# BAB X
# TUGAS KHUSUS

## 10.1 Pendahuluan

Industri kimia merupakan industri yang mengolah bahan baku menjadi produk dengan memanfaatkan proses-proses kimia. Ethylene merupakan salah satu produk yang dihasilkan oleh proses kimia. Ethylene dari LNG dibuat dengan menggunakan proses *cracking* (perengkahan) yang terbagi menjadi tiga proses yaitu *hydro cracking , thermal cracking (pyrolysis) ,* dan *catalytic cracking* (panda,2011)

Proses *Thermal cracking* merupakan proses perengkahan dengan cara memanaskan bahan polimer tanpa oksigen. Ethane dan Propane dipanaskan hingga temperature 700C dengan tekanan 3 atm sehingga terjadi proses perengkahan pada senyawa tersebut menghasilkan gas, Ethylene (C2H4) dan Hidrogen (H2) Reaksi perengkahan tersebut dapat dilihat pada persamaan 10.1 dan 10.2

$$C_2H_{6(g)} \longrightarrow C_2H_{4(g)} + H_{2(g)} \qquad (1)$$

$$C_3H_{8(g)} \longrightarrow C_2H_{4(g)} + CH_{4(g)} \qquad (2)$$

Perancangan pabrik Ethylene harus mempertimbangkan ketersediaan lahan dan bahan baku, pemilihan proses dan peralatan yang digunakan serta pemasaran hasil produksi. Tahapan proses produksi Ethylene dari LNG meliputi, tahap persiapan bahan baku, persiapan bahan bakar, perengkahan, pendinginan, dan tahap pemisahan. Sebelum produksi berjalan, langkah awal yang terlebih dahulu dilakukan yaitu membuat rancangan peralatan proses yang digunakan.

## 10.2 Ruang Lingkup Rancangan

Perancangan peralatan proses yang digunakan dalam produksi Ethylene, terdiri atas rancangan reactor, alat transportasi, perancangan alat perpindahan panas dan rancangan alat pemisah. Reactor adalah tempat terjadinya reaksi perengkahan dalam produksi Ethylene, alat transportasi padatan berupa Bucket elevator, alat perpindahan panas meliputi rancangan Cooler serta alat pemisah yaitu Destilasi. Rancangan lengkap peralatan proses dapat dilihat pada sub bab rancangan.

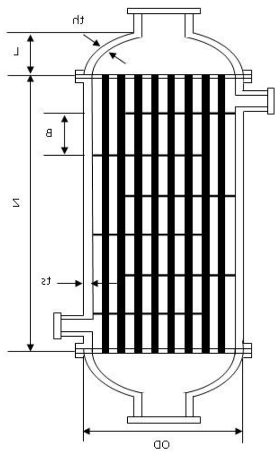
## 10.3 Rancangan

### 10.3.1 Reaktor

Fungsi : sebagai tempat terjadinya reaksi perengkahan Ethane dan Propane

Tipe : silinder vertical dengan alas dan tutup elipsoidal

Bahan : Hight alloy steels (SA-240 Grade 304, 18 CR-8 Ni)



Gambar 10.1 reaktor

Data :

- Laju alir massa : 223740.059 kg/jam = 7E+06 kmol/jam
- Densitas : 960.67 kg/m3
- Temperature : 700 C
- Tekanan : 3 atm = 44.088 psi
- Waktu operasi : 30 detik

| | | | | |
|---|---|---|---|---|
| **laju alir massa umpan, mb :** | **223691.7284** | **kg/jam** | **6772999** | **kmol/jam** |
| laju alir volumetrik umpan, Vb = | m | = | 232.8497 | m3/jam |
| | densitas | = | 3.881667 | m3/min |
| | | = | 0.064694 | m3/s |
| konsentrasi umpan, Cao = | mb | = | 29087.43 | kmol/m3 |
| | vb | | | |

| | | | | |
|---|---|---|---|---|
| **volume reaktor, Vr :** | 6985.491223 | m3 | | |
| | 20% | | | |
| maka Vr = | 8731.864029 | m3 | 2306697 | Gallon |

Diasumsikan aliran dalam reaktor adalah aliran *plug flow*, maka volume reaktor dapat dihitung dengan menggunakan persamaan sebagai berikut:

$$\frac{V_R}{F_{AO}} = \frac{\tau}{C_{AO}} \qquad (Levenspiel\ hal\ 194)$$

$V_R$ = Volume reaktor

$F_{AO}$ = Laju alir molar reaktan

$C_{AO}$ = Konsentrasi reaktan

Maka,

$$V_R = \frac{F_{AO}\ x\ \tau}{C_{AO}}$$

Dimensi reactor .

Reactor berbentuk silinder vertical dengan alas dan tutup berbentuk ellipsoidal

Volume silinder Vs = $V_s = \frac{\pi}{4}\ x\ D_t^2\ x\ H_s \qquad H_s = 1.5\ D_t$

Vs = $\frac{\pi}{4}\ x\ 1.5\ D_t^3$

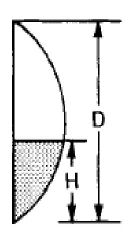
Volume head, Ve = $0{,}1308\ D_t^3 \qquad H_e = 1/4\ D_t$

Hemispherical head

$S = 1.571 D^2$
$V = (\pi/3)H^2(1.5D - H)$
$V_0 = (\pi/12)D^3$
$V/V_0 = 2(H/D)^2(1.5 - H/D)$

Ellipsoidal head ($h = D/4$)

$S = 1.09D^2$
$V_0 = 0.1309D^3$
$V/V_0 = 2(H/D)^2(1.5 - H/D)$



| | | |
|---|---|---|
| diameter reaktor Dt = | | |
| Vr = | Vs + 2 Ve | |
| Vr = | 1,4404 *Dt^3 | |
| Dt^3 = | Vr / 1.4404 | |
| Dt^3 = | 6062.110545 | |
| Dt = | 18.23369211 | m |
| | 59.82109709 | ft |
| | 717.8604585 | in |

| Nominal pipe size, in. | Outside diameter, in. | Schedule no. | Wall thickness, in. | Inside diameter, in. | Cross-sectional area of metal, in.$^2$ | Inside sectional area, ft$^2$ | Circumference, ft or surface, ft$^2$/ft of length: Outside | Circumference, ft or surface, ft$^2$/ft of length: Inside | Capacity at 1 ft/s velocity: U.S. gal/min | Capacity at 1 ft/s velocity: Water, lb/h | Pipe weight lb/ft |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\frac{1}{8}$ | 0.405 | 40 | 0.068 | 0.269 | 0.072 | 0.00040 | 0.106 | 0.0705 | 0.179 | 89.5 | 0.24 |
| | | 80 | 0.095 | 0.215 | 0.093 | 0.00025 | 0.106 | 0.0563 | 0.113 | 56.5 | 0.31 |
| $\frac{1}{4}$ | 0.540 | 40 | 0.088 | 0.364 | 0.125 | 0.00072 | 0.141 | 0.095 | 0.323 | 161.5 | 0.42 |
| | | 80 | 0.119 | 0.302 | 0.157 | 0.00050 | 0.141 | 0.079 | 0.224 | 112.0 | 0.54 |
| $\frac{3}{8}$ | 0.675 | 40 | 0.091 | 0.493 | 0.167 | 0.00133 | 0.177 | 0.129 | 0.596 | 298.0 | 0.57 |
| | | 80 | 0.126 | 0.423 | 0.217 | 0.00098 | 0.177 | 0.111 | 0.440 | 220.0 | 0.74 |
| $\frac{1}{2}$ | 0.840 | 40 | 0.109 | 0.622 | 0.250 | 0.00211 | 0.220 | 0.163 | 0.945 | 472.0 | 0.85 |
| | | 80 | 0.147 | 0.546 | 0.320 | 0.00163 | 0.220 | 0.143 | 0.730 | 365.0 | 1.09 |
| $\frac{3}{4}$ | 1.050 | 40 | 0.113 | 0.824 | 0.333 | 0.00371 | 0.275 | 0.216 | 1.665 | 832.5 | 1.13 |
| | | 80 | 0.154 | 0.742 | 0.433 | 0.00300 | 0.275 | 0.194 | 1.345 | 672.5 | 1.47 |
| 1 | 1.315 | 40 | 0.133 | 1.049 | 0.494 | 0.00600 | 0.344 | 0.275 | 2.690 | 1,345 | 1.68 |
| | | 80 | 0.179 | 0.957 | 0.639 | 0.00499 | 0.344 | 0.250 | 2.240 | 1,120 | 2.17 |
| $1\frac{1}{4}$ | 1.660 | 40 | 0.140 | 1.380 | 0.668 | 0.01040 | 0.435 | 0.361 | 4.57 | 2,285 | 2.27 |
| | | 80 | 0.191 | 1.278 | 0.881 | 0.00891 | 0.435 | 0.335 | 3.99 | 1,995 | 3.00 |
| $1\frac{1}{2}$ | 1.900 | 40 | 0.145 | 1.610 | 0.800 | 0.01414 | 0.497 | 0.421 | 6.34 | 3,170 | 2.72 |
| | | 80 | 0.200 | 1.500 | 1.069 | 0.01225 | 0.497 | 0.393 | 5.49 | 2,745 | 3.63 |

*(Continued)*

| | | | | | |
|---|---|---|---|---|---|
| tinggi reaktor, Hr = | Hs + 2He | | | | |
| tinggi silinder, Hs = 1,5 Dt | 27.35053817 | m | tinggi head, He = 0,25Dt | 4.558423 | m |
| | 89.73164563 | ft | | 14.95527 | ft |
| | 1076.790688 | in | | 179.4651 | in |
| tinggi reaktor, Hr = | 36.46738423 | m | | | |
| | 119.6421942 | ft | | | |
| | 1435.720917 | in | | | |

tebal dinding silinder, ts = $\dfrac{PR}{SE - 0{,}6P} + C$

| | | |
|---|---|---|
| P d = | 42.6 | psi |
| R = | 158.32 | in |
| S = | 10.332 | psi |
| E = | 0.85 | |
| C = | 0.002 | in/thn |
| n = | 10 | tahun |

| | | |
|---|---|---|
| ts = | 742.4261133 | in |
| | 18.85766099 | m |

tebal head, te = $t_e = \dfrac{PD_t}{2SE - 0{,}2P} + C$

| | | |
|---|---|---|
| = | 745.7225342 | in |
| | 18.94139025 | m |
| | 18941.39025 | mm |
| diameter tube, Du = | 0,0035 * Dt | |
| Du = | 0.063817922 | m |
| | 2.512511605 | in |

maka dipilih tube ukuran :

| | | | | |
|---|---|---|---|---|
| NPS : | 1 | in | 0.375 | |
| Sch No : | 40 | | | |
| OD : | 1.315 | in | | |
| ID : | 1.049 | in | 0.026645 | m |
| a" : | 0.494 | in2 | | |

UD : 150 Btu/jam ft2

L : 18.23369211

X : 139.04

Luas area A : 8.226529167 m2

| | | | | |
|---|---|---|---|---|
| dipilih tinggi tube standar | 10 | ft | 3.048037 | m |
| maka Z = 80% dt tinggi tube : | 8 | ft | 2.43843 | m |

jumlah tube, Nt : $\frac{139.04}{2.438429651}$

Nt = 57.020304 buah = 57 buah tube

mendesain tube

| | | |
|---|---|---|
| panas air pendingin, Q = | 410071690 | kj/jam |
| Asumsi $U_D$ = | 15 - 75 Btu/hr Ft$^2$ $^0$F | ( Tabel 8, D.Q Kern ) |
| UD = | 70 | BTU/hr ft2 F |
| Zc = | 2.438429651 | m |
| panjang pipa(tube), L = | 3.048037064 | m |
| luas penampang, a" = | 0.494 | in 2 |

susunan pipa trianguler

tebal pipa = $\frac{(OD-ID)}{2}$

t p = 0.133 In

pitch,Pt = 1,25 x OD

pitch,Pt = 1.64375 in

clearance, C = Pt- OD

C= 0.32875 in

Shell

diameter shell = diameter reaktor = 18.23369 m 169.9004866 13.03459

jarak buffle,B = Dshell *0,3

B = 5.4701076634 m

215.3581376 in

area peerpan dlm shell = $\frac{(P_t - OD) \times ID_s \times B}{P_t}$

A = 1.042918519 in2

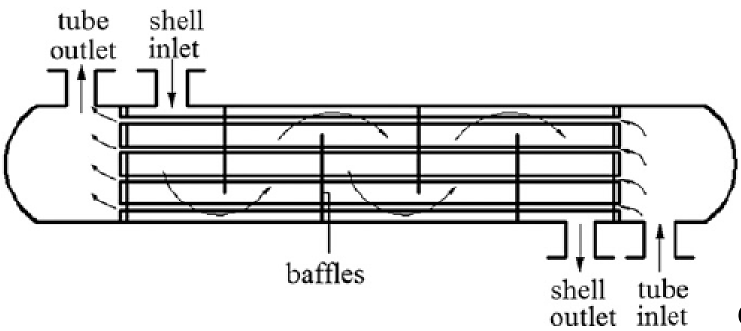
**10.3.2 Cooler**

Fungsi : Mendingikan air proses yang di alirkan ke mixer

Tipe : *Sheel and Tube Heat Exchanger*

Jumlah : 1 unit

Bahan Kontruksi : *Carbon steel*




Gambar 10.2 Cooler

**1. Data**

| | | | | |
|---|---|---|---|---|
| Fluida Panas | $C_2H_4$, $CH_4$ , $H_2$ | | | |
| Laju alir massa masuk | 223691.7 | kg/jam | 493150.785 | lb/jam |
| Temperatur masuk (T1) | 700 | c | 1292 | F |
| Temperatur keluar (T2) | 500 | c | 932 | F |
| | | | | |
| Fluida Dingin | *Cooling water* | | | |
| Laju alir massa masuk | 470241303.75 | kg/jam | 1036693978 | lb/jam |
| Temperatur masuk (t1) | 25 | c | 77 | F |
| Temperatur keluar (t2) | 100 | c | 212 | F |

**2. LMTD (*Log Mean Temperature Difference*)**

| Fluida Panas (F) | Temperatur | Fluida Dingin (F) | Selisih | |
|---|---|---|---|---|
| 1292 | Tinggi | 212 | 1080 | ΔT2 |
| 932 | Rendah | 77 | 855 | ΔT1 |

$$LMTD = (\Delta T2 - \Delta T1) / \ln(\frac{\Delta T2}{\Delta T1})$$

LMTD = 963.1237007

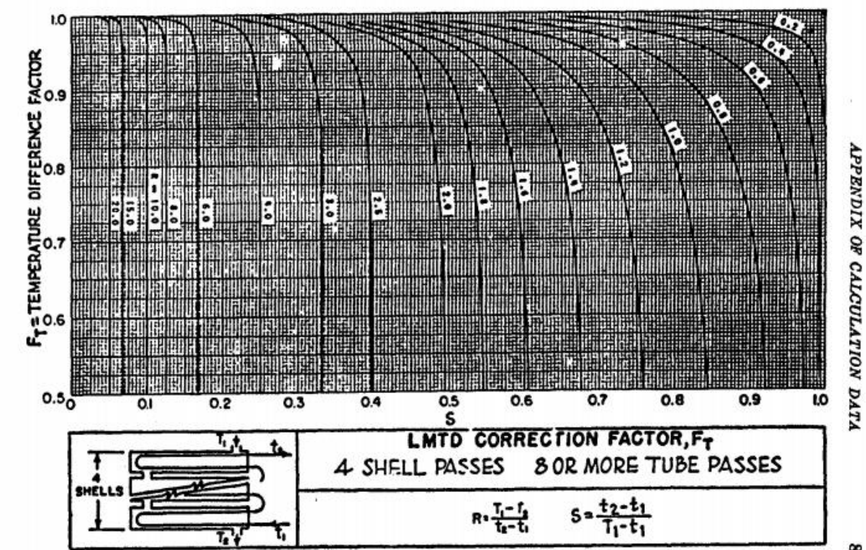



FIG. 21. LMTD correction factors for 4-8 exchangers. (*Standards of Tubular Exchanger Manufacturers Association*, 2d ed., New York, 1949.)

Faktor koreksi LMTD

$$R = \frac{T1 - T2}{t2 - t1}$$

2.666666667

$$S = \frac{t2 - t1}{T1 - t1}$$

0.111111111

Maka dari gambar 21 D.K. QERN didapatkam faktor koreksi adalah sebagai berikut:

$$ft =$$

1.5

Temperatur kalorik (Tc dan tc)

$$T_c = \frac{T_1 + T_2}{2}$$

$$t_c = \frac{t_1 + t_2}{2}$$

Tc = 1112 F

tc = 144.5 F

$$\Delta T_{LMTD} = ft x LMTD$$

ΔT LMTD = 1444.685551 F

TABLE 8. APPROXIMATE OVERALL DESIGN COEFFICIENTS
Values include total dirt factors of 0.003 and allowable pressure drops of 5 to 10 psi on the controlling stream
Coolers

| Hot fluid | Cold fluid | Overall $U_D$ |
|---|---|---|
| Water | Water | 250–500§ |
| Methanol | Water | 250–500§ |
| Ammonia | Water | 250–500§ |
| Aqueous solutions | Water | 250–500§ |
| Light organics* | Water | 75–150 |
| Medium organics† | Water | 50–125 |
| Heavy organics‡ | Water | 5–75‖ |
| Gases | Water | 2–50¶ |
| Water | Brine | 100–200 |
| Light organics | Brine | 40–100 |

## 3. Menentukan luas area perpindahan panas (A)

$$A = \frac{Q}{U_d x \Delta T_{LMTD}}$$

Dari tabel 8 D.Q. KERN maka didapatkan koefisien perpindahan panas sebesar:

| | | | | |
|---|---|---|---|---|
| Ud = | 150 | Btu/jam ft^2 F | | |
| Q = | 470241303.75 | kkal/jam | 1865917493 | Btu/jam |
| A = | 8610.48963 | ft^2 | | |

nilai A > 200 $ft^2$ maka tipe *heat excanger* yang digunakan adalah *Shell and Tube*. (DQ Kern Hal - 103)

## 4. Spesifikasi Shell and Tube

HE dirancang dengan menggunakan tube 1 in dengan 15 ft, maka dari tabel 10 D.Q.KERN diperoleh data sebagai berikut:

| OD (in) | A" ($ft^2$) | BWG | L (ft) |
|---|---|---|---|
| 1.9 | 0.422 | 18 | 25 |

## 5. Menentukan Jumlah Tube

$$Nt = \frac{A}{Lxa''}$$

Nt = 816.1601545
817 buah

Dari tabel 9 D.Q.KERN, untuk jumlah tube didapatkan spesifikasi perangcangan HE sebagai berikut:

842 *PROCESS HEA*

TABLE 9. TUBE-SHEET LAYOUT
Triangul

| ¾ in. OD tubes on 15⁄16-in. triangular pitch | | | | | |
|---|---|---|---|---|---|
| Shell ID, in. | 1-P | 2-P | 4-P | 6-P | 8-P |
| 8 | 36 | 32 | 26 | 24 | 18 |
| 10 | 62 | 56 | 47 | 42 | 36 |
| 12 | 109 | 98 | 86 | 82 | 78 |
| 13¼ | 127 | 114 | 96 | 90 | 86 |
| 15¼ | 170 | 160 | 140 | 136 | 128 |
| 17¼ | 239 | 224 | 194 | 188 | 178 |
| 19¼ | 301 | 282 | 252 | 244 | 234 |
| 21¼ | 361 | 342 | 314 | 306 | 290 |
| 23¼ | 442 | 420 | 386 | 378 | 364 |
| 25 | 532 | 506 | 468 | 446 | 434 |
| 27 | 637 | 602 | 550 | 536 | 524 |
| 29 | 721 | 692 | 640 | 620 | 594 |
| 31 | 847 | 822 | 766 | 722 | 720 |
| 33 | 974 | 938 | 878 | 852 | 826 |
| 35 | 1102 | 1068 | 1004 | 988 | 958 |
| 37 | 1240 | 1200 | 1144 | 1104 | 1072 |
| 39 | 1377 | 1330 | 1258 | 1248 | 1212 |

| ***Shell side*** | | ***Tube side (Tabel.10 DQ kern)*** | |
|---|---|---|---|
| Diameter dalam (ID) | 25 | Diameter dalam (ID) in | 1.4 |
| Baffle space (B)=0,4xID | 10 | Diameter luar (OD) in | 1.5 |
| Passes (n) | 6 | BWG | 18 |
| | | Pitch (Pt) | 1.75 |
| | | Passes (n) | 6 |
| | | Panjang (ft) | 25 |
| | | Panjang (m) | 7.62195122 |
| | | Jumlah Tube (N) | 817 |

| 1 in. OD tubes on 1¼-in. triangular pitch | | | | | |
|---|---|---|---|---|---|
| 8 | 21 | 16 | 16 | 14 | |
| 10 | 32 | 32 | 26 | 24 | |
| 12 | 55 | 52 | 48 | 46 | 44 |
| 13¼ | 68 | 66 | 58 | 54 | 50 |
| 15¼ | 91 | 86 | 80 | 74 | 72 |
| 17¼ | 131 | 118 | 106 | 104 | 94 |
| 19¼ | 163 | 152 | 140 | 136 | 128 |
| 21¼ | 199 | 188 | 170 | 164 | 160 |
| 23¼ | 241 | 232 | 212 | 212 | 202 |
| 25 | 294 | 282 | 256 | 252 | 242 |
| 27 | 349 | 334 | 302 | 296 | 286 |
| 29 | 397 | 376 | 338 | 334 | 316 |
| 31 | 472 | 454 | 430 | 424 | 400 |
| 33 | 538 | 522 | 486 | 470 | 454 |
| 35 | 608 | 592 | 562 | 546 | 532 |
| 37 | 674 | 664 | 632 | 614 | 598 |
| 39 | 766 | 736 | 700 | 688 | 672 |

| 1¼ in. OD tubes on 19⁄16-in. triangular pitch | | | | | |
|---|---|---|---|---|---|
| 10 | 20 | 18 | 14 | | |
| 12 | 32 | 30 | 26 | 22 | 20 |
| 13¼ | 38 | 36 | 32 | 28 | 26 |
| 15¼ | 54 | 51 | 45 | 42 | 38 |
| 17¼ | 69 | 66 | 62 | 58 | 54 |
| 19¼ | 95 | 91 | 86 | 78 | 69 |
| 21¼ | 117 | 112 | 105 | 101 | 95 |
| 23¼ | 140 | 136 | 130 | 123 | 117 |
| 25 | 170 | 164 | 155 | 150 | 140 |
| 27 | 202 | 196 | 185 | 179 | 170 |
| 29 | 235 | 228 | 217 | 212 | 202 |
| 31 | 275 | 270 | 255 | 245 | 235 |
| 33 | 315 | 305 | 297 | 288 | 275 |
| 35 | 357 | 348 | 335 | 327 | 315 |
| 37 | 407 | 390 | 380 | 374 | 357 |
| 39 | 449 | 436 | 425 | 419 | 407 |

**Shell, Fluida Dingin**

6. Flow Area

| | | |
|---|---|---|
| B = | 6 1/9 | in |
| Clearence (C')=Pt-OD | 0.25 | in |

$$as = \frac{\pi\left(D_2^2 - D_1^2\right)}{4}$$

| | | |
|---|---|---|
| **α ' shell =** | 0.129201389 | ft^2 |

7. Mass Velocity

$$g_s = \frac{W}{a_s}$$

| | | |
|---|---|---|
| W | 470241303.75 | kg/jam |
| | 1036693978 | lb/jam |
| **α ' shell =** | 0.129201389 | ft^2 |
| Gs = | 8023860944 | lb/ft^2 jam |

8. Bilangan Reynold

| | | |
|---|---|---|
| Pt^2 = | 1.5625 | in^2 |

$$D_s = 4\left(\frac{P_t^2 - \pi.\frac{OD^2}{4}}{\pi.OD}\right)$$

| | | |
|---|---|---|
| = | 1 | in^2 |
| Ds = | 0.99044586 | in |
| | 0.08250414 | ft |

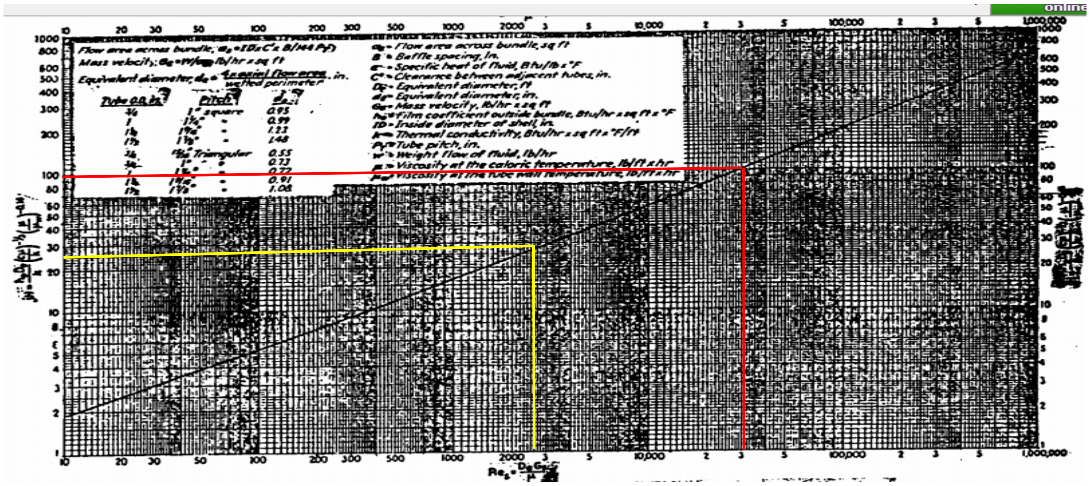
$$\text{Re}_s = \left(\frac{Ds.Gs}{\mu}\right)$$

| | | |
|---|---|---|
| ı = | 1 | Cp |
| | 2.4191 | lb/ft.h |
| Re s = | 273656214.2 | |

9. Nilai Jh

Dari gambar 24 D.Q.KERN maka didapatkan nilai Jh sebagai berikut:

| | |
|---|---|
| Re s = | 273656214.2 |
| Jh = | 25 |



10. Tc

$$\left(Cp\ \frac{\mu}{k}\right)^{1/3}$$

| | | | | |
|---|---|---|---|---|
| Tc= | 240.8 | F | | |
| Cp = | 0.9 | btu/lb F | *Fig 2 Hal 804* | |

| T (F) | k (btu/jam ft F) |
|---|---|
| 32 | 0.93 |
| 240.8 | x |
| 86 | 0.356 |

x = -1.289466667

*Table 4 Hal 801*

$$\left(Cp\ \frac{\mu}{k}\right)^{1/3} = -1.289466667 \text{ btu/jam ft F}$$

**-0.562814083**

11. Pencarian ho

$$h_0 = Jh.\frac{k}{D_s}.\left(Cp\ \frac{\mu}{k}\right)^{1/3}$$

h0 = 219.9071461 btu/jam ft^2

12. Clean overall coefficient, Uc

$$U_c = \frac{h_{io} x h_o}{h_{io} + h_o}$$

Uc = 178.5227036 btu/jam F

13. Faktor Pengotor, Rd

$$R_D = \frac{U_C - U_D}{U_C \; x \; U_D}$$

Rd = -0.001601528

14. Pressure Drop pada Shell

| | | |
|---|---|---|
| Re s = | 273656214.2 | |
| f = | 0.0016 | DARI FIG 29 hal 389 |
| S = | 1 | *Fig 6 Hal 809* |
| Ds = | 0.08250414 | ft |
| Gs = | 8023860944 | lb/ft^2 jam |
| Gs^2 = | 6.43823E+19 | |

TEMPERATUR DINDING

| | | |
|---|---|---|
| hio = | 948.627451 | btu/jam F |
| ho = | 219.9071461 | btu/jam ft^2 |
| Tc = | 240.8 | F |
| tc = | 108.5 | F |

| | | |
|---|---|---|
| Øs = | 1 | lb/ft h |

$$N + 1 = N + \frac{L}{B}$$

| | | |
|---|---|---|
| N = | 8 | |
| L = | 4.573170732 | m |
| B = | 6.1 | |

$$N + 1 = N + \frac{L}{B}$$

8.74970012

Maka;

$$\Delta P_s = \frac{f.G_s^2.D_s.(N+1)}{5{,}22.10^{10}.D_s.\phi_s}$$

ΔPs = 17266703.66 psi

Pressure drop kecil dari 2 psi, maka spesifikasi dapat diterima

*APPENDIX OF CALCULATION DATA* 843

TABLE 10. HEAT EXCHANGER AND CONDENSER TUBE DATA

| Tube OD, in. | BWG | Wall thickness, in. | ID, in. | Flow area per tube, in.² | Surface per lin ft, ft² | | Weight per lin ft, lb steel |
|---|---|---|---|---|---|---|---|
| | | | | | Outside | Inside | |
| ½ | 12 | 0.109 | 0.282 | 0.0625 | 0.1309 | 0.0748 | 0.493 |
| | 14 | 0.083 | 0.334 | 0.0876 | | 0.0874 | 0.403 |
| | 16 | 0.065 | 0.370 | 0.1076 | | 0.0969 | 0.329 |
| | 18 | 0.049 | 0.402 | 0.127 | | 0.1052 | 0.258 |
| | 20 | 0.035 | 0.430 | 0.145 | | 0.1125 | 0.190 |
| ¾ | 10 | 0.134 | 0.482 | 0.182 | 0.1963 | 0.1263 | 0.965 |
| | 11 | 0.120 | 0.510 | 0.204 | | 0.1335 | 0.884 |
| | 12 | 0.109 | 0.532 | 0.223 | | 0.1393 | 0.817 |
| | 13 | 0.095 | 0.560 | 0.247 | | 0.1466 | 0.727 |
| | 14 | 0.083 | 0.584 | 0.268 | | 0.1529 | 0.647 |
| | 15 | 0.072 | 0.606 | 0.289 | | 0.1587 | 0.571 |
| | 16 | 0.065 | 0.620 | 0.302 | | 0.1623 | 0.520 |
| | 17 | 0.058 | 0.634 | 0.314 | | 0.1660 | 0.469 |
| | 18 | 0.049 | 0.652 | 0.334 | | 0.1707 | 0.401 |
| 1 | 8 | 0.165 | 0.670 | 0.355 | 0.2618 | 0.1754 | 1.61 |
| | 9 | 0.148 | 0.704 | 0.389 | | 0.1843 | 1.47 |
| | 10 | 0.134 | 0.732 | 0.421 | | 0.1916 | 1.36 |
| | 11 | 0.120 | 0.760 | 0.455 | | 0.1990 | 1.23 |
| | 12 | 0.109 | 0.782 | 0.479 | | 0.2048 | 1.14 |
| | 13 | 0.095 | 0.810 | 0.515 | | 0.2121 | 1.00 |
| | 14 | 0.083 | 0.834 | 0.546 | | 0.2183 | 0.890 |
| | 15 | 0.072 | 0.856 | 0.576 | | 0.2241 | 0.781 |
| | 16 | 0.065 | 0.870 | 0.594 | | 0.2277 | 0.710 |
| | 17 | 0.058 | 0.884 | 0.613 | | 0.2314 | 0.639 |
| | 18 | 0.049 | 0.902 | 0.639 | | 0.2361 | 0.545 |
| 1¼ | 8 | 0.165 | 0.920 | 0.665 | 0.3271 | 0.2409 | 2.09 |
| | 9 | 0.148 | 0.954 | 0.714 | | 0.2498 | 1.91 |
| | 10 | 0.134 | 0.982 | 0.757 | | 0.2572 | 1.75 |
| | 11 | 0.120 | 1.01 | 0.800 | | 0.2644 | 1.58 |
| | 12 | 0.109 | 1.03 | 0.836 | | 0.2701 | 1.45 |
| | 13 | 0.095 | 1.06 | 0.884 | | 0.2775 | 1.28 |
| | 14 | 0.083 | 1.08 | 0.923 | | 0.2839 | 1.13 |
| | 15 | 0.072 | 1.11 | 0.960 | | 0.2896 | 0.991 |
| | 16 | 0.065 | 1.12 | 0.985 | | 0.2932 | 0.900 |
| | 17 | 0.058 | 1.13 | 1.01 | | 0.2969 | 0.808 |
| | 18 | 0.049 | 1.15 | 1.04 | | 0.3015 | 0.688 |

**Tube, Fluida Panas**

6. Flow Area

$$a_t = \frac{N \cdot a_t'}{144 \cdot n}$$

0.594 in^2

at = 0.0391875 ft^2

0.785

7. Mass Velocity

W 223691.7 kg/jam

493150.7845 lb/jam

$$g_t = \frac{W}{a_t}$$

0.0391875 ft^2

gt = 12584390.04 lb/ft^2 jam

8. Bilangan Reynold

Dt = 0.87 in

0.072471 ft

μ = 1 Cp

2.419 lb/ft.h

$$\text{Re}_t = \left(\frac{Dt.Gt}{\mu}\right)$$

Re t = 377016.6723

9. Nilai Jh

Dari gambar 24 D.Q.KERN maka didapatkan nilai Jh sebagai berikut:

Re t = 377016.6723

Jh = 98

804 *PROCESS HEAT TRANSFER*

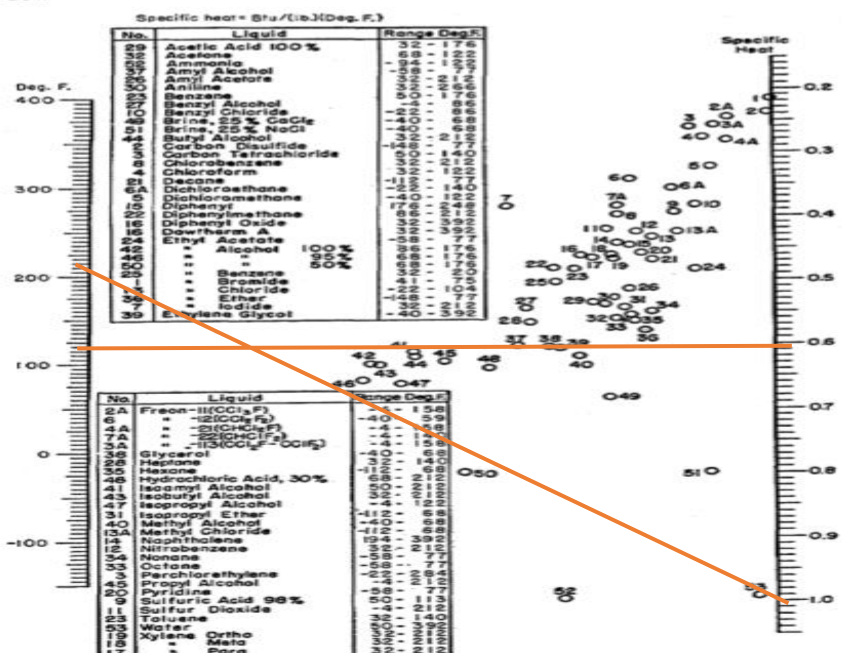



Fig. 2. Specific heats of liquids. (*Chilton, Colburn, and Vernon, based mainly on data from International Critical Tables. Perry, "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Book Company, Inc., New York,* 1950.)

10. Tc

$$\left( Cp \; \frac{\mu}{k} \right)^{1/3}$$

Tc= 108.5 F

Cp = 1 btu/lb F *Fig 2 Hal 804*

| T (F) | k (btu/jam ft F) |
|---|---|
| 32 | 0.93 |
| 108.5 | x |
| 86 | 0.356 |

x = 0.116833333

$$\left( Cp \; \frac{\mu}{k} \right)^{1/3}$$ 0.116833333 btu/jam ft F

**6.901569187**

11. Pencarian hi

$$h_i = Jh.\frac{k}{D_t}.\left(Cp\frac{\mu}{k}\right)^{0,3}$$

hi = 1090.37638 btu/jam ft^2

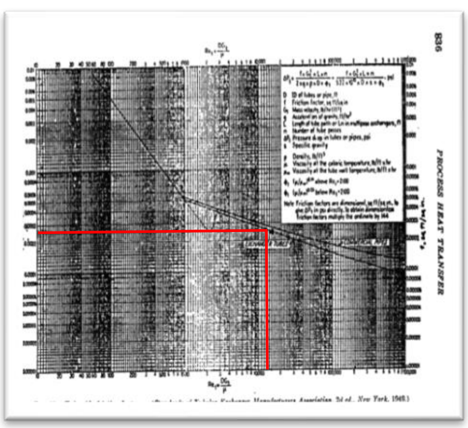
Koreksi hio ke permukaan OD

$$h_{i0} = h_i x \frac{ID}{OD}$$

hio = 948.627451 btu/jam F

14. Pressure Drop pada Tube

| | | |
|---|---|---|
| Re t = | 377016.6723 | |
| f = | 0.00025 | DARI FIG 29 hal 386 |
| S = | 1 | *Fig 6 Hal 809* |
| Dt = | 0.072471 | ft |
| Gt = | 12584390.04 | lb/ft^2 jam |
| Gt^2 = | 1.58367E+14 | lb/ft^2 jam |
| n = | 4 | |
| L = | 15 | ft |
| µ = | 2.419 | lb/ft h |



Øt = 1 lb/ft h

Maka;

$$\Delta P_t = \frac{f.G_s^2.L.n}{5{,}22.10^{10}.D_t.s.\phi_t}$$

ΔPt = 627.9438949 psi

Gt = 12584390.04 lb/ft^2 jam

dari FIG 27 hal 837 diperoleh

$$\frac{V^2}{2g}$$ 0.028

$$\Delta P_r = \frac{4n}{s} x \frac{V^2}{2g}$$

ΔPr = 0.448 psi

$$\Delta P_f = \Delta P_t + \Delta P_r$$ 628.3918949 psi

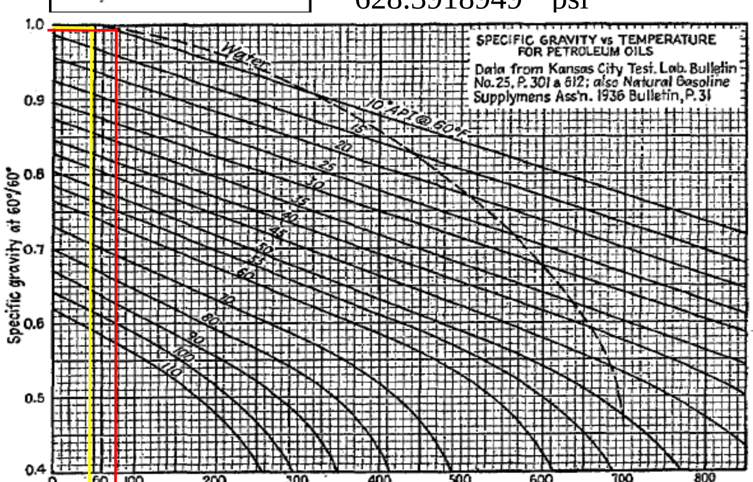



FIG. 6. Specific gravities of hydrocarbons.

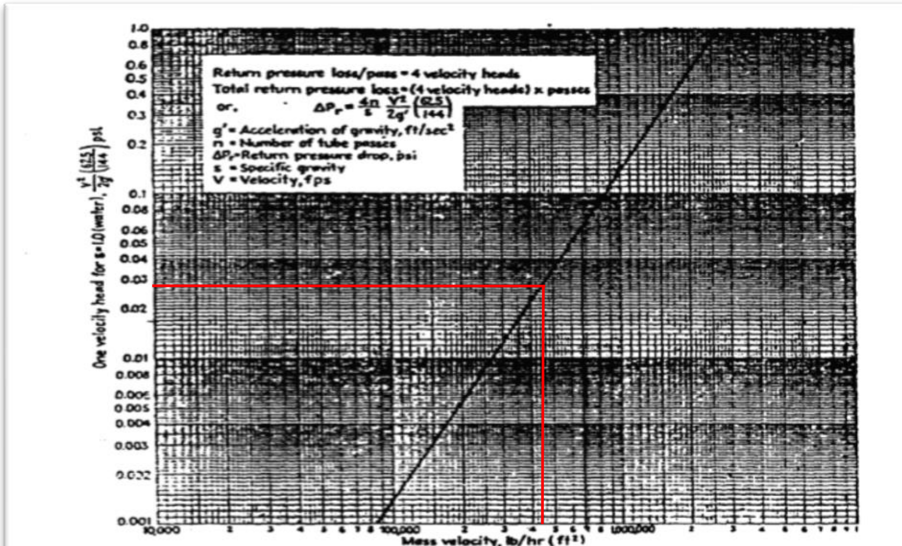
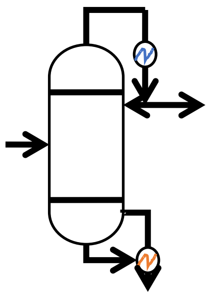



FIG. 27. Tube-side return pressure loss.

### 10.3.3 Distilasi $H_2$



umpan masuk

| komponen | BM | Massa (kg/jam) | Mol (kmol/jam) | % berat | % mol | Densitas (kg/m³) | x/bm | Viskositas (Cp) | x/μ | $\mu_{mix}$ (Cp) | Bm camp (kg/kmol) | densitas |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CH4 | 16.04 | 0.00 | 3.56731E-29 | 0.000 | 0.000 | 117.114 | 5.E-34 | 0.806 | 9.E-33 | | | 0.00 |
| C2H6 | 30.09 | 0.00 | 0.00 | 0.000 | 0.000 | 325.163 | 4.E-24 | 0.907 | 1.E-22 | | | 0.00 |
| C3H8 | 44.11 | 145.01 | 3.29 | 0.002 | 0.000 | 491.302 | 4.E-05 | 0.829 | 2.E-03 | 0.65 | 2.05 | 0.04 |
| C2H4 | 28.06 | 1243.55 | 44.32 | 0.016 | 0.001 | 369.143 | 6.E-04 | 0.854 | 2.E-02 | | | 0.44 |
| H2 | 2.02 | 75769.45 | 37509.63 | 0.982 | 0.999 | 395.641 | 5.E-01 | 0.652 | 2.E+00 | | | 395.14 |
| | | | | | | | | | | | | 0.00 |
| SUB TOTAL | | 77158.01 | 37557.23 | 1 | 1 | | 5.E-01 | | 2.E+00 | | | 395.62 |

**Distilat**

| komponen | BM | Massa (kg/jam) | Mol (kmol/jam) | % berat | % mol | Densitas (kg/m³) | x/bm | Viskositas (Cp) | x/μ | $\mu_{mix}$ (Cp) | Bm camp (kg/kmol) | densitas |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CH4 | 16.04 | 0.0 | 0.0 | 0.0 | 0.0 | 117.1 | 0.0 | 0.8 | 0.0 | 0.7 | 2.0 | 0.0 |
| C2H6 | 30.09 | 0.0 | 0.0 | 0.0 | 0.0 | 325.2 | 0.0 | 0.9 | 0.0 | | | 0.0 |
| C3H8 | 44.11 | 0.1 | 0.0 | 0.0 | 0.0 | 491.3 | 0.0 | 0.8 | 0.0 | | | 0.0 |
| C2H4 | 28.06 | 39.0 | 1.4 | 0.0 | 0.0 | 369.1 | 0.0 | 0.9 | 0.0 | | | 0.0 |
| H2 | 2.02 | 75018.5 | 37137.9 | 1.0 | 1.0 | 395.6 | 0.5 | 0.7 | 1.5 | | | 395.6 |
| | | | | | | | | | | | | 0.0 |
| SUB TOTAL | | 75057.6 | 37139.3 | 1.0 | 1.0 | | 0.5 | | 1.5 | | | 395.6 |

**Bottom**

| komponen | BM | Massa (kg/jam) | Mol (kmol/jam) | % berat | % mol | Densitas (kg/m$^3$) | x/bm | Viskositas (Cp) | x/μ | $\mu_{mix}$ (Cp) | Bm camp (kg/kmol) | densitas |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CH4 | 16.04 | 0.0 | 0.0 | 0.0 | 0.0 | 117.1 | 0.0 | 0.8 | 0.0 | 0.8 | 5.0 | 0.0 |
| C2H6 | 30.09 | 0.0 | 0.0 | 0.0 | 0.0 | 325.2 | 0.0 | 0.9 | 0.0 | | | 0.0 |
| C3H8 | 44.11 | 145.0 | 3.3 | 0.1 | 0.0 | 491.3 | 0.0 | 0.8 | 0.1 | | | 3.9 |
| C2H4 | 28.06 | 1204.5 | 42.9 | 0.6 | 0.1 | 369.1 | 0.0 | 0.9 | 0.7 | | | 37.9 |
| H2 | 2.02 | 750.9 | 371.8 | 0.4 | 0.9 | 395.6 | 0.2 | 0.7 | 0.5 | | | 351.9 |
| SUB TOTAL | | 2100.4 | 418.0 | 1.0 | 1.0 | | 0.2 | | 1.3 | | | 393.7 |

MAKA

F = 37557.2 Kmol/jam

D = 37139.3 Kmol/jam

R = 1.44

Ln = R x D

L n = 53468.1 kmol/jam

L = 108058

Vn = Ln + D

Vn = 90607.4 kmol/jam

Lm = Ln + F　　　Vm = Lm – B

Lm = 91025.3 kmol/jam　　　Vm = 90607.4

L = 457430

F = D + B

B = F – D

B = 417.963 kmol/jam

rectifying

P = 1 atm

R = 0.082 m3.atm/kmol.K

T = 469.15 K

stripping

P = 1 atm

R = 0.082 m3.atm/kmol.K

T = 533.15 K

perkiraan
D kolom

V = 183115 KG/jam

168098,79 lb/jam

V = 455329 KG/jam

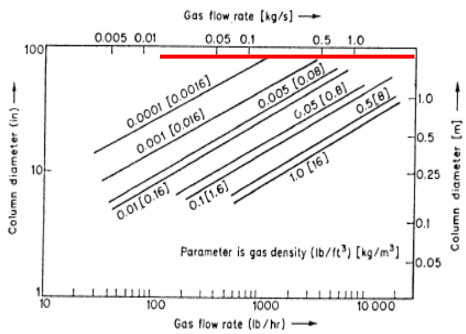



FIGURE 4–1. Estimation of column diameter[9]

Diameter asumsi 2.2 m

T kolom = 228 C

$\alpha_{avg}$ = 0.46522

$\mu_{camp}$ = 0.65

$\alpha_{avg} \times \mu_{camp}$ = 0.30461

Efesiensi (η) = Eo = 32%

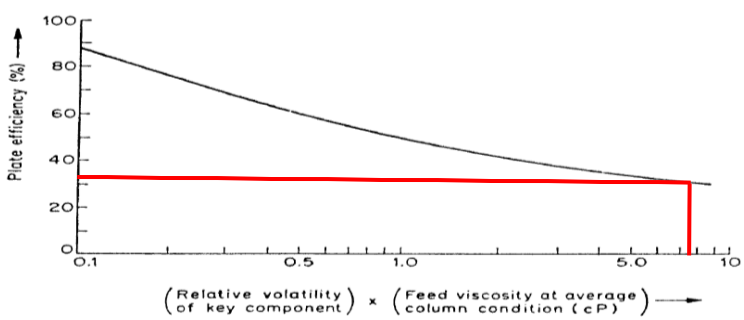



FIGURE 4–9. The efficiency correlation of O'Connell[39]

PLATE ACTUAL, Nact

s = 1 dr neraca massa

$$N_{act} = \frac{s}{Eo}$$

Nact = 3.125

feed plate =

sr = 1

$$Sv = \frac{Sr}{Eo}$$

Sv = 3.125

feed plate pada plate ke 7

flow rate rectifying

**vapour**

| | | | | |
|---|---|---|---|---|
| R = | 1.44 | | | |
| L = | 108058 | KG/JAM | 30.01605817 | Kg/s |
| V = | 183115 | KG/JAM | 50.86539671 | kg/s |

$$\text{Laju alir volum, } Qv = \frac{V}{\rho_v}$$

Qv = 0.12856 m3/s

**liquid**

$$Q_L = \frac{L}{\rho_L}$$

QL = 0.07625 m3/s

parameter aliran (Flv)

$$F_{LV} = \left(\frac{L}{V}\right)\left(\frac{\rho_v}{\rho_L}\right)^{0,5}$$

Flv = 0.59158

## Kapasitas uap ($C_{sb}$)

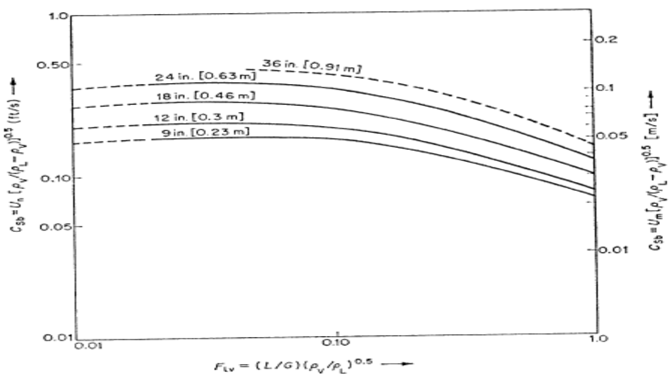



FIGURE 6–3. Sieve tray flooding capacity[6]

csb = 0.06 m/s

$$U_{nf} = C_{sb}\left(\frac{\rho_L - \rho_v}{\rho_v}\right)^{0,5}$$

0.052 m/s

pemilihan tray

Digunakan single cross flow tray dengan segmental Downcomer. single cross flow tray digunakan untuk laju alir liquid 50-500 g.p.m (0.003-0.03 m/s)

The crossflow tray is most commonly used and is simple and economic in construction, and is used for liquid flow rates of approximately 50–500 g.p.m. [0.003–0.03 $m^3/s$] and gives high plate efficiencies.

**Untuk jenis tray ini mempunyai konfigurasi :** Process Plant Design, Harker, hal 180

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Area downcomer (Ad) | = | 0.12 At | | | | | |
| Weir length (Lw) | = | 0.77 Dt | | | | | |
| Net area (An) | = | 0.88 At | | | | | |
| Weir height (hw) | = | 50 | mm | | | | |
| Hole diameter | = | 0.1875 | in | = | 4.6725 | mm | (Diameter lubang) |
| Tray thickness | = | 0.074 | in | = | 1.88 | mm | |

## f. Diameter tower, Dt

Dipilih desain floading, (F*) = 80% (asumsi)

Un* = F* x Um (Pers 6-25, Harker hal 175)

= 80% x 0.052 m/s

= 0.0416 m/s

Area menara, At

$$At = \frac{Qv}{0.88 \times Un^*}$$

$$= \frac{0.12856485 \text{ m3/s}}{0.036608 \text{ m/s}}$$

= 3.51193305 m2

Ad = 0.12 At

Ad = 0.12 3.5119

Ad = 0.421431967 m2

Diameter Menara, Dt

$$Dt = \left(\frac{4.At}{\pi}\right)^{0.5}$$

= 2.11513595 m

= 6.9376459 ft

| 1 m | 3.28 | ft |
|---|---|---|

harker hal

*4.3.1 System Factors*

(i) *Scale.* For column diameters of less than approximately 3 ft [1 m], it is more usual to employ packed towers because of the high fabrication costs of the small trays. For a very large column, liquid distribution problems may arise and this fact, coupled with the weight considerations of a large volume of packing, may lead to the choice of a plate tower. A preliminary estimate of tower diameter may be obtained from Figure 4-1.[9]

Luas Penampang menara, At

$$At = \frac{1}{4} \pi Dt^2$$

= 3.51193305 m2

## g. Tabulasi area menara

| | | | | | |
|---|---|---|---|---|---|
| Tower area, At | = | 3.51193305 | m2 | | |
| Downcomer area, Ad | = | 0.12 At | = | 0.42143 | m2 |
| Net area, An(Aa+Ad) | = | 0.88 At | = | 3.0905 | m2 |
| Active area, Aa | = | 0.76 At | = | 2.66907 | m2 |
| Hole area. Ah | = | 0.1 At | = | 0.35119 | m2 (Pers 6-27, Harker hal 175) |

## h. Flooding check, F

$$Un = \frac{Qv}{An}$$ (Pers 6-28, Harker hal 176)

$$= \frac{0.12856485 \text{ m3/s}}{3.09050109 \text{ m2}}$$

= 0.0416 m/s

F = *F**(Un/Un*)

= 80%

## i. Perhitungan entrainment

| | | |
|---|---|---|
| Untuk Flv | = | 0.5<br>916 |
| F | = | 80<br>% |

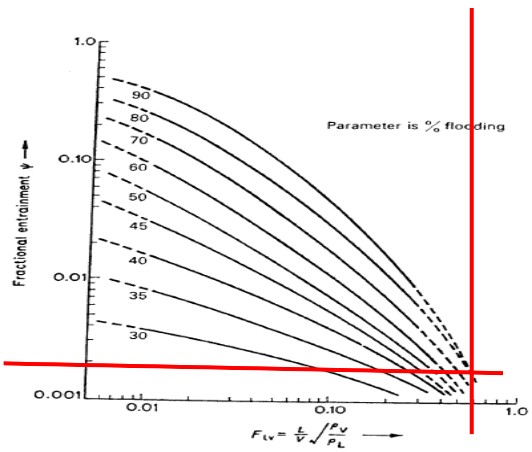



FIGURE 6-4. Sieve tray fractional entrainment[6]

Process Plant Design, Harker, Fig 6-4, hal 167

Dari Fig 6-4 diperoleh fractional entrainment :

ψ = 0.00<br>15

Maka, Total entrainment (e) yaitu :

$$e = \frac{\psi L}{1-\psi}$$

e = $\frac{0.00\ 15 \quad 30.0160\ 5817}{0.9985}$

e = 0.04<br>51 kg/s

## j. Perhitungan pressure drop tray

**Hole velocity, Vh**

$$Vh = \frac{Qv}{Ah}$$

$$= \frac{0.12856\ 485\ \text{m3/s}}{0.35119\ 331\ \text{m2}}$$

$$= 0.36608\ \text{m/s}$$

| | | | | |
|---|---|---|---|---|
| Tebal Tray / Diameter Hole | = | 0.074 / 0.1875 | = | 0.39467 |

| | | |
|---|---|---|
| Hole area / Active Area | = | Ah / Aa |
| | = | 0.35119331 / 2.66906912 |
| | = | 0.13157895 |

| | | |
|---|---|---|
| Gross % free area (Ah/At) | = | Ah / At |
| | = | 0.35119331 / 3.51193305 |
| | = | 10% |

Maka didapatkan harga (1/Cvo)^2 = 1.7

Process Plant Design, Harker, Fig 6-8, hal 172

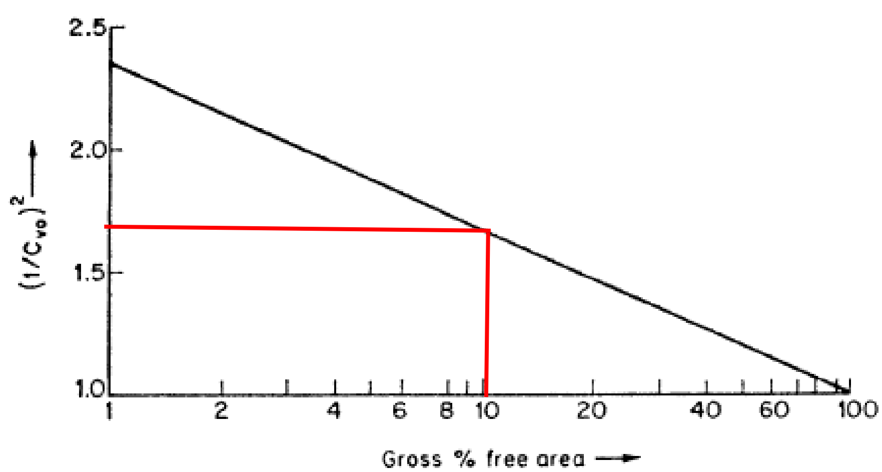



FIGURE 6–8. Orifice coefficient and free area for sieve trays[15]

Process Plant Design, Harker, Fig 6-8, hal 172

(Pers 6-9, Harker hal 176)

ΔP dry =

| | | | | |
|---|---|---|---|---|
| ΔP dry = | 5.08 | 395.6400103 / 393.6717004 | 0.134 | 1.7 |
| ΔP dry = | 1.1631 | cm | | |

**Areated liquid drop, ha**

(Pers 6-32, Harker hal 176)

| | | | |
|---|---|---|---|
| Fva | = | 0.12856485 × 19.8907016 / 2.66906912 | |
| Fva | = | 0.95810369 | m |

Aeration factor, Φp = 0.78 Process Plant Design, Harker, Fig 6-9, hal 173

froth density, Φ = 0.43

Process Plant Design, Harker, Fig 6-9, hal 173

Tinggi liquid menguap diatas weir, how

| | | | | |
|---|---|---|---|---|
| how | = | 66.6 | 0.0762 / 1.6287 | m3/s / m |
| | = | 8.563194952 | cm | |

Weir height, hw

| | | | | |
|---|---|---|---|---|
| hw | = | 50 | mm | (Harker hal 180) |
| | = | 5 | cm | |

Aerated liquid drop, ha (Pers 6-12, Harker hal 176)

| | | | |
|---|---|---|---|
| ha | = | Φp | $(0,1\ h_w + h_{ow})$ |
| | = | 0.78 | 9.0632 |
| | = | 7.069292063 | cm |

Total tray pressure drop, Pt

| | | | | | |
|---|---|---|---|---|---|
| $P_T$ | = | $P_{dry}$ | + | ha | (Pers 6-33, Harker hal 176) |
| | = | 1.163136402 | + | 7.069292063 | cm |
| | = | 8.232428464 | cm | | |

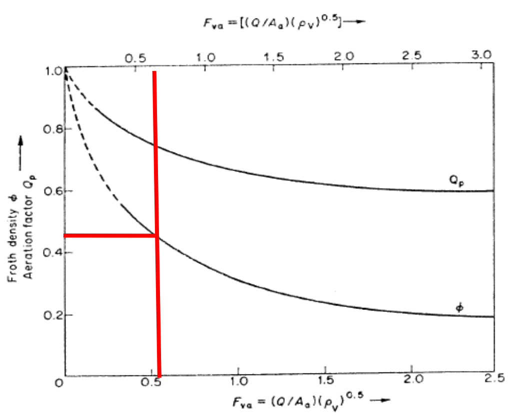



FIGURE 6-9. Aeration factor and relative froth density for sieve trays[15a]

## k. Down comer residence time, Vd

(Pers 6-35, Harker hal 177)

$$Vd = \frac{30.0160582\ \text{kg/s}}{0.42143197 \quad 395.64001}$$

$$= 0.18002216\ \text{m/s}$$

Vd (kecepatan aliran di downcomer area)

Residence time = Tray spacing / Vd (Pers 6-36, Harker hal 177)

= 0.46 m / 0.18002216 m/s

= 2.55524091 sekon — Memenuhi syarat karena besar dari 3 detik

## I. Liquid gradience,

**1/. Tinggi froth pada tray, hf**

(Pers 6-37, Harker hal 177)

$$h_f = \frac{ha}{2(Q_P - 1)}$$

hf = 7.06929206 cm / 0.44

= 16.0665729 cm  0.16067 m  160.6657287 mm

**2/. Hodraulic radius, Rh**

(Pers 6-40, Harker hal 177)

$$Df = \frac{Lw + Dt}{2}$$

Df = (1.62865468 + 2.11514) / 2

= 1.87189531 m

(Pers 6-39, Harker hal 177)

$$Rh = \frac{hf + Df}{2hf + 100\,Df}$$

Rh = (0.16066573 + 1.8719) / (0.32133146 + 187.19) m

= 0.0108397 m

**3/. Velocity of aerated mass, Uf**

Φ = froth density = 0.43 Process Plant Design, Harker, Fig 6-9, hal 173

$$V_f = \frac{100 \times Q_L}{h_f \times \Phi \times D_f}$$ (Pers 6-41, Harker hal 178)

| | | | | |
|---|---|---|---|---|
| Uf | = | 100 | 0.07624642 | |
| | | 0.16066573 | 0.43 | 1.8719 |
| Uf | = | 58.9584696 | m/s | |

**4/. Renold modulus, Reh**

$$R_{eh} = \frac{Rh \times Uf \times \rho_L}{\mu_L}$$ 6-43, Harker hal 178)

| | | | | |
|---|---|---|---|---|
| Reh | = | 0.0108397 | 58.9584696 | 393.672 |
| | | | 0.00065476 | |
| | = | 384252.08 | | |

**5/. Faktor friksi, f**

f = 0.23

Process Plant Design, Harker, Fig 6-10, hal 174

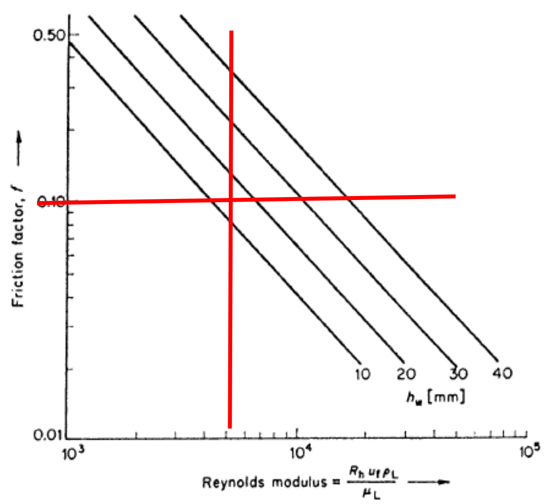



FIGURE 6–10. Sieve tray friction factor[1]

**6/. Perhitungan liquid gradience, Δ**

| | | | | | |
|---|---|---|---|---|---|
| Lf | = | 0.77 | Dt | | |
| | = | 0.77 | 2.11513595 | | |
| | = | 1.62865468 | m | | |

(Pers 6-41, Harker hal 178)

$$\Delta = \frac{10^4 \times f \times Uf^2 \times Lf}{Rh \times 981}$$

| | | | | | |
|---|---|---|---|---|---|
| Δ | = | 100 | 0.23 | 3476.1 | 1.6287 |
| | | | 0.0108397 | 981 | |
| | = | 12245.1209 | cm | | |

**Asumsi *clearance,***

| | | | | | |
|---|---|---|---|---|---|
| C' | = | 38 | mm | | |
| $A_{da}$ | = | C' x Lw | | | |
| | = | 0.038 | 1.628655 | | |
| | = | 0.061888878 | $m^2$ | | |
| | | | | | |
| $h_{da}$ | = | $16{,}5\ (Q_L/A_{da})^2$ | | (Pers. 6-19 hal 174. | |
| | = | 16.5 | 0.076246 | | |
| | | | 0.061889 | | |
| | = | 16.5 | 1.517797 | | |
| | = | 25.04365159 | cm | | |
| | | | | | |
| $h_{de}$ | = | $P_T + h_w + h_{ow} + \Delta + h_{da}$ | | | |
| | = | 8.232428464 | 0.5 | 8.56319 | 12245.1 |
| | = | 12287.4602 | cm | | |
| | | | | | |
| tinggi areal liquid | = | $h_{de}$ / φP | | | |
| | = | 12287.4602 | = | 15753.2 | cm |
| | | 0.78 | | | |

m **Tinggi Kolom, H**

| | | | | | |
|---|---|---|---|---|---|
| H | = | ( N act x Plate Spacing) + (N act x tebal plate) | | | |
| | = | 3.125 | 0.46 | + | 3.12 |
| | = | 1.4375 | + | 0.00588 | |
| | = | 1.443375 | m | | |

**Tebal dinding kolom, t**

Bahan konstruks *Stenlis stee*

$$t = \frac{PR}{SE - 0{,}6P} + c$$

(Peters, hal 5

| | | | | | | |
|---|---|---|---|---|---|---|
| P | = | 14.696 | Psia | | | |
| D | = | 2.1151359 | m | = | 83.272902 | |
| R | = | 41.636451 | in | | | |
| c | = | 0.002 | in/tahun thn | = | 0.02 | |
| S | = | 13700 | psia | pada T | 446 | oF |
| E | = | 85% | | | | |

t = (14.696 × 41.636) / (11645 - 8.81)

= 611.889285 / 11636.182

= 0.0725850 in = 0.00184366

OD kolom = ID + 2 t

= 2.1151359 + 0.00369

= 2.1188232 m

### *10.3.4 Bucket elevator*

fungsi : untuk mengangkut batu bara ke furnace
jenis : vertical belt elevator
bahan : karbon steel

| | | |
|---|---|---|
| tekanan : | 1 | atm |
| temperatur : | 30 | C |
| laju alir umpan: | 11.8 | kg/jam |
| faktor keamanan : | 20% | |

untuk menentukan kapasitas dari bucket dapat dilihat dari tabel

**ELEVATOR CAPACITY SELECTION**

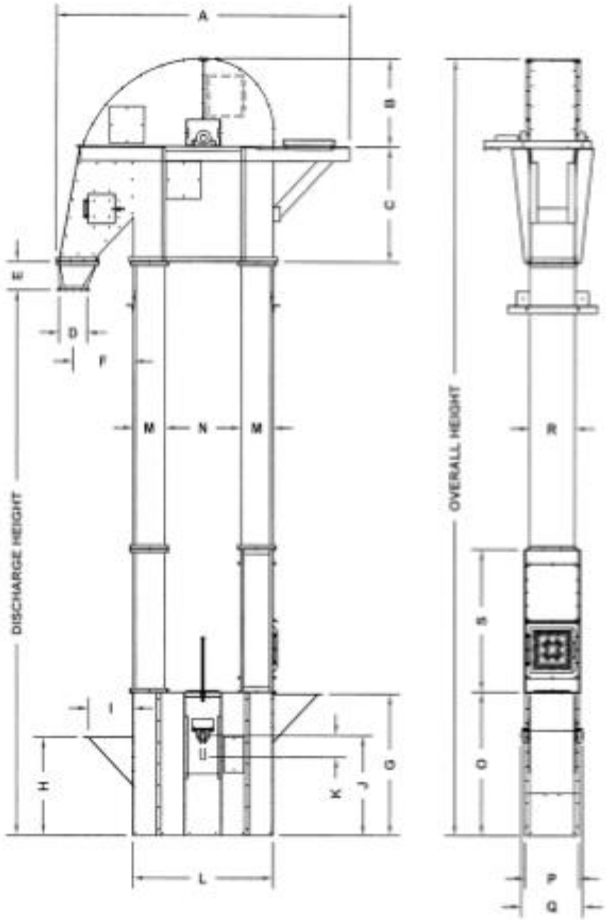
| CAPACITY BPH (*MTPH*) | PULLEY DIAMETER INCHES (*mm*) | BELT SPEED | | BUCKET & SPACING INCHES (*mm*) |
|---|---|---|---|---|
| | | FPM (*M/S*) | RPM | |
| 500 (13) | 10 *(254.0)* | 314 *(1.59)* | 109 | 6x4 *(152.4x101.6)* @ 12" *(304.8)* |
| 750 (20) | 10 *(254.0)* | 314 *(1.59)* | 109 | 6x4 *(152.4x101.6)* @ 6" *(152.4)* |
| 1,000 *(27)* | 16 *(406.4)* | 414 *(2.10)* | 93 | 9x6 *(228.6x152.4)* @ 20" *(508.0)* |
| 2,000 *(54)* | 16 *(406.4)* | 414 *(2.10)* | 93 | 9x6 *(228.6x152.4)* @ 10" *(254.0)* |
| 3,000 *(81)* | 16 *(406.4)* | 414 *(2.10)* | 93 | 9x6 *(228.6x152.4)* @ 7" *(177.8)* |
| | 24 *(609.6)* | 478 *(2.43)* | 73 | 12x6 *(304.8x152.4)* @ 10" *(254.0)* |
| 4,000 *(108)* | 24 *(609.6)* | 478 *(2.43)* | 73 | 12x6 *(304.8x152.4)* @ 8" *(203.2)* |
| | 30 *(762.0)* | 544 *(2.76)* | 67 | 12x6 *(304.8x152.4)* @ 9" *(228.6)* |
| 5,000 *(136)* | 30 *(762.0)* | 544 *(2.76)* | 67 | 12x6 *(304.8x152.4)* @ 7" *(177.8)* |
| | 36 *(914.4)* | 630 *(3.20)* | 65 | 12x7 *(304.8x177.8)* @ 12" *(304.8)* |
| 6,000 *(163)* | 36 *(914.4)* | 630 *(3.20)* | 65 | 12x7 *(304.8x177.8)* @ 10" *(254.0)* |
| 7,500 *(204)* | 36 *(914.4)* | 630 *(3.20)* | 65 | 12x7 *(304.8x177.8)* @ 8" *(203.2)* |
| | 36 *(914.4)* | 630 *(3.20)* | 65 | 16x7 *(406.4x177.8)* @ 11" *(266.7)* |
| 10,000 (272) | 36 *(914.4)* | 630 *(3.20)* | 65 | 16x7 *(406.4x177.8)* @ 8.5" *(215.9)* |
| | 42 (*1066.8)* | 642 *(3.26)* | 57 | 16x8 *(406.4x203.2)* @ 11.5" *(292.1)* |
| 12,000 *(326)* | 42 *(1066.8)* | 642 *(3.26)* | 57 | 16x8 *(406.4x203.2)* @ 10" *(254.0)* |

untuk desain bucket dapat dilihat dari tabel

**Bucket Elevator Design Specification Table**

| Pulley Diameter Inches (mm) | Bucket Size Inches (mm) | Trunking Size Inches (mm) | Standard Gauging | | | | | Urethane Lined Head Section and Discharge Hopper | Belting | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Head | | Trunking | | Boot | | PVC (Standard) | SOR (Optional) |
| | | | Housing | Hoods | Through 150' | Over 150' | | | | |
| 10 (254.0) | 6x4 (152.4x101.6) | 8.5x10 (215.9x254.0) | 11 | 14 | 16 | - | 11 | Optional | 250 lb | 330 lb |
| 16 (406.4) | 9x6 (228.6x152.4) | 13x10 (330.2x254.0) | 11 | 14 | 14 | - | 8 | Optional | 250 lb | 330 lb |
| 24 (609.6) | 12x6 (304.8x152.4) | 16x10 (406.4x254.0) | 11 | 14 | 14 | - | 8 | Optional | 350 lb | 440 lb |
| 30 (762.0) | 12x6 (304.8x152.4) | 16x10 (406.4x254.0) | 11 | 12 | 14 | 12 | 8 | Optional | 350 lb | 440 lb |
| 36 (914.4) | 12x7 (304.8x177.8) | 16x14 (406.4x355.6) | 8 | 11 | 12 | 10 | 8 | Standard | 350 lb | 440 lb |
| 36 (914.4) | 16x7 (406.4x177.8) | 20x14 (508.0x355.6) | 8 | 11 | 12 | 10 | 8 | Standard | 350 lb | 440 lb |
| 42 (1066.8) | 16x8 (406.4x203.2) | 20x14 (508.0x355.6) | 8 | 11 | 12 | 10 | 8 | Standard | 450 lb | 600 lb |
| 42 (1066.8) | (2) 14x8 (355.6x203.2) | 38x14 (965.2x355.6) | 8 | 11 | 10 | 10 | 8 | Standard | 450 lb | 600 lb |

desain bucket elevator dapat dilihat gambar :



| Standard Dimensions for Models CBE16-CBE42 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pulley Diameter Inches (mm) | 16" (406.4) | 16" (406.4) | 16" (406.4) | 24" (609.6) | 24" (609.6) | 30" (762.0) | 30" (762.0) | 36" (914.4) | 36" (914.4) | 36" (914.4) | 36W" (914.4) | 36W" (914.4) | 42" (1066.8) | 42" (1066. |
| Capacity BPH (M/TPH) | 1,000 (25.4) | 2,000 50.8 | 3,000 76.2 | 3,000 76.2 | 4,000 101.6 | 4,000 101.6 | 5,000 127.0 | 5,000 127.0 | 6,000 152.4 | 7,500 190.5 | 7,500 190.5 | 10,000 254.0 | 10,000 254.0 | 12,00 306.0 |
| A | 76 (1930.4) | 76 (1930.4) | 76 (1930.4) | 84 (2133.6) | 84 (2133.6) | 103 (2616.2) | 103 (2616.2) | 130 (3302.0) | 130 (3302.0) | 130 (3302.0) | 130 (3302.0) | 130 (3302.0) | 142 (3606.8) | 142 3606. |
| B | 22 (558.8) | 22 (558.8) | 22 (558.8) | 26 (660.4) | 26 (660.4) | 32 (812.8) | 32 (812.8) | 37 (939.8) | 37 (939.8) | 37 (939.8) | 37 (939.8) | 37 (939.8) | 42 (1066.8) | 42 1066. |
| C | 22 (558.8) | 22 (558.8) | 22 (558.8) | 22 (558.8) | 22 (558.8) | 34 (863.6) | 34 (863.6) | 48 (1219.2) | 48 (1219.2) | 48 (1219.2) | 48 (1219.2) | 48 (1219.2) | 58 (1473.2) | 58 1473. |
| D | 6"RD (152.4) | 8"RD (203.2) | 8"RD (203.2) | 8"RD (203.2) | 10"RD (254.0) | 10"RD (254.0) | 10"RD (254.0) | 12"RD (304.8) | 12"RD (304.8) | 14"RD (203.2) | 14"RD (203.2) | 16"RD (406.4) | 16"RD (406.4) | 18"R (406.4 |
| E | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8) | 12 (304.8 |
| F | 17 (431.8) | 16 (406.4) | 16 (406.4) | 16 (406.4) | 15 (381.0) | 23 (584.2) | 23 (584.2) | 27 (685.8) | 27 (685.8) | 29 (736.6) | 29 (736.6) | 25 (635.0) | 31 (787.4) | 31 (787.4 |
| G | 39 (990.6) | 39 (990.6) | 39 (990.6) | 44 (1117.6) | 44 (1117.6) | 55 (1397.0) | 55 (1397.0) | 59 (1498.6) | 59 (1498.6) | 59 (1498.6) | 59 (1498.6) | 59 (1498.6) | 62 (1574.8) | 62 1574. |
| H | 29 (736.6) | 29 (736.6) | 29 (736.6) | 35 (889.0) | 35 (889.0) | 37 (939.8) | 37 (939.8) | 41 (1041.4) | 41 (1041.4) | 41 (1041.4) | 41 (1041.4) | 41 (1041.4) | 44 (1117.6) | 44 1117. |
| I | 13 (330.2) | 13 (330.2) | 13 (330.2) | 18 (457.2) | 18 (457.2) | 18 (457.2) | 18 (457.2) | 18 (457.2) | 18 (457.2) | 18 (457.2) | 18 (457.2) | 18 (457.2) | 18 (457.2) | 18 (457.2 |
| J | 25 (635.0) | 25 (635.0) | 25 (635.0) | 31 (787.4) | 31 (787.4) | 37 (939.8) | 37 (939.8) | 39 (990.6) | 39 (990.6) | 39 (990.6) | 39 (990.6) | 39 (990.6) | 47 (1193.8) | 47 1193. |
| K | 9 (228.6) | 9 (228.6) | 9 (228.6) | 9 (228.6) | 9 (228.6) | 12 (304.8) | 12 (304.8) | 9 (228.6) | 9 (228.6) | 9 (228.6) | 9 (228.6) | 9 (228.6) | 12 (304.8) | 12 (304.8 |
| L | 34 (863.6) | 34 (863.6) | 34 (863.6) | 42 (1066.8) | 42 (1066.8) | 48 (1219.2) | 48 (1219.2) | 62 (1574.8) | 62 (1574.8) | 62 (1574.8) | 62 (1574.8) | 62 (1574.8) | 68 (1727.2) | 68 1727. |
| M | 10 (254.0) | 10 (254.0) | 10 (254.0) | 10 (254.0) | 10 (254.0) | 10 (254.0) | 10 (254.0) | 14 (355.6) | 14 (355.6) | 14 (355.6) | 14 (355.6) | 14 (355.6) | 14 (355.6) | 14 (355.6 |
| N | 14 (355.6) | 14 (355.6) | 14 (355.6) | 22 (558.8) | 22 (558.8) | 28 (711.2) | 28 (711.2) | 34 (863.6) | 34 (863.6) | 34 (406.4) | 34 (406.4) | 34 (863.6) | 40 (1016.0) | 40 1016. |
| O | 48 (1219.2) | 48 (1219.2) | 48 (1219.2) | 48 (1219.2) | 48 (1219.2) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 10/14/2010 | 60 (1524.0) | 72 (1828.8) | 72 1828. |
| P | 16 (406.4) | 16 (406.4) | 16 (406.4) | 20 (508.0) | 20 (508.0) | 20 (508.0) | 20 (508.0) | 20 (508.0) | 20 (508.0) | 20 (508.0) | 24 (609.6) | 24 (609.6) | 24 (609.6) | 24 (609.6 |
| Q | 20 (508.0) | 20 (508.0) | 20 (508.0) | 23 (584.2) | 23 (584.2) | 23 (584.2) | 23 (584.2) | 23 (584.2) | 23 (584.2) | 23 (584.2) | 28 (711.2) | 28 (711.2) | 28 (711.2) | 28 (711.2 |
| R | 13 (330.2) | 13 (330.2) | 13 (330.2) | 16 (406.4) | 16 (406.4) | 16 (406.4) | 16 (406.4) | 16 (406.4) | 16 | 16 | 20 (508.0) | 20 (508.0) | 20 (508.0) | 20 (508.0 |
| S | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 (1524.0) | 60 1524. |

penentuan besar hopper.

| Inlet Hopper Dimensions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Standard Inlet | | | | Optional Flared Inlet | | | |
| Model | Trunking | Width | | Length | | Width | | Length | |
| | | Inches | (mm) | Inches | (mm) | Inches | (mm) | Inches | (mm) |
| 10 | 8.5x10 | 10.00 | (254.0) | 10.00 | (254.0) | 16.00 | (406.4) | 12.00 | (304.8) |
| 16 | 13x10 | 13.00 | (330.2) | 13.00 | (330.2) | 25.00 | (635.0) | 16.00 | (406.4) |
| 24 | 16x10 | 16.00 | (406.4) | 18.00 | (457.2) | 30.00 | (762.0) | 18.00 | (457.2) |
| 30 | 16x10 | 16.00 | (406.4) | 18.00 | (457.2) | 30.00 | (762.0) | 18.00 | (457.2) |
| 36 | 16x14 | 16.00 | (406.4) | 18.00 | (457.2) | 30.00 | (762.0) | 18.00 | (457.2) |
| 36W | 20x14 | 20.00 | (508.0) | 18.00 | (457.2) | 34.00 | (863.6) | 20.00 | (508.0) |
| 42 | 20x14 | 20.00 | (508.0) | 18.00 | (457.2) | 34.00 | (863.6) | 20.00 | (508.0) |