* 90° = 0,9

  (Sumber: Dake, J.M.K., Endang P. Tachyan dan Y.P. Pangaribuan, 1985. "Hidrolika Teknik Edisi II". Erlangga. Jakarta)

- K *increaser* = 0,25
- K *check valve* = 2,0

(*Sumber: Pratical Hydrolics For The Public Work Engineer, 1968)*

- Data Perencanaan
- *Elbow* 90° *suction* = 3 buah ; k = 0,3
- *Elbow* 90° *discharge* = 2 buah ; k = 0,3
- *Check valve* = 1 buah
- Q resirkulasi = 0,0036 m^3/s = 12,96 m^3/s
- H suction = 5,16 m
- H discharge = 0,32 m
- H statis = H suction + H discharge

  = 5,16 m + 0,32 m = 5,48 m
- L *suction* = 14,58 m
- L *discharge* = 2,69 m
- Diameter pipa = 5" = 125 mm (pasaran)
- Kecepatan pipa (v) = 0,5 m/s
- Koefisien kekasaran (C)s = 130
- Perhitungan
- Perhitungan *Suction*
- *Headloss mayor*

$$Hf = \left(\frac{Q}{0{,}2785 \times C \times D^{2,63}}\right)^{1,85} \times L$$

$$Hf = \left(\frac{0{,}005\ m^3/s}{0{,}2785 \times 130 \times 0{,}125^{2,63}}\right)^{1,85} \times 14{,}58\ m$$

Hf = 0,028 m

Headloss minor (elbow 90°)

$$Hf_{elbow} = n \times k \times \frac{v^2}{2g}$$

$$= 3 \times 0{,}9 \times \frac{0{,}5^2}{2 \times 9{,}81}$$

= 0,034 m

- *Headloss minor (increaser 90°)*

Hf$_{increaser}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}25 \times \frac{0{,}5^2}{2\times 9{,}81}$

= 0,003 m

ΣHf minor

Hf$_{minor}$ = Hf minor elbow *90°* + Hf minor increaser

= 0,034 m + 0,003 m

= 0,037 m

- ΣHf *suction*

Hfs = Hf mayor + Hf minor

= 0,028 m + 0,037 m

= 0,065 m

○ Perhitungan *Discharge*

- *Headloss mayor*

$$Hf = \left(\frac{Q}{0{,}2785 \times C \times D^{2{,}63}}\right)^{1{,}85} \times L$$

$$Hf = \left(\frac{0{,}005\ m^3/s}{0{,}2785 \times 130 \times 0{,}125^{2{,}63}}\right)^{1{,}85} \times 2{,}69\ m$$

Hf = 0,004 m

- *Headloss minor*

Hf$_{elbow}$ $= n \times k \times \frac{v^2}{2g}$

$= 2 \times 0{,}9 \times \frac{0{,}5^2}{2\times 9{,}81}$

= 0,022 m

- *Headloss minor (check valve)*

Hf$_{chcek\ valve}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}2 \times \frac{0{,}5^2}{2\times 9{,}81}$

= 0,0025 m

- Headloss minor (increaser)

$Hf_{increaser}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}25 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,003 m

ΣHf minor

Hf_{minor} = Elbow+Hf minor checek valve + Hf minor increaser

= 0,022 m + 0,0025 m + 0,003 m

= 0,027 m

- ΣHf *discharge*

Hfd = Hf mayor + Hf minor

= 0,004 m + 0,027 m

= 0,031 m

- Perhitungan *head* total (*head* pompa)

- *Head* total = *Head* statis + ΣHf *suction* + ΣHf *discharge*

= 5,48 m + 0,065 m + 0,031 m

= 2,35 m

- Head statis < Head pompa = 5,48 < 5,57 m

Berdasarkan perencanaan debit (Q) = 12,96 m^3/jam dan head pump = 2,35 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa slury pump UHB-ZK50/20-20 dengan spesifikasi pompa sebagai berikut:

Model and parameter

Table 1: Light duty: 2P Motor Speed=2900RPM Design pressure: 1.6 MPa "*"Standard data

Item	Model	Flow (m3/h)	Head (m)	Efficiency (%)	NPSHa (m)	Inlet x outlet (mm)	Motor Power (KW)	Pump and motor weight (kg)
1	UHB-ZK40/10-20	5 *10 12	22 20 18	18 28 30	3.00	40*32	3.00	100.00
2	UHB-ZK40/10-30	5 *10 12	32 30 27	18 36 30	3.00	40*32	4.00	105.00
3	UHB-ZK50/20-20	12 *20 25	22 20 17	30 37 40	3.00	50*40	4.00	130.00
4	UHB-ZK50/20-30	12 *20 25	32 30 28	30 36.5 40	3.00	50*40	5.50	150.00
5	UHB-ZK65/30-20	20 *30 35	13 20 18	34 36 40	3.50	65*50	5.50	150.00
6	UHB-ZK65/30-30	20 *30 35	32 30 18	34 37 40	3.50	65*50	7.50	150.00
7	UHB-ZK65/30-50	20 *30 35	52 50 47	30 35.5 38	3.50	65*50	15.00	280.00

Gambar 5. 15 Katalog Pompa Untuk Sludge

Gambar 5. 16 Pompa resirkulasi slury pump UHB-ZK50/20-20

ff) Pompa menuju clarifier

- Kriteria Perencanaan

- K *Elbow* 90° = 0,9

  (Sumber: Dake, J.M.K., Endang P. Tachyan dan Y.P. Pangaribuan, 1985. "Hidrolika Teknik Edisi II". Erlangga. Jakarta)

- K *increaser* = 0,25

- K *check valve* = 2,0

  (*Sumber: Pratical Hydrolics For The Public Work Engineer, 1968)*

- Data Perencanaan

- *Elbow* 90° *suction*	= 1 buah ; k = 0,3
- *Elbow* 90° *discharge*	= 4 buah ; k = 0,3
- *Check valve*	= 1 buah
- Q bak	= 0,005 m^3/s
- H suction	= 1,52 m
- H discharge	= 0,42 m
- H statis	= H suction + H discharge
	= 1,52 m + 0,42 m = 1,94 m
- L *suction*	= 2,05 m
- L *discharge*	= 17,7 m
- Diameter pipa	= 8" = 200 mm (pasaran)
- Kecepatan pipa (v)	= 0,5 m/s
- Koefisien kekasaran (C)s	= 130

- Perhitungan

○ Perhitungan *Suction*

- *Headloss mayor*

Hf $= \left(\frac{Q}{0{,}2785 \times C \times D^{2{,}63}}\right)^{1{,}85} \times L$

Hf $= \left(\frac{0{,}005\ m^3/s}{0{,}2785 \times 130 \times 0{,}125^{2{,}63}}\right)^{1{,}85} \times 2{,}05\ m$

Hf = 0,003 m

Headloss minor (elbow 90°)

$Hf_{elbow} = n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}9 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,011 m

- *Headloss minor (increaser 90°)*

$Hf_{increaser} = n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}25 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,003 m

ΣHf minor

Hf_{minor} = Hf minor elbow *90°* + Hf minor increaser

= 0,011 m + 0,003 m

= 0,014 m

- ΣHf *suction*

Hfs = Hf mayor + Hf minor

= 0,003 m + 0,014 m

= 0,017 m

○ Perhitungan *Discharge*

- *Headloss mayor*

$$Hf = \left(\frac{Q}{0,2785 \times C \times D^{2,63}}\right)^{1,85} \times L$$

$$Hf = \left(\frac{0,005\ m^3/s}{0,2785 \times 130 \times 0,125^{2,63}}\right)^{1,85} \times 17,7\ m$$

Hf = 0,031 m

- *Headloss minor*

$$Hf_{elbow} = n \times k \times \frac{v^2}{2g}$$

$$= 4 \times 0,9 \times \frac{0,5^2}{2 \times 9,81}$$

= 0,022 m

- *Headloss minor (check valve)*

$$Hf_{chcek\ valve} = n \times k \times \frac{v^2}{2g}$$

$$= 1 \times 0,2 \times \frac{0,5^2}{2 \times 9,81}$$

= 0,045 m

- Headloss minor (increaser)

$$Hf_{increaser} = n \times k \times \frac{v^2}{2g}$$

$$= 1 \times 0,25 \times \frac{0,5^2}{2 \times 9,81}$$

= 0,003 m

ΣHf minor

Hf_{minor} = Elbow+Hf minor checek valve + Hf minor increaser

= 0,022 m + 0,045 m + 0,003 m

= 0,07 m

- ΣHf *discharge*

  Hfd = Hf mayor + Hf minor

  = 0,031 m + 0,07 m

  = 0,101 m

o Perhitungan *head* total (*head* pompa)

- *Head* total = *Head* statis + ΣHf *suction* + ΣHf *discharge*

  = 1,94 m + 0,017 m + 0,101 m

  = 2,05 m

o Head statis < Head pompa = 1,94 < 2,05 m

Berdasarkan perencanaan debit (Q) = 18,75 m^3/jam dan head pump = 34,2 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa sentrifugal Grundfos tipe NKE 32-180/177 ASA1F1S3ESBQQEIWB dengan spesifikasi pompa sebagai berikut:

- Merk = Grundfos
- Tipe pompa = NKE 32-180/177 ASA1F1S3ESBQQEIWB
- Flow Rated = 21,77 m^3/h
- Rated Head = 19,95
- Diameter pipa suction = 50 DN
- Diameter pipa discharge = 32 DN

Gambar 5. 17 Pompa Grundfos NKE 32-180/177 ASA1F1S3ESBQQEIWB

<u>Resume Bangunan Bak *Activated Sludge*</u>

- REMOVAL
  - BOD = 1,55 mg/l = 0,0015 kg/m^3
  - COD = 104 mg/l
  - NH3 = 3,75 mg/l
- Koefisien kineti pada suhu 28˚C
  - Kd = 0,082 hari
  - Y = 0,821 VSS/mg.BOD
- BOD yang teremoval = 0,029 kg/m^3
- COD yang teremoval = 1,97 kg/m^3
- Ammonia yang teremoval = 0,067 kg/m^3
- Rasio resirkulasi (R) = 0,45
- Debit resirkulasi (Qr) = 0,003 m^3/s
- Qa = 0,008 m^3/s =28,8 m^3/jam = 691, 2 m^3/hari
- Ca BOD = 19,95 mg/l = 0,019 kg/m^3
- Ca COD = 1339mg/l = 1,3 kg/m^3
- V = 962 m^3
- L (panjang bak) = 22 m
- B (lebar bak) = 11 m
- Jari-jari hidrolis = 0,56 m
- γ_{obs} = 058
- Xr = 6964,3 mg/l
- Sr = 0,67 kg/hari

- Pxv = 0,36 kg VSS/hari
- Px (MLVSS) = 0,000077 kg/s = 6,65 kg/hari
- Px (MLSS) = 7,98 kg VSS/hari = 0,00009 kg VSS/s
- Qex = 2,81 m^3/hari
- F/M = 0,39 / hari (memenuhi 0,2 – 0,6 / hari)
- Keb. O_2 BOD = 0,00036 kg O_2/s = 1,29 kg O_2/jam = 30,96 kg O_2/hari
- Keb. O_2 NH3 = 0,00075 kg O_2/s = 2,7 kg O_2/jam = 64,8 kg O_2/hari
- Keb. O_2 COD = 0,033 kg O_2/s = 118,8 kg O_2/jam = 2851,2 kg O_2/hari
- Keb. O_2 Total = 2946 kg $O2/hari$
- Penggunaan Diffuser =
  - Merk : Aquamart, HBLQ Fine Bubble Disk Diffuser
  - Model : HLBQ 170
  - Bubble Type : Coarse bubble
  - Diameter : 6 inch = 0,15 m
  - Efisiensi transfer O_2 : 10%
  - A service / Aliran design : 5 m^3/jam
- Keb. Udara teoritis = 11690 kg/hari = 0,13 kg/s
- Keb. Udara actual = 116900 kg/hari = 1,35 kg/s = 4860 kg/jam
- Debit udara = 4050 m^3/jam
- N = 2,2 kgO2/kw.jam = 52,8 kgO2/kw.hari
- P = 7,1 Kw
- Penggunaan Blower =
  - Merk : Showfou
  - Type : BS-1032, 50 Hz
  - Max discharge : 9 m^3/min
  - Daya : 7,5 Kw

- A disk = 0,017 m^2
- N disk = 810 buah
- Pipa outlet =
  - A : 0,016 m^2
  - Diameter pipa : 0,15 m = 150 mm
  - V cek : 0,5 m/s (memenuhi)
- Pompa resirkulasi
  Head statis < Head pompa = 5,48 < 5,57 m
  Berdasarkan perencanaan debit (Q) = 12,96 m^3/jam dan head pump = 2,35 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa slury pump UHB-ZK50/20-20
- Pompa menuju Clarifier
  - Head statis < Head pompa = 1,94 < 2,05 m
    Berdasarkan perencanaan debit (Q) = 18,75 m^3/jam dan head pump = 2,05 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa sentrifugal Grundfos tipe NKE 32-180/177 ASA1F1S3ESBQQEIWB dengan spesifikasi pompa sebagai berikut:
  - Merk = Grundfos
  - Tipe pompa = NKE 32-180/177 ASA1F1S3ESBQQEIWB
  - Flow Rated = 21,77 m^3/h
  - Rated Head = 19,95
  - Diameter pipa suction = 50 DN
  - Diameter pipa discharge = 32 DN

5.8 Clarifier

a. Kriteria Perencanaan

- Bentuk bak sedimen akhir = 1 lingkaran (*circular*)
- Kedalaman bak (H) = 3 – 6 m

Sumber: Qasim. Wastewater Treatment. 1999 CRC Press LLC, hlm 156 based on pdf page)

- Diameter bak (D) = 3 – 60 m
- Slope dasar bak (S) = 1/16 – 1/6 mm/mm
- Flight speed = 0,02 – 0,05 m/menit

Sumber: Metcalf & Eddy, Waste Water Engineering Treatment & Reuse, 4th Edition, hlm 398

- Waktu detensi bak sedimentasi = 1,5 – 2,5 jam
- Over flowrate bak
  - Average = 30 – 50 m^3/m^2.hari
  - Peak = 80 – 120 m^3/m^2.hari
- Weir loading rate = 125 – 500 m^3/m^2.hari

Sumber: Metcalf & Eddy, Waste Water Engineering Treatment & Reuse, 4th Edition, hlm 401

- Diameter inlet well = 15% - 20% diameter bak
- Konsentrasi solid = 4% - 12%
- Massa jenis air (ρ), T 28˚C = 996,36 kg/m^3
- Viskositas kinematik (υ) = 0,8746 x $10^{-6}$$m^2$/s
- Viskositas dinamik (μ) = 0,8746 x 10-3 N s/m^2
- (*Sumber: Reynolds, Tom D. dan Paul A. Richards. 1996. Unit Operations and Processes in Environmental Engineering 2nd edition, hlm 762 (Appendix C). Boston: PWS Publishing Company*)
- Bilangan Reynold (NRe) untuk Vs = <1 (laminar)

(*Sumber: Reynolds, Tom D. dan Paul A. Richards. 1996. Unit Operations and Processes in Environmental Engineering 2nd edition, hal 224. Boston: PWS Publishing Company*)

- *Spesific gravity sludge* (Sg) = 1,005
- *Spesific gravity solids* (Ss) = 1,25

(*Sumber: Metcalf & Eddy, Waste Water Engineering Treatment & Reuse, 4th Edition, hlm 1456*)

- Bilangan Reynold (NRe) untuk Vh = <2000 (aliran laminar)

- Bilangan Froude (NFr) = >10-5

  (*Sumber: SNI 6774 Tata Cara Perencanaan Unit Paket Instalasi Pengolahan Air Limbah 2008, hlm 6*)

- Ketinggian *inlet well* = 0,5 – 0,7m
- Kecepatan *inlet well* = 0,3 – 0,75m/s

  (*Sumber: Metcalf & Eddy, Waste Water Engineering Treatment & Reuse, 4th Edition, hlm 401*)

- MLVSS bak sedimentasi 2 = 8000 – 11000 mg/L

b. Data Perencanaan

- Menggunakan 1 bak sedimentasi berbentuk lingkaran (circular)
- Debit masuk Qin = 0,008 m^3/s
- Waktu tinggal = 2 jam = 7200 detik
- Suhu air limbah = 28°C
- Massa jenis air T 28°C = 996,36 kg/m^3
- Viskositas kinematis (v) = $0{,}8746 \times 10^{-6}\ m^2/s$ (suhu 28°C)
- Viskositas absolut (μ) = $0{,}8363 \times 10^{-3}\ m^2/s$ (suhu 28°C)
- *Spesific gravity solid* = $1{,}4 \times 996{,}36\ kg/m^3$(massa jenis air)
- Koefisien manning = 0,013
- *Overflow rate* = 35 m^3/m^2.hari
- Diameter inlet well (D') = 20% diameter bak
- Waktu pengurasan = 7 hari
- Dengan menggunakan V notch untuk outlet sedimentasi, dengan kemiringan 45°
- Jarak V notch = 20 cm
- MLVSS pada clarifier = 8000 mg/L
- MLSS pada clarifier = 9604 mg/L
- Massa jenis *sludge* = sg x ρ = 1,005 x 996 kg/m^3 = 1000,98 kg/m^3
- Rasio resirkulasi

  $$R = \frac{\text{MLVSS Activated Sludge}}{\text{MLVSS Clarifier} - \text{MLVSS Activated sludge}}$$

$= \frac{2500 \text{ mg/L}}{8000 \text{ mg/L} - 2500 \text{ mg/L}}$

= 0,45

- Debit resirkulasi

Qr = R x Q

= 0,45 x 0,008 m^3/s

= 0,0036 m^3/s

= 311,04 m^3/hari

= 12,96 m^3/jam

- Pipa resirkulasi
  - A $= \frac{Qr}{V}$

    $= \frac{0{,}0036 \text{ m3/s}}{0{,}3 \text{ m/s}}$

    = 0,012 m^2
  - Diameter pipa (D)

    D $= \sqrt{\frac{4 \times A}{\pi}}$

    $= \sqrt{\frac{4 \times 0{,}012 \text{ m2}}{3{,}14}}$

    = 0,123 m = 123 mm

    = (pipa pasaran pvc = 125 mm)

c. Perhitungan

<u>Zona Settling</u>

a) Qin pada clarifier

Qin = Qo + Qr

= 0,008 m^3/s + 0,0036 m^3/s

= 0,0116 m^3/s

= 1002,24 m^3/hari

= 41,76 m^3/jam

b) Volume bak

V = Qin x td

= 0,0116 m^3/s x 7200 s

= 83,52 m^3

c) Luas permukaan bak

A = $\frac{Q}{\text{over flow rate}}$

= $\frac{1002{,}24\ m3/hari}{35\ m^3/m^2.hari}$

= 28,63 m^2

d) Diameter bak

D = $\sqrt{\frac{4 \times A}{\pi}}$

= $\sqrt{\frac{4 \times 28{,}63\ m2}{3{,}14}}$

= 6 m (memenuho 3 – 60 m)

r = 3 m

Diameter inlet well = 20 % diameter bak

= 20% $\times$ 6 m

= 1,2 m

e) Kedalaman zona settling

H = $\frac{V}{A}$

= $\frac{83{,}52\ m3}{28{,}63\ m2}$

= 2,91 m

H total = H + freeboard

= 2,91 m + (2,9 x 20%)

= 3,49 m

f) Slope dasar bak

S = 10 % x r

= 10 % x 3 m

= 0,3 m

g) Cek waktu detensi

Td = $\frac{V}{Qin}$

= $\frac{\frac{1}{4} \times \pi \times D^2 \times h}{0{,}0116\ m3/s}$

$= \frac{\frac{1}{4} \times 3{,}14 \times (6)^2 \times 3{,}49\ m}{0{,}0116\ m3/s}$

= 6164,2 s

= 1,7 jam (memenuhi 1,5 – 2,5 jam)

h) Kecepatan Pengendapan

Vs $= \frac{H}{td}$

$= \frac{3{,}49\ m}{6164{,}2\ s}$

= 0,0005 m/s

i) Diameter partikel

Dp $= \sqrt{\frac{Vs \times 18 \times \upsilon}{g\ (Ss-1)}}$

$= \sqrt{\frac{0{,}0005\ m/s \times 18 \times 0{,}8764 \times 10^{-6} m2/s}{9{,}81\ m/s2\ (1{,}25-1)}}$

= 5,67 x 10^{-5} m

j) Cek bilangan Nre

Nre $= \frac{\rho sludge \times Dp \times vs}{\mu}$

$= \frac{1000{,}98\ kg/m3 \times 5{,}67 \times 10^{-5}\ m \times 0{,}0005\ m/s}{0{,}8363 \times 10^{-3} m2/s}$

= 0,033 (memenuhi syarat Nre untuk Vs < 1)

k) Kecepatan horizontal (Vh)

Vh $= \frac{Qin}{2 \times \pi \times r \times h}$

$= \frac{0{,}0116\ m3/s}{2 \times 3{,}14 \times 3\ m \times 3{,}49\ m}$

= 0,00017 m/s

l) Jari - jari hidrolis

R $= \frac{r \times h}{r + 2h}$

$= \frac{3\ m \times 3{,}49\ m}{3\ m + 2 \times 3{,}49\ m}$

= 1,04 m

m) Cek bilangan Nre

Nre $= \frac{Vh \times R}{v}$

$= \frac{0{,}00017\ m/s \times 1{,}04\ m}{0{,}8746 \times 10^{-5}}$

= 20,21 (memenuhi syarat Nre < 2000)

n) Cek bilangan Froude (Nfr)

Nfr $= \frac{Vh}{\sqrt{g \times h}}$

$= \frac{0{,}00017\ m/s}{\sqrt{9{,}81 \times 3{,}49\ m}}$

= 2,9 x 10^{-5}

o) Cek kecepatan penggerusan (*scouring*)

K = konstanta kohesi untuk partikel yang saling mengikat = 0,06

F = Faktor friksi Darcy-Weisbach = 0,02 – 0,03

*apabila Vsc > Vh tidak terjadi penggerusan

Vh = 0,00017 m/s

Vsc $= \sqrt{\frac{(8 \times K \times (Ss - 1) \times g \times dp)}{f}}$

$= \sqrt{\frac{(8 \times 0{,}06 \times (1{,}25 - 1) \times 9{,}81 \times\ 5{,}67 \text{ x } 10^{-5}\ m)}{0{,}03}}$

= 0,047 m/s (memenuhi) Tidak terjadi penggerusan

Resume Clarifier Zona Settling

- Diameter pipa resirkulasi = pipa pasaran (pvc) = 125 mm
- Qin Clarifier = 0,0116 m^3/s = 1002,24 m^3/hari
- Volume zona settling = 83,52 m^3
- Luas permukaan bak = 28,63 m^2
- Diameter permukaan bak = 6 m dan diameter inlet well = 1,2 m
- Kedalaman zona settling (H) = 2,91 m
- Kedalaman total zona settling = 3,49 m
- Slope dasar bak = 0,3 m
- Cek waktu detensi (td) = 1,7 jam (memenuhi 1,5 – 2,5 jam)
- Kecepatan pengendapan (Vs) = 0,0005 m/s

- Cek bilangan Nre = 0,033 (memenuhi syarat Nre untuk Vs < 1)
- Kecepatan horizontal (Vh) = 0,00017 m/s
- Jari – jari hidrolis (R) = 1,04 m

  Nre = 20,21 (memenuhi syarat Nre < 2000)
- Nfr = $2,9 \times 10^{-5}$

  Cek kecepatan penggerusan = 0,047 m/s (memenuhi) Tidak terjadi penggerusan

Zona Inlet Clarifier

a) Diameter *inlet well* (D')

D' = 20 % diameter bak

= 20 % x 6 m

= 1,2 m

- Perhitungan pipa inlet

$$A = \frac{\text{Debit air (Qin)}}{\text{kecepatan aliran (V)}}$$

$$= \frac{0{,}0116\ m3/s}{0{,}5\ m/s}$$

$$= 0{,}023\ m^2$$

- Diameter pipa (D)

$$D = \sqrt{\frac{4 \times A}{\pi}}$$

$$= \sqrt{\frac{4 \times 0{,}023\ m2}{3{,}14}}$$

= 0,171 m = 171 mm (pipa pasaran pvc = 200 mm)

- Cek kecepatan (v cek) pipa outlet

$$V = \frac{Q}{A}$$

$$= \frac{0{,}0116\ m3/s}{\frac{1}{4} \times 3{,}14 \times (0{,}2\ m)^2}$$

= 0,36 m/s (memenuhi)

Resume Inlet Clarifier

- Diameter pipa inlet = pipa pasaran pvc = 200 mm
- Cek Kecepatan = 0,36 m/s

Zona Thickening

1. Data Perencanaan

- MLVSS bak clarifier = 8000 mg/L
- MLSS bak clarifier = 9604 mg/L
- MLVSS bak *Activated Sludge* = 2500 mg/L
- MLVSS (x) bak *Activated Sludge* = 3000 mg/L
- Volume Clarifier = 83,52 m^3
- Luas permukaan clarifier = 28,63 m^2
- Diameter permukaan clarifier = 6 m

2. Perhitungan

a) MLVSS dalam clarifier

MLVSS yang tetep tinggal di clarifier:

$MLVSS_{AS}$ = 2500 mg/L

MLVSS clarifier = MLVSS clarifier – MLVSS $_{AS}$

= 8000 mg/L – 2500 mg/L

= 5500 mg/L = 5500 g/m3

b) Massa Solid total di clarifier

M solid total = MLVSS clarifer x V clarifier

= 5500 mg/L x 83,52 m^3

= 459360 g

= 459, 36 kg

c) Kedalaman zona thickening

$$H = \frac{M\ solid}{x\ .\ A}$$

$$= \frac{459{,}36\text{ kg}}{8\ kg/m3 \times\ 28{,}63\text{ m2}}$$

= 2 m

Resume Clarifier Zona Thickening

- MLVSS dalam clarifier = 5500 mg/l = 5500 g/m^3
- Massa solid total di clarifier = 459,36 kg

- Kedalaman zona thickening = 2 m

Zona Sludge

1. Data perencanaan

- Ruang lumpur direncanakan berbentuk kerucut terpancung
- Waktu pengurasan = 10 hari
- Diamter permukaan atas = 6 m
- Diameter permukaan dasar = 3 m (asumsi)
- Qr = 0,0036 m^3/s

b. Perhitungan

a) Removal TSS

Cn = Co – (Co x (100% - % removal TSS)

= 16,75 mg/l – (16,75 mg/l x (100 % - 50%))

= 8,37 mg/l = kg/m3

b) Berat Solid

Berat solid = (removal tss x Qr) + Px mlvss

= (0,008 kg/m3 x 0,0036 m^3/s) + 6,65 kg VSS/hari

= 6,65 kg/hari

c) Berat air

Berat air $= \frac{95\%}{5\%} \times \text{Berat solid}$

$= \frac{95\%}{5\%} \times 6{,}65 \text{ kg/hari}$

= 126,35 kg/hari

d) Berat jenis solid

Berat jenis solid $= \text{Ss} \times \rho\text{air}$

$= 1{,}4 \times 996 \text{ kg/m3}$

= 1394,4 kg/m3

e) Volume solid

Volume solid $= \frac{\text{berat solid}}{\text{berat jenis solid}}$

$= \frac{6{,}65 \text{ kg/hari}}{1394{,}4 \text{ kg/m3}}$

= 0,004 m3

f) Volume air = $\frac{\text{berar air}}{\text{berat jenis air}}$

= $\frac{126{,}35 \text{ kg/hari}}{996 \text{ kg/m3}}$

= 0,126 m3

g) Volume sludge TSS

Volume sludge = Volume solid + Volume air

= 0,004 m3 + 0,126 m3

= 0,13 m3

h) Berat jenis sludge

Berat jenis sludge = Sg $\times$ ρsludge

= $1{,}005 \times 1394{,}4$ kg/m3

= 1401,3 Kg/m3

i) Berat sludge

j) Berat sludge = Volume sludge x berat jenis sludge

= 0,13 m3 x 1401,3 Kg/m3

= 182,16 Kg

k) Debit sludge = $\frac{\text{berat sludge}}{\text{berat jenis sludge}}$

= $\frac{182{,}16 \text{ Kg}}{1401{,}3 \text{ Kg/m3}}$

= 0,12 m3/hari

l) Total produksi lumpur dari removal TSS pada clarifier

Total lumur TSS = produksi lumpur TSS x waktu pengurasan

= 0,12 m3/hari x 7 hari

= 0,84 m3

m) Total lumpur

Total lumpur (TL) = Px mlvss x waktu pengurasan

= 6,65 kg VSS/hari x 7 hari

= 46,55 Kg VSS

n) Total masa lumpur pada bak

Tms = TL + M solid total

= 46,55 Kg VSS + 459, 36 kg

= 505,91 Kg

o) Volume lumpur pada bak

VL = $\frac{Tms}{\rho s}$

= $\frac{505{,}91\ \text{Kg}}{1000{,}98\ kg/m3}$

= 0,5 m3

p) Volume air

Volume air = 95% x 0,5 m3

= 0,47 m3

q) Berat air

Berat air = Volume air x berat jenis air

= 0,47 m3 x 996 kg/m3

= 468,12 kg

r) Volume solid

Volume solid = 5 % x VL

= 5 % x 0,5 m3

= 0,025 m3

s) Volume sludge

V sludge (V2) = V solid + V air

= 0,025 m3 + 0,47 m3

= 0,49 m3

t) Volume total lumpur pada bak

V total = V sludge TSS + V2

= 0,84 m3 + 0,49 m3

= 1,33 m3

u) Dimensi ruang lumpur

Direncanakan pengurasan dari clarifier dilakukan setiap 7 hari sekali, dan ruang lumpur bak sedimentasi berbentuk kerucut terpancung dengan asumsi diameter ruang lumpur sebagai berikut

- Diameter permukaan atas = diameter bak settling = 6 m
- Jari – jari permukaan atas (r) = 3 m

- Diameter permukaan bawah = 3 m (asumsi)
- Jari – jari permukaan bawah (r) = 1,5 m

Volume ruang lumpur = volume kerucut terpancung

Volume $= \frac{1}{3} \times \pi \times H \times (R^2 + r^2 + Rr)$

1,33 m3 $= \frac{1}{3} \times 3{,}14 \times H \times (3^2 + 1{,}5^2 + (3 \times 1{,}5))$

H = 0,08 m = 8 cm

v) Kedalaman total clarifier

H total = H settling + H thickening + H sludge

= 3,49 m + 2 m + 0,08 m

= 5,57 m

Perhitungan Dimensi Pipa Penguras

Qs $= \frac{\text{volume lumpur 1 kali pengurasan}}{\text{periode pengurasan}} = \frac{1{,}33 \text{ m3}}{43200 \text{ s}}$ = 0,00003 m3/s

Qp $= \frac{\text{volume lumpur 1 kali pengurasan}}{\text{periode pengurasan}} = \frac{1{,}33 \text{ m3}}{3600 \text{ s}}$ = 0,0003 m3/s

A $= \frac{Q}{v} = \frac{0{,}0003 \text{ m3/s}}{0{,}5 \text{ m/s}}$ = 0,0006 m2

D $= \sqrt{\frac{4 \times A}{\pi}} = \sqrt{\frac{4 \times 0{,}0006 \text{ m2}}{3{,}14}} = 0{,}027\ m$ = 27 mm = (pipa pasaran pvc = 100 mm)

Resume Clarifier Zona Sludge

- Volume sludge resirkulasi (TSS) = 0,12 m3/hari
- Volume sludge 1 (TSS) = 0,84 m3
- Total lumpur (MLVSS) = 46,55 Kg VSS
- Total massa lumpur pada bak (MLVSS) = 505,91 Kg
- Volume sludge 2 (MLVSS) = 0,49 m3
- Volume total lumpur pada bak clarifier = 1,33 m3
- Kedalaman zona sludge (H) = 0,08 m = 8 cm
- Kedalaman clarifier total (H) = 5,57 m
- Dimensi pipa penguras: = $0{,}027\ m$ = 27 mm = (pipa pasaran pvc = 100 mm)

Zona Outlet Clarifier

a) Panjang keliling weir

P = π × diameter bak

= 3,14 × 6 m

= 18,84 m

b) Jumlah V notch setiap pelimpah (weir)

n Notch = panjang keliling / jarak antar V notch

= 18,84 m / 0,2 m

= 94 buah

c) Debit V notch

Q v notch $= \frac{Qin}{n\ notch}$

$= \frac{0{,}0116\ \mathrm{m3/s}}{94}$

= 0,00012 m3/s

d) Tinggi pelimpah setelah melalui V notch

Q v notch $= \frac{8}{15} \times cd \times \sqrt{2.g} \times \tan\frac{\alpha}{2} \times H^{5/2}$

0,00012 m3/s $= \frac{8}{15} \times 0{,}6 \times \sqrt{2 \times 9{,}81} \times \tan\frac{90}{2} \times H^{5/2}$

$H^{5/2}$ = 8,4 x 10^{-5}

H = 0,024 m

e) Panjang basah tiap pelimpah

Li $= \frac{2 \times \mathrm{H}}{\mathrm{tg}\ 45°}$

$= \frac{2 \times 0{,}024\ \mathrm{m}}{\mathrm{tg}\ 45°}$

= 0,048 m

f) Panjang basah total

Ln = Li x n notch

= 0,048 m x 94

= 4,5 m

g) Luas permukaan saluran pelimpah

A $= \frac{\mathrm{Qin}}{v}$

$= \frac{0,0116 \text{ m3/s}}{0,3 \ m/s}$

= 0,038 m2

h) Dimensi saluran pelimpah

A = B x H, direncanakan B = 2 x H

0,038 m2 = 2H x H

H = 0,13 m

H total = 0,13 m + (0,13 m x 20 %)

= 0,15 m

B = 2 x H

= 2 x 0,15 m

= 0,3 m = 30 cm

Pipa Outlet Clarifier

Pipa outlet sedimentasi akhir (clarifier) menggunakan saluran tertutup atau pipa dan menggunakan sistem gravitasi dalam pengalirannya menuju ke pengolahan berikutnya,

a) Debit outlet pada pipa outlet

Qoutlet $= 0{,}0116 \text{ m3/s}$

b) Luas penampang pipa

A = Q/V

$= 0{,}0116 \frac{\text{m3}}{\text{s}} \div 0.5 \text{ m/s}$

= 0,023 m2

c) Diameter pipa outlet

D $= \sqrt{\frac{4 \times \text{A}}{\pi}}$

$= \sqrt{\frac{4 \times 0{,}023 \text{ m2}}{3{,}14}}$

= 0,171 m = 171 mm = diameter pipa pasaran pvc = 200 mm

d) Cek kecepatan pipa outlet

V $= \frac{Q}{A}$

$= \frac{0,0116 \frac{m3}{s}}{\frac{1}{4} \times 3,14 \times (0,2)^2}$

= 0,36 m/s (memenuhi syarat 0,3 < v < 2,5 m/s)

<u>Resume Clarifier Zona Outlet</u>

- Panjang keliling weir = 18,84 m
- Jumlah V notch = 94 buah
- Debit V notch = 0,00012 m3/s
- Tinggi pelimpah setelah melalui V notch = 0,024 m
- Panjang basah tiap pelimpah = 0,048 m
- Luas permukaan saluran pelimpah = 0,038 m2
- Dimensi saluran pelimpah:
  - H air = 0,13 m
  - H total = 0,15 m
  - B = 0,3 m = 30 cm
- PIpa outlet clarifier
  - Luas penampang = 0,023 m2
  - Diameter pipa = 0,171 m = 171 mm
    = diameter pipa pasaran pvc = 200 mm
  - Cek v = 0,36 m/s (memenuhi syarat 0,3 < v < 2,5 m/s)

5.9 Screw Press

a. Data Perencanaan

<u>Dissolved Air Flotation (DAF)</u>

- Total solid pada unit dissolved air flotatiom = 0,32 kg/m^3 = 318,25 mg/l
- Q in = 0,005 m^3/s
- Direncanakan mesin screw press operasional selama 18 jam

<u>Secondary Clarifier</u>

- TSS pada bak activated sludge = 2500 mg/L
- TSS pada clarifier = 8000 mg/L

- Debit (Qa) = 0,008 m^3/s =28,8 m^3/jam = 691, 2 m^3/hari
- Direncanakan mesin screw press operasional selama 18 jam

5.10.1 Perhitungan

a. Dissolved Air Flotation

Total solid pada unit dissolved air flotation = 0,32 kg/m^3 = 318,25 mg/l

Q in = 0,005 m^3/s = 450 m^3/hari

1) TSS yang diolah = 335 mg/L
2) Dry Solid (DS) = $\frac{0,32}{1000}\ kg/m^3\ \times 450\ \text{m3/hari}$
   = 0,144 kg/hari
3) Sludge (1% DS) = 0,144 kg/hari x 1%
   = 0,0014 kg/hari

b. Secondary Clarifier

TSS pada bak activated sludge = 2500 mg/L

TSS pada clarifier = 8000 mg/L

1) TSS yang diolah = 8000-2500 = 5500 mg/L
2) Dry Solids (DS) = $\frac{5500}{1000}\ kg/m^3\ \times 691,2\ \text{m3/hari}$
   = 3801,6 kg/hari = 158, 4 L/jam
3) Sludge (1% DS) = 3801,6 kg/hari x 1%
   = 38,01 kg/hari

c. Total sludge menuju screw press

Total Sludge = 0,0014 kg/hari + 38,01 kg/hari
= 38,0114 kg/hari = 1,58 kg/jam

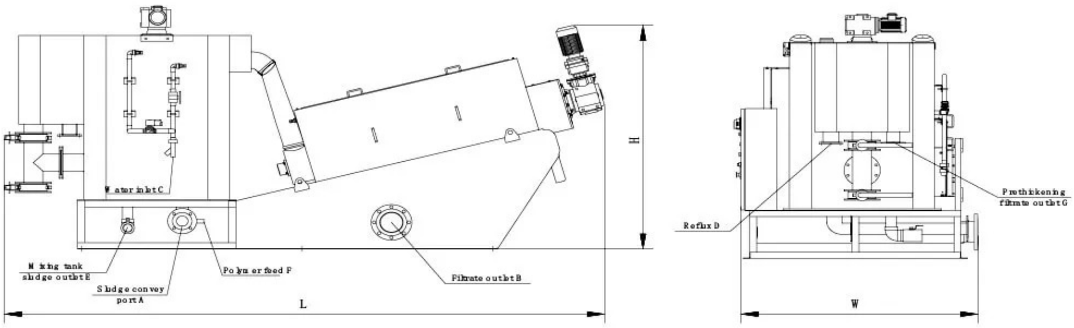
Per jam = 38,0114 kg/hari : 18 jam
= 2,11 kg/jam

Berdasarkan perhitungan diatas, diperoleh spesifikasi mesin screw press yang akan digunakan dalam tugas perancangan ini sebagai berikut.

Model	DS Standard Capacity(kg/h)		Sludge Treatment Capacity (m^3/h)					
	Low Concentration	High Concentration	2000mg/L	4000mg/L	10000mg/L	20000mg/L	25000mg/L	50000mg/L
MDS101	3	6	1.5	0.75	0.6	0.3	0.24	0.12
MDS131	6	12	3	1.5	1.2	0.6	0.48	0.24
MDS132	12	24	6	3	2.4	1.2	0.96	0.48
MDS201	12	20	6	3	2	1	0.8	0.4
MDS202	24	40	12	6	4	2	1.6	0.8
MDS301	30	60	15	7.5	6	3	2.4	1.2
MDS302	60	120	30	15	12	6	4.8	2.4
MDS303	90	180	45	22.5	18	9	7.2	3.6
MDS351	60	120	30	15	12	6	4.8	2.4
MDS352	120	240	60	30	24	12	9.6	4.8
MDS353	180	360	90	45	36	18	14.4	7.2
MDS354	240	480	120	60	48	24	19.2	9.6
MDS401	100	170	50	25	17	8.5	6.8	3.4
MDS402	200	340	100	50	34	17	13.6	6.8
MDS403	300	510	150	75	51	25.5	20.4	10.2
MDS404	400	680	200	100	68	34	27.2	13.6

Model	Sludge Cake Discharge Height (mm)	Size (mm)			Net Weight (kg)	Running Weight (kg)	Power (kw)	Rinsing Water (L/H)
		L	W	H				
MDS101	215	1860	750	1080	205	295	0.2	24
MDS131	250	1860	750	1080	205	300	0.2	24
MDS132	250	1960	870	1080	275	425	0.3	48
MDS201	350	2440	860	1380	320	470	0.3	32
MDS202	350	2580	977	1270	470	730	0.3	64
MDS301	495	3350	941	1564	910	1320	0.8	40
MDS302	495	3570	1260	1670	1350	2130	1.2	80
MDS303	495	3830	1620	1670	1820	2880	1.95	120
MDS351	585	3900	1160	2190	1610	2210	1.9	72
MDS352	585	4240	1550	2190	2300	3400	3.75	144
MDS353	585	4460	2100	2190	3350	4850	6.0	216
MDS354	585	4660	2650	2190	4500	6100	8.2	288
MDS401	759	4356	1170	2400	1850	2850	2.25	80
MDS402	759	4900	1640	2400	3480	5200	4.5	160
MDS403	759	5030	2240	2400	4550	7050	6.7	240

Gambar 5. 18 Katalog Unit Screw Press



Gambar 5. 19 Unit Screw Press

- Merk = Benenv
- Model = MDS302
- Kapasitas Max = 15 m^3/hour
- Panjang (L) = 3,57 m
- Lebar (W) = 1,26 m
- Tinggi (H) = 1,67 m

d. Kebutuhan Polymer

Dosis: Standar Trchase 3 – 6 gr polymer/kg-DS (ambil 6 gr polymer/kg-DS)

1) Kebutuhan polymer

Kebutuhan Polymer = Dosis x total sludge
= 6 gr polymer/kg-DS x 38,0114 kg/hari
= 228,06 gr polymer/hari
= 0,228 kg polymer/hari

Kebutuhan Polymer (/jam) = 228,06 gr polymer/hari : 18 hour
= 12,67 gr polymer/hour
= 0,012 kg polymer/hour

2) Pelarutan flokulant (polymer)

Konsentrasi pelarutan floklant = 1%

Pelarutan flokulant = 0,012 kg polymer/hour x 1%
= 12 LPH = 0,2 LPM

Berdasarkan spesifikasi dosing pump dengan debit 12 L/jam maka didapatkan dosing pump:

DDA 60-10 AR-PVC/E/C-F-31A7A7BG

Note!

Product No.: On request
DDA 60-10 AR-PVC/E/C-F-31A7A7B

Gambar 5. 20 Dosing Pump Grundfos DDA 60-10 AR-PVC/E/C-F-31A7A7B

- Merk = Grundfos
- Jenis pompa = Dossing Pump Digital
- Tipe = DDA 60-10 AR-PVC/E/C-F-31A7A7B
- Max flow = 15 L/jam

3) Kebutuhan tangki chemical

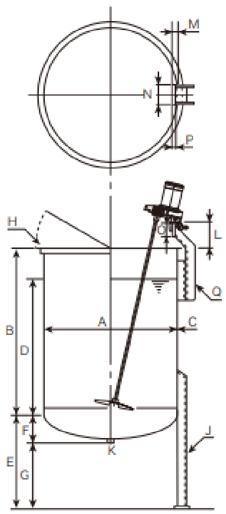
Td = 2,5 hour

V tangki = 12 LPH x td

= 12 LPH x 2,5 hour

= 30 liter = 0,03 m^3

Specification of optional tanks



Model	Available capacity	Maximum capacity	Tank dimension (mm)										Weight (kg)	
	ℓ	ℓ	A	B	C	D	E	F	G	H(SUS)	J(SS)	K	Tank	Lid*
ZTF-100	100	130	500	600	3	450	450	134	316	L25×25×3	3-L50×50×6	1/2 B Socket	43	3
ZTF-150	150	182	550	700	3	562	450	144	306	L30×30×3	3-L50×50×6	1/2 B Socket	51	4
ZTF-200	200	260	650	700	3	520	450	163	287	L30×30×3	3-L50×50×6	1/2 B Socket	60	5.5
ZTF-300	300	361	700	850	3	692	500	173	327	L40×40×3	4-L50×50×6	1/2 B Socket	77	6.5
ZTF-400	400	478	800	850	3	695	500	192	308	L40×40×3	4-L50×50×6	1/2 B Socket	88	8
ZTF-500	500	600	850	950	3	770	500	202	298	L40×40×3	4-L65×65×6	1/2 B Socket	106	9
ZTF-800	800	963	1000	1100	3	900	550	240	310	L40×40×5	4-[100×50×5	1B Socket	155	12
ZTF-1000	1000	1177	1100	1100	3	910	550	260	290	L40×40×5	4-[100×50×5	1B Socket	170	19
ZTF-1500	1500	1721	1250	1245	4	1065	600	290	310	L40×40×5	4-[100×50×5	1B Socket	260	24
ZTF-2000	2000	2275	1300	1550	4	1345	600	298	302	L50×50×6	4-[125×65×6	1B Socket	335	26
ZTF-2000S	2000	2273	1400	1300	4	1125	600	318	282	L50×50×6	4-[125×65×6	1B Socket	325	30
ZTF-2500	2500	3073	1500	1550	4	1230	700	370	330	L50×50×6	4-[125×65×6	1B JIS 10KF	400	34
ZTF-3000	3000	3603	1500	1850	4	1510	700	370	330	L50×50×6	4-[125×65×6	1B JIS 10KF	448	34
ZTF-3000S	3000	3521	1600	1550	4	1290	750	400	350	L50×50×6	4-[125×65×6	1B JIS 10KF	422	38
ZTF-3500	3500	4125	1600	1850	4	1540	700	400	300	L50×50×6	4-[150×75×9	1B JIS 10KF	524	38
ZTF-3500S	3500	4004	1700	1550	4	1330	800	430	370	L50×50×6	4-[150×75×9	1B JIS 10KF	514	43
ZTF-4000	4000	4685	1700	1850	4	1550	800	430	370	L65×65×6	4-[150×75×9	1 1/2 B JIS 10KF	575	45
ZTF-4000S	4000	4520	1800	1500	4	1345	800	450	350	L65×65×6	4-[150×75×9	1 1/2 B JIS 10KF	550	50
ZTF-4500	4500	5285	1800	1850	5	1542	800	450	350	L65×65×6	4-[200×90×8	1 1/2 B JIS 10KF	750	50
ZTF-5000	5000	5924	1900	1850	5	1530	900	500	400	L65×65×6	4-[200×90×8	2B JIS 10KF	800	56

*The lids have a thickness of 1.5t for A dimension up to 1000, and 2.0t for A dimension above that.

*Jacket type is also available.

Gambar 5. 21 Katalog Satake Mixer Tanks

Dari perhitungan dimensi diatas, diperoleh spesifikasi tangki pembubuhan koagulan yang akan digunakan adalah sebagai berikut:

- Merek: Satake Mixer Tanks
- Model Tangki: ZT Series/ZTF-100
- Kapasitas Tangki: 100 L
- Kapasitas maksimal: 130 L
- Diameter tangki: 500 mm = 0,5 m
- Kedalaman bak: 600 mm + 134 mm = 734 mm = 0,734 m
- Kedalaman air : 450 mm + 134 mm = 584 mm = 0,584 m

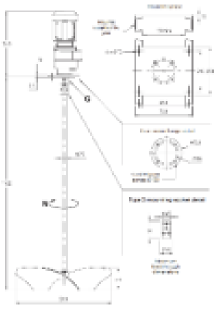
1) Daya Pengaduk

P = G^2 x μ x V

= $(700/s)^2$ x 0,000836 $N.s/m^2$ x 0,03 m^3

= 0,01 N.m/s

= 0,00001 Kw



Type	Ø Impeller	P (kw)	N (tr/min)	Q (m3/h)	Weight (kg)
F...0201	200	0,12	31	20	19
F...0301	300	0,12	31	50	20
F...0401	400	0,12	31	115	20,5
F...0501	500	0,12	31	210	21
F...0601	600	0,12	31	355	22
F...0701	700	0,12	31	570	24
F...0801	800	0,18	36	960	30
F...0902	900	0,18	28	1106	42
F...1002	1000	0,18	24	1258	44

Gambar 5. 22 Katalog Impeller

Dari perhitungan daya pengadukam diatas, diperoleh spesifikasi impeller yang akan digunakan adalah sebagai berikut:

- Merek/Model : TMI / F…0401
- Power : 0,12
- Diameter : 200 mm = 0,2 m

2) Cek Nre $= \frac{Di^2 \times n \times \rho}{\mu}$

$= \frac{0{,}2^2 \times 0{,}3\ rps \times 996\ Kg/m^2}{0{,}0008363\ N.s/m^2}$

= 14291

3) Cek Di = $\frac{Di}{D}$ x 100%

= $\frac{0{,}2\ m}{0{,}5\ m}$ x 100%

= 40% **(memenuhi kriteria 30-50% D bak)**

4) Jarak impeller dengan dasar

Hi = 50% x Di

= 50% x 0,2 m

= 0,1 m

5) Lebar Impeller

Wi = $\frac{Di}{8}$

= $\frac{0{,}2\ m}{8}$

= 0,025 m

Cek Wi = $\frac{Wi}{Di}$

= $\frac{0{,}025\ m}{0{,}2\ m}$ = 0,125 m

6) Bak Penampung Sludge

Total Sludge = 38,0114 kg/hari

Debit = 38,0114 L/hari = 0,038 m^3/hari = 0,91 m^3/jam

Volume = Q x td

= 0,91 m^3/jam x 8 jam

= 7,28 m^3

* direncanakan tinggi bak = 0,5 m

* Dimensi bak =

Dimensi bak penampung (P = L)

$V = P\ x\ L\ x\ H$

$7{,}28\ m3 = L\ x\ L\ x\ \ 0{,}5\ m$

$7{,}28\ m3 = 0{,}5\ L^2\ m$

$L^2 = \frac{7{,}28\ m3}{0{,}5\ m}$

$\boldsymbol{L = 4\ m}$; $\boldsymbol{P = 4\ m}$

7) Pompa Sludge Menuju Bak Sludge

- Kriteria Perencanaan
- K *Elbow* 90° = 0,9

  (Sumber: Dake, J.M.K., Endang P. Tachyan dan Y.P. Pangaribuan, 1985. "Hidrolika Teknik Edisi II". Erlangga. Jakarta)
- K *increaser* = 0,25
- K *check valve* = 2,0

  (*Sumber: Pratical Hydrolics For The Public Work Engineer, 1968)*
- Data Perencanaan
- *Elbow* 90° *suction* = 4 buah ; k = 0,3
- *Elbow* 90° *discharge* = 2 buah ; k = 0,3
- *Check valve* = 1 buah
- Q sludge = 3801,6 kg/hari = 158, 4 L/jam = 0,00004 m3/s
- H suction = 6,03 m
- H discharge = 0,32 m
- H statis = H suction + H discharge

  = 6,03 m + 0,32 m = 6,35 m
- L *suction* = 24,83 m
- L *discharge* = 1,26 m
- Diameter pipa = 5" = 125 mm (pasaran)
- Kecepatan pipa (v) = 0,5 m/s
- Koefisien kekasaran (C)s = 130
- Perhitungan
- Perhitungan *Suction*
- *Headloss mayor*

  $$Hf = \left(\frac{Q}{0{,}2785 \times C \times D^{2{,}63}}\right)^{1{,}85} \times L$$

  $$Hf = \left(\frac{0{,}00004\ m^3/s}{0{,}2785 \times 130 \times 0{,}125^{2{,}63}}\right)^{1{,}85} \times 24{,}83\ m$$

Hf = 0,0004 m

Headloss minor (elbow 90°)

$Hf_{elbow} = n \times k \times \frac{v^2}{2g}$

$= 4 \times 0{,}9 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,045 m

- *Headloss minor (increaser 90°)*

$Hf_{increaser} = n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}25 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,003 m

ΣHf minor

Hf_{minor} = Hf minor elbow *90°* + Hf minor increaser

= 0,045 m + 0,003 m

= 0,048 m

- ΣHf *suction*

Hfs = Hf mayor + Hf minor

= 0,0004 m + 0,048 m

= 0,048 m

○ Perhitungan *Discharge*

- *Headloss mayor*

$Hf = \left(\frac{Q}{0{,}2785 \times C \times D^{2{,}63}}\right)^{1{,}85} \times L$

$Hf = \left(\frac{0{,}0004\ m^3/s}{0{,}2785 \times 130 \times 0{,}125^{2{,}63}}\right)^{1{,}85} \times 1{,}26\ m$

Hf = 0,00002 m

- *Headloss minor*

$Hf_{elbow} = n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}9 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,011 m

- *Headloss minor (check valve)*

Hf$_{chcek\ valve}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}2 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,0025 m

- Headloss minor (increaser)

Hf$_{increaser}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}25 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,003 m

ΣHf minor

Hf$_{minor}$ = Elbow+Hf minor checek valve + Hf minor increaser

= 0,011 m + 0,0025 m + 0,003 m

= 0,016 m

- ΣHf *discharge*

Hfd = Hf mayor + Hf minor

= 0,00002 m + 0,016 m

= 0,016 m

- Perhitungan *head* total (*head* pompa)

- *Head* total = *Head* statis + ΣHf *suction* + ΣHf *discharge*

= 6,35 m + 0,048 m + 0,016 m

= 6,41 m

- Head statis < Head pompa = 6,35 < 6,41 m

Berdasarkan perencanaan debit (Q) = 158, 4 L/jam dan head pump = 6,41 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa slury pump UHB-ZK150/250-30 dengan spesifikasi pompa sebagai berikut:

Model and parameter

Table 1: Light duty: 2P Motor Speed=2900RPM Design pressure: 1.6 MPa "*"Standard data

Item	Model	Flow (m3/h)	Head (m)	Effic-iency (%)	NPSHa (m)	Inlet x outlet (mm)	Motor Power (KW)	Pump and motor weight (kg)
1	UHB-ZK40/10-20	5 *10 12	22 20 18	18 28 30	3.00	40*32	3.00	100.00
2	UHB-ZK40/10-30	5 *10 12	32 30 27	18 36 30	3.00	40*32	4.00	105.00
3	UHB-ZK50/20-20	12 *20 25	22 20 17	30 37 40	3.00	50*40	4.00	130.00
4	UHB-ZK50/20-30	12 *20 25	32 30 28	30 36.5 40	3.00	50*40	5.50	150.00
5	UHB-ZK65/30-20	20 *30 35	13 20 18	34 36 40	3.50	65*50	5.50	150.00
6	UHB-ZK65/30-30	20 *30 35	32 30 18	34 37 40	3.50	65*50	7.50	150.00
7	UHB-ZK65/30-50	20 *30 35	52 50 47	30 35.5 38	3.50	65*50	15.00	280.00

Gambar 5. 23 Katalog Pompa Sludge

Gambar 5. 24 Pompa slury pump UHB-ZK50/20-20

8) Pompa Menuju Screw Press

- Kriteria Perencanaan
- K *Elbow* 90° = 0,9
  (Sumber: Dake, J.M.K., Endang P. Tachyan dan Y.P. Pangaribuan, 1985. "Hidrolika Teknik Edisi II". Erlangga. Jakarta)
- K *increaser* = 0,25
- K *check valve* = 2,0
  (*Sumber: Pratical Hydrolics For The Public Work Engineer, 1968)*

- Data Perencanaan

- *Elbow* 90° *suction* = 1 buah ; k = 0,3
- *Elbow* 90° *discharge* = 3 buah ; k = 0,3
- *Check valve* = 1 buah
- Q sludge = 3801,6 kg/hari = 158, 4 L/jam = 0,00004 m3/s
- H suction = 0,33 m
- H discharge = 1,26 m
- H statis = H suction + H discharge
  = 0,33 m + 1,26 m = 1,59 m
- L *suction* = 0,64 m
- L *discharge* = 3,89 m
- Diameter pipa = 5” = 125 mm (pasaran)
- Kecepatan pipa (v) = 0,5 m/s
- Koefisien kekasaran (C)s = 130

- Perhitungan

  - Perhitungan *Suction*

- *Headloss mayor*

$$Hf = \left(\frac{Q}{0{,}2785 \times C \times D^{2,63}}\right)^{1,85} \times L$$

$$Hf = \left(\frac{0{,}00004\ m^3/s}{0{,}2785 \times 130 \times 0{,}125^{2,63}}\right)^{1,85} \times 0{,}64\ m$$

Hf = 1,51 m

Headloss minor (elbow 90°)

$$Hf_{elbow} = n \times k \times \frac{v^2}{2g}$$

$$= 1 \times 0{,}9 \times \frac{0{,}5^2}{2 \times 9{,}81}$$

= 0,011 m

- *Headloss minor (increaser 90°)*

$$Hf_{increaser} = n \times k \times \frac{v^2}{2g}$$

$= 1 \times 0{,}25 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,003 m

ΣHf minor

Hf_{minor} = Hf minor elbow *90°* + Hf minor increaser

= 0,011 m + 0,003 m

= 0,014 m

- ΣHf *suction*

Hfs = Hf mayor + Hf minor

= 1,51 m + 0,014 m

= 1,52 m

○ Perhitungan *Discharge*

- *Headloss mayor*

$$Hf = \left(\frac{Q}{0{,}2785 \times C \times D^{2{,}63}}\right)^{1{,}85} \times L$$

$$Hf = \left(\frac{0{,}0004\ m^3/s}{0{,}2785 \times 130 \times 0{,}125^{2{,}63}}\right)^{1{,}85} \times 3{,}89\ m$$

Hf = 6,51 m

- *Headloss minor*

Hf_{elbow} $= n \times k \times \frac{v^2}{2g}$

$= 3 \times 0{,}9 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,034 m

- *Headloss minor (check valve)*

$Hf_{chcek\ valve}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}2 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,0025 m

- Headloss minor (increaser)

$Hf_{increaser}$ $= n \times k \times \frac{v^2}{2g}$

$= 1 \times 0{,}25 \times \frac{0{,}5^2}{2 \times 9{,}81}$

= 0,003 m

ΣHf minor

Hf_{minor} = Elbow+Hf minor checek valve + Hf minor increaser

= 0,034 m + 0,0025 m + 0,003 m

= 0,039 m

- ΣHf *discharge*

Hfd = Hf mayor + Hf minor

= 6,51 m + 0,039 m

= 6,54 m

○ Perhitungan *head* total (*head* pompa)

- *Head* total = *Head* statis + ΣHf *suction* + ΣHf *discharge*

= 1,52 m + 1,52 m + 6,54 m

= 6,41 m

○ Head statis < Head pompa = 1,52 < 9,58 m

Berdasarkan perencanaan debit (Q) = 158, 4 L/jam dan head pump = 9,58 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa slury pump UHB-ZK150/250-30 dengan spesifikasi pompa sebagai berikut:

Table 2: Light duty pump, 4P motor, Speed=1450RP Design pressure: 1.6MPa

Item	Model	Flow (m3/h)	Head (m)	Effic-iency (%)	NPSHa (m)	Inlet x outlet (mm)	Motor Power (KW)	Pump and motor weight (kg)
19	UHB-ZK150/250-30	120 *250 300	34 30 26	45 55 50	4.00	150*125	45.00	840.00
20	UHB-ZK200/400-25	240 *400 500	28 25 20	55 64 60	5.50	200*150	75.00	1180.00

Gambar 5. 25 Katalog Pompa SLudge

Gambar 5. 26 Pompa slury pump UHB-ZK150/250-30

<u>Resume Mesin *Screw Press*</u>

- Total sludge dari sedimen 1 = 0,0014 kg/hari
- Total sludge dari clarifier = 38,01 kg/hari
- Mesin operasional 18 jam
- Sludge per jam = 2,11 kg/jam
- Mesin screw press = Benenv/MDS302
- Kebutuhan polymer = 0,228 kg polymer/hari
- Dossing pump = Grundfos/ DDA 60-10 AR-PVC/E/C-F-31A7A7B
- Volume bak pelarutan = 30 liter = 0,03 m^3
- Tangki chemical
  - Merek: Satake Mixer Tanks
  - Model Tangki: ZT Series/ZTF-100
  - Kapasitas Tangki: 100 L
- Pengaduk
  - Merek/Model : TMI / F…0401
  - Power : 0,12
  - Diameter : 200 mm = 0,4 m
- Bak penampung sludge
  - H : 0,5 m
  - L : 4 m

- P : 4 m

- Pompa Sludge Menuju Bak Penampung

  Head statis < Head pompa = 6,35 < 6,41 m

  Berdasarkan perencanaan debit (Q) = 158, 4 L/jam dan head pump = 6,41 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa slury pump UHB-ZK150/250-30

- Pompa Sludge menuju Screw Press

  Head statis < Head pompa = 1,52 < 9,58 m

  Berdasarkan perencanaan debit (Q) = 158, 4 L/jam dan head pump = 9,58 m yang telah di plot pada grafik performance centrifugal pump, maka diperoleh pompa slury pump UHB-ZK150/250-30