

LAMPIRAN A

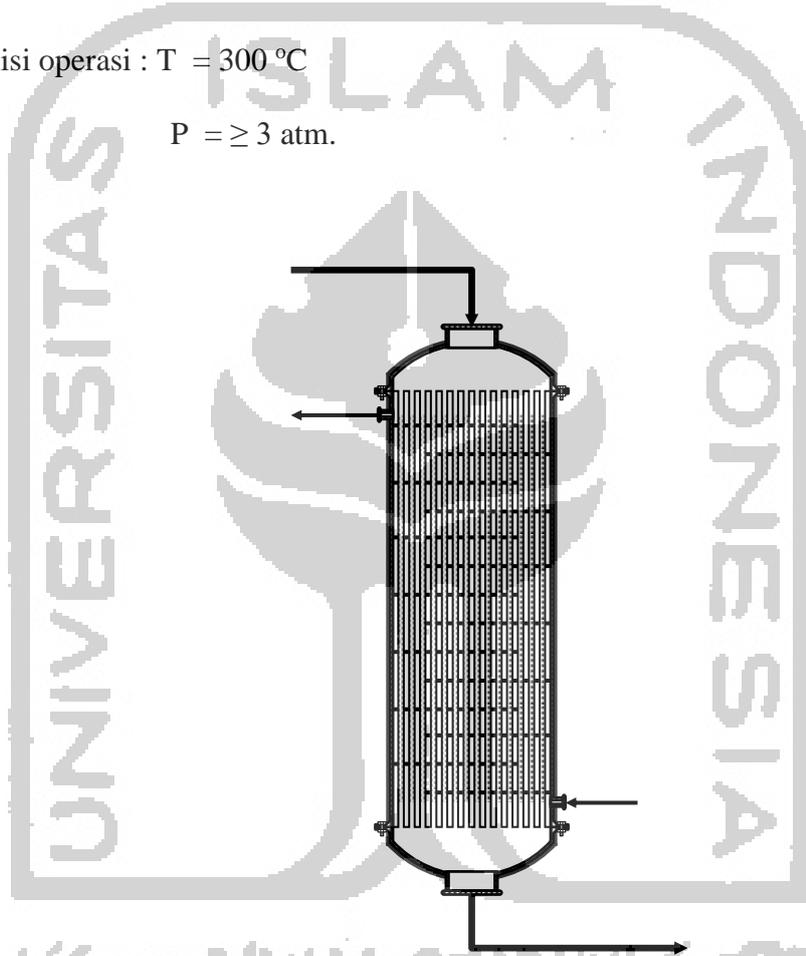
REAKTOR

Tugas : Mereaksikan diisobutene dengan hidrogen dengan kecepatan umpan masuk sebesar 70965,54 kg/jam.

Tipe Alat : Reaktor Fixed bad multi tube.

Kondisi operasi : $T = 300\text{ }^{\circ}\text{C}$

$P \geq 3\text{ atm.}$



NERACA MASSA

1. Umpan Masuk : H_2	=	1187,2845	kmol/ jam	=	2374,5691	kg/jam
CH_4	=	50,2177	kmol/jam	=	803,4831	kg/jam
C_8H_{16}	=	593,6423	kmol/jam	=	66487,9345	kg/jam
C_8H_{18}	=	11,3996	kmol/jam	=	1299,5581	kg/jam
Total	=	1842,5441	kmol/jam	=	70965,5448	kg/jam



Katalis : *Nickel*

Konversi : 0,9193 (91 %) terhadap C_8H_{16}

Reaksi bisa ditulis :



Maka pada saat konversi = X_A

$$n_A = n_{A0}(1 - X_A)$$

$$n_b = n_{B0} - 3n_{A0}X_A$$

$$n_C = n_{A0}X_A$$

Maka pada konversi $X_A = 0,9193$

Maka diperoleh hasil reaksi :

$$H_2 = 641,5492 \text{ kmol/jam} = 1283,0984 \text{ kg/jam}$$

$$CH_4 = 50,2177 \text{ kmol/jam} = 803,4831 \text{ kg/jam}$$

$$C_8H_{16} = 47,9069 \text{ kmol/jam} = 5365,5763 \text{ kg/jam}$$

$$C_8H_{18} = 557,1350 \text{ kmol/jam} = 63513,3869 \text{ kg/jam}$$

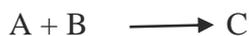
$$\text{Total} = 1296,8088 \text{ kmol/jam} = 70965,5448 \text{ kg/jam}$$

PENENTUAN KONSTANTA KECEPATAN REAKSI

Reaksi



Reaksi diatas dapat disederhanakan menjadi



Persamaan kecepatannya dapat ditulis sebagai berikut:

$$-r_a = k C_{A0}(1 - X_A)C_{A0}(M - 3 X_A)$$

$$-r_a = k C_{A0}^2(1 - X_A)(M - 3 X_A)$$

Untuk reaktor fixed-bed

$$\frac{V}{Fv} = C_{A0} \int_0^{x_a} \frac{dX_a}{-r_a}$$

$$\tau = CA_0 \int_0^{X_A} \frac{dX_A}{k \frac{CA}{CB}}$$

$$\tau = CA_0 \int_0^{X_A} \frac{dX_A}{k C_{A0}^2 (1 - X_A)(M - 3 X_A)}$$

Bila diselesaikan menjadi,

$$\ln \frac{M - 3 X_A}{M(1 - X_A)} = C_{A0}(M - 3)kt$$

$$k = \frac{1}{C_{A0}(M - 3)t} \ln \frac{M - 3 X_A}{M(1 - X_A)}$$

Konsentrasi awal A (C_8H_{16})

$$CA_0 = \frac{n_{A0} \cdot Pt}{nT \cdot R \cdot T}$$

$$\begin{aligned} n_{A0} &= 100 \text{ mol} \\ n_{B0} &= 200 \text{ mol} \\ n_t = n_{t0} &= 300 \text{ mol} \\ R &= 0,08205 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \\ P &= 2 \text{ atm} \\ T &= 573 \text{ K} \end{aligned}$$

$$CA_0 = \frac{n_{A0} \cdot Pt}{nT \cdot R \cdot T}$$

$$CA_0 = \frac{100 \text{ mol} \cdot 5 \text{ atm}}{550 \text{ mol} \cdot 0,08205 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 473 \text{ K}}$$

$$CA_0 = 0,02342 \frac{\text{mol}}{\text{L}}$$

Perbandingan Reaktan

$$M = \frac{n_{B0}}{n_{A0}}$$

$$= 2$$

Waktu Reaksi (θ) untuk suhu = 573 K

$$\theta = 1,2857 \text{ detik}$$

Konversi

$$X_A = 0,9193$$

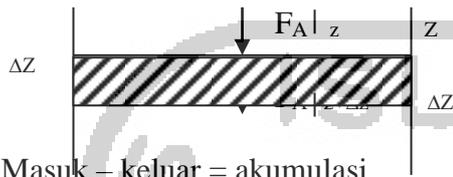
$$k = \frac{1}{C_{A0}(M - 3)t} \ln \frac{M - 3 X_A}{M(1 - X_A)}$$

$$k = \frac{1}{0,02342 \frac{\text{mol}}{\text{L}} (4,5 - 3) 1,2857 \text{ detik}} \ln \frac{4,5 - 3 \times 0,98}{4,5(1 - 0,98)}$$

$$K = 63,1578 \frac{L}{\text{mol. detik}}$$

PENYUSUNAN MODEL MATEMATIS PADA ELEMEN VOLUME

1. NERACA MASSA PADA ELEMEN VOLUME



Masuk - keluar = akumulasi

$$F_A|_z - [F_A|_{z+\Delta Z} + (-r_A) dv] = \text{Acc}$$

$$dV = A \cdot \Delta Z$$

$$\text{dimana } A = \frac{\pi \cdot D_i^2}{4}$$

Neraca massa elemen volume juga meninjau ruang kosong diantara tumpukan katalis sehingga porositas (ϵ) berpengaruh. Porositas (ϵ) didapat dari Brown, fig.219 & 220.

Maka :

$$dV = \frac{\pi \cdot D_i^2}{4} \epsilon \cdot \Delta Z$$

$$F_A|_z - F_A|_{z+\Delta Z} - (-r_A) \frac{\pi D_i}{4} \epsilon \Delta Z = 0$$

$$\frac{F_A|_z - F_A|_{z+\Delta Z}}{\Delta Z} - \frac{(-r_A) \pi D_i^2}{4} \epsilon = 0$$

$$\text{dimana } F_A = F_{A0}(1-X_A)$$

$$\Delta F_A = -F_{A0} \cdot \Delta X_A$$

$$F_{A0} \frac{\Delta X_A}{\Delta Z} = \frac{(-r_A) \cdot \pi \cdot D_i^2}{4} \epsilon$$

$$\frac{\Delta X_A}{\Delta Z} = \frac{(r_A) \cdot \pi \cdot D_i^2}{4 F_{A0}} \epsilon$$

$$\lim \Delta Z \rightarrow 0$$

$$\frac{dX_A}{dz} = \frac{(-r_A) \cdot \pi \cdot D_i^2}{4 F_{A0}} \epsilon$$

$$(-r_A) = \text{kecepatan reaksi} = k \cdot C_A \cdot C_B$$

$$\frac{dX_A}{dz} = \frac{(kC_A C_B) \cdot \pi \cdot Di^2}{4F_{A0}} \varepsilon$$

$$C_A = \frac{n_A}{n_t} \frac{Pt}{RT}$$

$$= \frac{n_{A0}(1 - X_A)Pt}{n_t \cdot RT}$$

$$C_B = \frac{n_B}{n_t} \frac{Pt}{RT}$$

$$= \frac{n_{A0} \left(\frac{n_{B0}}{n_{A0}} - X_A \right) Pt}{n_t \cdot RT}$$

Maka :

$$\frac{dX_A}{dz} = \frac{\left(\frac{n_{A0}}{n_t} \cdot \frac{Pt}{RT} \right)^2 k(1 - X_A) \left(\frac{n_{B0}}{n_{A0}} - X_A \right) \pi \cdot Di^2 \varepsilon}{4F_{A0}} \dots\dots\dots(1)$$

Dimana :

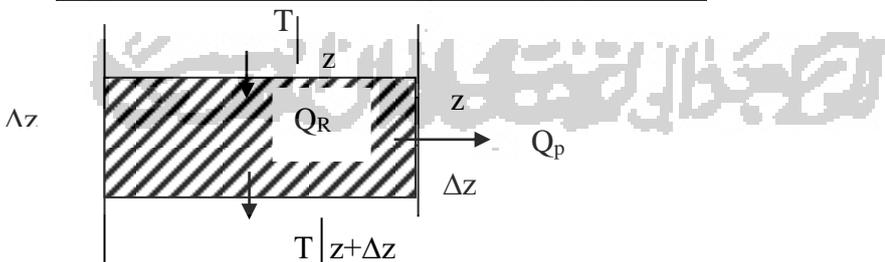
$\frac{dX_A}{dz}$ = Perubahan konversi persatuan panjang

Di = Diameter dalam

ε = porositas tumpukan katalis

F_{A0} = Kecepatan molar A mula-mula

2. NERACA PANAS PADA ELEMEN VOLUME



Masuk – keluar = ak

$$\sum m \cdot c_p (T|_z - T_0) - (\sum m \cdot c_p (T|_{z+\Delta z} - T_0) + Q_R + Q_P) = 0$$

$$Q_R = \Delta H_R \cdot n_{A0} \cdot \Delta X_A$$

$$Q_P = U \cdot A \cdot \Delta T$$

$$= U \cdot \pi \cdot D_0 \cdot \Delta z \cdot (T_s - T)$$

$$\sum m.C_p (T|_z - T|_{z+\Delta z}) - \Delta H_R \cdot n_{A0} \cdot \Delta X_A - U \cdot \pi \cdot D_o \cdot \Delta z \cdot (T_s - T) = 0$$

$$\sum m.C_p (T|_z - T|_{z+\Delta z}) = \Delta H_R \cdot n_{A0} \cdot \Delta X_A + U \cdot \pi \cdot D_o \cdot \Delta z \cdot (T_s - T)$$

$$T|_z - T|_{z+\Delta z} = \frac{\Delta H_R n_{A0} \Delta X_A + U \pi D_o (T_s - T)}{\sum m.C_p} : \Delta z$$

$$\frac{T|_z - T|_{z+\Delta z}}{\Delta z} = \frac{\Delta H_R n_{A0} \frac{\Delta X_A}{\Delta z} + U \cdot \pi \cdot D_o \cdot (T_s - T)}{\sum m.C_p}$$

$$\frac{\Delta T}{\Delta z} = \frac{\Delta H_R n_{A0} \frac{\Delta X_A}{\Delta z} + U \cdot \pi \cdot D_o (T_s - T)}{\sum m.C_p}$$

Lim $\Delta z \rightarrow 0$

$$\frac{dT}{dz} = \frac{-\Delta H_R \cdot n_{A0} \frac{\Delta X_A}{\Delta z} + U \cdot \pi \cdot D_o (T_s - T)}{\sum m.C_p} \dots\dots\dots(2)$$

dimana :

dT/dz = perubahan suhu persatuan panjang katalis

ΔH_R = panas reaksi

U = over all heat transfer coefficient

D_o = diameter luar

T = suhu gas

T_s = suhu penelitian

$\sum m.C_p$ = kapasitas panas

PENURUNAN TEKANAN (*PRESSURE DROP*)

Penurunan tekanan dalam pipa yang berisi katalisator (fixed bed) menggunakan rumus 11.6 (Chapter 11, Rase) hal 492, Chemical Reactor Design for Process Plants.

$$\frac{gc \cdot dP}{\mu s \cdot dz} = 150 \frac{(1-\varepsilon)^2}{\varepsilon^3} \frac{\mu s}{D_p^2} + 1,75 \left(\frac{1-\varepsilon}{\varepsilon^3} \right) \frac{G}{D_p}$$

Persamaan di atas dapat ditulis :

$$\boxed{\frac{dP}{dz} = \frac{f_k \cdot G^2}{D_p \cdot \rho_f \cdot gc} \left(\frac{1-\varepsilon}{\varepsilon^3} \right)} \quad \dots\dots\dots(4)$$

dimana :

$$f_k = 1,75 + 150 \left(\frac{1-\varepsilon}{D_p \cdot G/\mu} \right)$$

dimana :

$\frac{dP}{dz}$ = perubahan tekanan per satuan panjang

f_k = faktor friksi

gc = konstanta gravitasi

G = kecepatan aliran massa gas dalam pipa, g/cm³

ρ_f = densitas gas, g/cm³

D_p = diameter partikel katalisator, cm

ε = porositas tumpukan katalisator

μ = viskositas gas, g/cm.jam

Sehingga diperoleh 4 persamaan differensial simultan sebagai berikut :

$$1) \quad \boxed{\frac{dX_A}{dz} = \frac{\left(\frac{n_{A0}}{n_t} \cdot \frac{Pt}{RT} \right)^2 \cdot k(1-X_A) \left(\frac{n_{B0}}{n_{A0}} - X_A \right) \pi \cdot Di^2 \varepsilon}{4F_{A0}}}$$

$$2) \quad \boxed{\frac{dT}{dz} = \frac{-\Delta H_R \cdot n_{A0} \frac{\Delta X_A}{\Delta Z} + U \cdot \pi \cdot \pi_0 (T_s - T)}{\Sigma m \cdot Cp}}$$

$$3) \quad \boxed{\frac{dT_s}{dz} = - \frac{U \cdot \pi \cdot Do \cdot (T - T_s)}{(m \cdot Cp)_p}}$$

$$4) \quad \boxed{\frac{dP}{dz} = \frac{f_k \cdot G^2}{D_p \cdot \rho_f \cdot gc} \left(\frac{1-\varepsilon}{\varepsilon^3} \right)}$$

Selanjutnya persamaan differensial simultan tersebut diatas diselesaikan dengan program computer dengan Metode Numeris Runge Kutta.

OVERALL HEAT TRANSFER

1. Koefisien transfer panas pipa (h_{io})

Dari pers. 6-2, Kern diperoleh :

$$h_{io} = 0,027 \left(\frac{D_p \cdot G_t}{\mu} \right)^{0,8} \left(\frac{C_p \cdot \mu}{k} \right)^{1/3} \left(\frac{k}{D_i} \right) \dots\dots\dots(5)$$

Persamaan diatas berlaku untuk organic liquid, larutan aqueous, dan gas pada Re > 10.000

dimana :

- D_p = diameter partikel katalis
- D_i = diameter dalam pipa
- k = konduktivitas thermal
- μ = viskositas gas
- C_p = panas jenis gas
- G_t = kecepatan massa per satuan luas
- h_i = koefisien transfer panas pipa dalam
- h_{io} = h_i · $\frac{ID}{OD}$ (Kern,1983)

2. Koefisien transfer panas dinding pipa dalam shell (h_o)

Dari persamaan, Kern :

$$h_o = 0,36 \left(\frac{D_e \cdot G_p}{\mu_p} \right)^{0,55} \left(\frac{C_{p_p} \cdot \mu_p}{k_p} \right)^{0,33} \left(\frac{k_p}{D_e} \right) \dots\dots\dots(Kern,1983,p137) \dots\dots\dots(6)$$

Persamaan diatas berlaku untuk Re antara 2000 – 1.000.000

dimana :

- h_o = koefisien transfer panas
- D_e = diameter equivalent

G_p = kecepatan massa pendingin per satuan luas

μ_p = viskositas pendingin

k_p = konduktivitas thermal pendingin

C_{p_p} = panas spesifik pendingin

3. Overall heat tray coefficient

$$Rd = \frac{Uc - Ud}{Uc \cdot Ud}$$
$$Ud = \frac{Uc}{Rd \cdot Uc + 1}$$

Dimana;

Uc = Overall heat transfer pada saat bersih

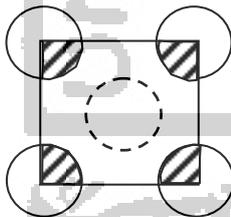
Ud = Overall heat transfer pada saat kotor

Rd = Faktor tahanan panas karena kotoran

LAY OUT PIPA DALAM REAKTOR (Kern, 1983, P. 139)

Pipa dalam reaktor disusun secara square pitch, dimana luas penampang 1 pipa menempati luasan sebesar Pt^2 .

1 pipa menempati luasan = Pt^2



maka luas total penampang reaktor (over design 10%)

$$A_s = 1,1 \cdot N_t \cdot Pt^2$$

dimana :

A_s = Luas penampang shell

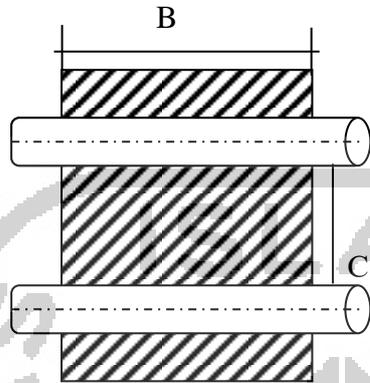
N_t = jumlah pipa

Pt = pitch

Alasan penyusunan pipa secara square pitch :

1. mudah pembersihannya.
2. pressure drop kecil.

1) FLOW AREA DALAM SHELL



$$A_s = \frac{ID_s \cdot B \cdot C'}{Pt} \dots\dots\dots(7)$$

dimana :

- B = Jarak baffle, in
- C' = Clearance, in
- Pt = Pitch, in
- ID_s = Diameter dalam shell, in
- A_s = Flow area shell, in²

DIAMETER EQUIVALEN (De)

Diameter equivalen dapat dipahami sebagai diameter dari area dalam shell, bila dipandang sebagai pipa (Kern, 1983) p.139

$$De = \frac{4 \left(Pt^2 - \frac{\mu \cdot OD^2}{4} \right)}{\mu \cdot OD} = \frac{4 \times \text{free area}}{\text{wetted perimeter}}$$

$$De = \frac{4Pt^2 - \mu \cdot OD^2}{4 \cdot \mu \cdot OD} \dots\dots\dots(8)$$

a. DIAMETER SHELL

Diameter shell yang dipakai untuk Nt pipa

$$\text{Luas shell} = A_s = 1,1 \cdot Nt \cdot Pt^2 = \frac{\pi \cdot (ID_s)^2}{4}$$

Diameter shell :

$$ID_s = \sqrt{\frac{4.A_s}{\mu}}$$

.....(9)

KATALISATOR (Rase, 1977)

Katalisator yang digunakan berupa Nickel dengan :

- Bentuk = pellet
- Ukuran
D = 0,3175 cm
H = 0,3175 cm
- Bulk density = 8,9 Kg/dm³
- Formula = Ni

DIAMETER PARTIKEL (Dp)

Yaitu diameter partikel katalis yang ekuivalen dengan diameter bola dengan volume yang sama dengan volume katalis (Rase, 1977, p.493)

$$\begin{aligned} V_{\text{kat}} &= \frac{\mu.D^2}{4} . H \\ &= \frac{\mu.0,3175^2}{4} . 0,3175 \\ &= 0,025125 \text{ cm}^3 \end{aligned}$$

$$V_{\text{bola}} = V_{\text{kat}}$$

$$V_{\text{Bola}} = \frac{\mu.Dp^3}{4}$$

Maka :

$$\begin{aligned} Dp &= \sqrt[3]{\frac{V_B . 6}{\mu}} \\ &= \sqrt[3]{\frac{0,025125 . 6}{\mu}} \\ &= 0,36345 \text{ cm} \end{aligned}$$

PEMILIHAN PIPA

Dalam pemilihan pipa harus diperhatikan faktor perpindahan panas. Pengaruh bahan isian di dalam pipa terhadap koefisien transfer panas konveksi dididik oleh Colburn (Smith, JM., p.571) dan diperoleh hubungan pengaruh rasio (D_p/D_t) atau perbandingan diameter katalis dengan diameter pipa dengan koefisien transfer panas pipa berisi katalis disbanding transfer panas konveksi pada pipa kosong.

D_p/D_t	0,05	0,1	0,15	0,2	0,25
H_{io}/h	5,5	7	7,8	7,5	7,0

Dimana :

(D_p/D_t) = rasio diameter katalis per diameter pipa

(h_{io}/h) = rasio koefisien transfer panas pipa berisi katalis disbanding koefisien transfer panas pada pipa kosong.

Dari data diatas diperoleh $(h_{io}/h)_{\max}$ terjadi pada 7,8 pada $(D_p/D_t) = 0,15$

$$\frac{D_p}{D_t} = 0,15$$

$$D_t = \frac{D_p}{0,15}$$

$$D_t = \frac{0,36345}{0,15} \text{ cm}$$

$$= 2,42298 \text{ cm}$$

Dipilih pipa dengan ukuran standar (Kern, table 11) :

$$NP_s = 1 \text{ in}$$

$$OD = 1,32 \text{ in}$$

$$ID = 1,049 \text{ in}$$

$$Sch = 40$$

JUMLAH PIPA (Brown, 1950)

Jumlah pipa ditentukan berdasarkan turbulensi gas dalam pipa berkatalis. Dalam suatu reaksi khusus terjadi tumbukan molekul yang optimum (well mixed). Keadaan di atas terjadi bila pada keadaan turbulen yaitu bilangan Reynold diatas 3100.

$$\text{Sphercity } (\varphi) = \frac{\text{Luas area bola}}{\text{luas area katalis}}$$

$$\begin{aligned} \text{Luas area bola} &= \pi \cdot D_p^2 \\ &= 3,14 \cdot 0,36345 \\ &= 0,4148 \text{ cm}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas area katalis} &= \pi \cdot D_H + \frac{2 \cdot \mu \cdot D}{4} \\ &= 0,4748 \text{ cm}^2 \end{aligned}$$

$$\text{maka } \varphi = \frac{0,4148}{0,4748} = 0,8736$$

Dari fig. 223 Brown diperoleh $\epsilon = 0,35$

a. Jumlah pipa maksimum

Jumlah pipa maksimum terjadi bila fluida dalam pipa pada keadaan turbulen minimum $Re = 3100$

$$Re = \frac{F_{Re} \cdot D_p \cdot Gt}{\mu} \dots\dots\dots (\text{pers.166, Brown, 1950,p.210})$$

Dari fig brown 219 diperoleh $F_{Re} = 50,5$

$$\begin{aligned} \text{Viskositas gas} &= 0,0539 \text{ Cp} \\ &= 0,0005390 \text{ gr/cm.dt} \end{aligned}$$

diameter partikel (D_p)= 0,36345 cm

Maka :

$$3100 = \frac{51 \cdot 0,36345 \cdot Gt}{0,000215}$$

$$Gt = 0,120386 \text{ gr/dt.cm}^2$$

$$\begin{aligned} \text{Kecepatan gas} &= 59223,7148 \text{ kg/j} \\ &= 16451,0319 \text{ gr/dt} \end{aligned}$$

$$\begin{aligned} \text{luas penampang pipa} = A_o &= \frac{\pi \cdot D_i^2 \varepsilon}{4} \\ &= \frac{(3,14) \cdot (2,664462) \cdot (0,35)}{4} \\ &= 1,950546 \text{ cm}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas total A} &= \frac{16451,0319 \text{ gr} / \text{dt}}{0,03596 \text{ gr} / \text{dt} \cdot \text{cm}^2} \\ &= 464196,0851 \text{ cm}^2 \end{aligned}$$

jumlah pipa maksimum :

$$\begin{aligned} N_t \text{ maks} &= \frac{464196,0851 \text{ cm}^2}{1,950546 \text{ cm}^2 / \text{pipa}} \\ &= 237982,6393 \text{ pipa} \\ &\sim 237983 \text{ pipa} \end{aligned}$$

b. Jumlah Pipa minimum

Jumlah pipa minimum ditentukan oleh kecepatan linier maksimum. Kecepatan linier maksimum suatu fluida melewati suatu padatan dicari dari Brown hal 74

$$V \text{ maks} = \sqrt{\frac{4(\rho_b - \rho_g) \cdot g \cdot D_p}{3\rho_g \cdot f_b}} \dots\dots\dots (\text{Brown, 1950, p.74})$$

Dari fig 70 Brown hal 76 didapat $f_b = 1$

$$Re = 3100$$

$$\rho \text{ bulk katalis} = 1106,13 \text{ kg/m}^3 = 1,10613 \text{ g / cm}^3$$

$$\begin{aligned} \rho_g &= \frac{P_t \cdot B_M}{RT} \\ &= \frac{2,5 \text{ atm} \cdot 19,56296 \text{ g} / \text{gmol}}{82,06 \frac{\text{cm}^3 \text{ atm}}{\text{gmol} \cdot \text{K}} \cdot 723 \text{ K}} \\ &= 0,000824 \text{ g} / \text{cm}^3 \end{aligned}$$

$$g = 981 \text{ cm/dt}^2$$

$$D_p = 0,36345 \text{ cm}$$

$$\text{Sehingga : } V \text{ maks} = \sqrt{\frac{4(1,10613 - 0,000824) \text{ g/cm}^3 \cdot 981 \text{ cm/dt}^2 \cdot 0,36345 \text{ cm}}{3,000824 \text{ g/cm}^3 \cdot 1}}$$

$$= 798,5532 \text{ cm/dt}$$

Kecepatan volumetrik umpan :

$$Q_v = \frac{16451,0319 \text{ g/dt}}{0,000824 \text{ g/cm}^3}$$

$$\text{Maka } A = \frac{20257877,69 \text{ cm}^3 / \text{dt}}{798,5532 \text{ cm/dt}} = 25368,2255 \text{ cm}^2$$

$$N_t \text{ min} = \frac{A}{A_o} = \frac{25368,2255 \text{ cm}^2}{1,950546 \text{ cm}^2} = 13005,7048 \text{ pipa}$$

Maka diperoleh range jumlah pipa antara 13006 pipa – 237983 pipa , dan dipilih jumlah pipa = 14000 pipa.

SIFAT FISIS

a) Spesifik Heat

$$C_p = A + BT + CT^2 + DT^3$$

Komponen	Cp (Kcal/mol.K)			
	A	B	C	D
H ₂	6.483	0.00222	-3.3E-06	1.83E-09
CH ₄	4.598	0.01245	2.86E-06	-2.70E-09
C ₈ H ₁₆	-15.26	0.2124	-0.000122	2.634E-08
C ₈ H ₁₈	-1.782	0.1858	-1.024E-4	2.191E-08

$$C_p = \sum C_{pi} \cdot y_i$$

b) Viskositas

$$\mu = (.00036(4.61(T/T_c)^{0.618} - 2.04 \text{ EXP}(-0.449(T/T_c)) + 1.94 \text{ EXP}(-4.058(T/T_c)) + 0.1)/(T_c^{1/6} B M^{(-0.5)} P_c^{(-2/3)})) / 100$$

Komponen	Tc (K)	Pc (atm)
H ₂	3.2	12.8
CH ₄	190.6	45.4
C ₈ H ₁₆	566.6	25.9
C ₈ H ₁₈	568.8	24.5

$$\mu_i = \frac{\sum \mu_i \cdot BM^{1/2} \cdot y_i}{\sum BM^{1/2} \cdot y_i}$$

c) Konduktivitas Thermal

$$\tau_i = \frac{T_c^{1/6} \cdot BM^{1/2}}{P_c^{2/3}}$$

$$k = ((14,54 \cdot T/T_c) - 5,14)^{2/3} \cdot C_p/\tau_i \cdot 10^6$$

Komponen	Tc (K)	Pc (atm)
H ₂	3.2	12.8
CH ₄	190.6	45.4
C ₈ H ₁₆	566.6	25.9
C ₈ H ₁₈	568.8	24.5

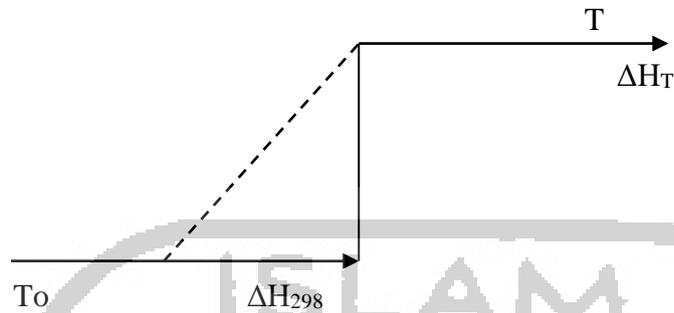
d) Sifat Pendingin

$$C_p = 0,509 \text{ Btu/lb}^\circ\text{K}$$

$$\mu = 0,40 \text{ micropoise.K}$$

$$k = 0,68 \text{ Btu/jam.ft.}^\circ\text{K}$$

PANAS REAKSI



$$\Delta H_T = \Delta H_{298} + \int \Delta C_p dT$$

Dimana :

$$\begin{aligned} \Delta H_{R\ 298} &= \Delta H_f^0 \text{ produk} - \Delta H_f^0 \text{ reaktan} \\ &= (\Delta H_f^0 \text{ C}_8\text{H}_{18}) - (\Delta H_f^0 \text{ C}_8\text{H}_{16} + \Delta H_f^0 \text{ H}_2) \\ &= -54.6100 + 2(-242,76) - (-99.16) - 3(0) \\ &= -440,97 \text{ KJ/mol} \\ &= -440970 \text{ J/mol} \end{aligned}$$

Komponen	Cp (Kcal/mol.K)			
	A	B	C	D
H ₂	6.483	0.00222	-3.3E-06	1.83E-09
CH ₄	4.598	0.01245	2.86E-06	-2.70E-09
C ₈ H ₁₆	-15.26	0.2124	-0.000122	2.634E-08
C ₈ H ₁₈	-1.782	0.1858	-1.024E-4	2.191E-08

$$\Delta H_{R(T)} = \Delta H_{R\ 298} + \int (\Delta\alpha + \Delta\beta T + \Delta\gamma T^2 + \Delta\delta T^3) dT$$

$$\Delta\alpha = A_P - A_R = -31,344$$

$$\Delta\beta = B_P - B_R = -3,94 \cdot 10^{-2}$$

$$\Delta\gamma = C_P - C_R = 2,441 \cdot 10^{-5}$$

$$\Delta\delta = D_P - D_R = -5,192 \cdot 10^{-9}$$

Sehingga :

$$\Delta H_{R(T)} = \Delta H_{R\ 298} + \int (\Delta\alpha + \Delta\beta T + \Delta\gamma T^2 + \Delta\delta T^3) dT$$

$$\begin{aligned} \Delta H_{R(T)} &= -440970 \text{ J/mol} + \left(\int (-31,3442 - 3,94 \cdot 10^{-2} (T - T_{\text{ref}}) + 2,441 \cdot 10^{-5} (T^2 - T_{\text{ref}}^2) - 5,192 \cdot 10^{-9} (T^3 - T_{\text{ref}}^3) dT \right) \text{ J/mol} \\ &= -440970 \text{ J/mol} + (-31,3442 (T - T_{\text{ref}}) - \frac{1}{2} 3,94 \cdot 10^{-2} (T^2 - T_{\text{ref}}^2) + \frac{1}{3} 2,441 \cdot 10^{-5} (T^3 - T_{\text{ref}}^3) - \frac{1}{4} 5,192 \cdot 10^{-9} (T^4 - T_{\text{ref}}^4)) \\ &= (-440970 - 31,3442 (T - T_{\text{ref}}) - 1,97 \cdot 10^{-2} (T^2 - T_{\text{ref}}^2) + 8,13727 \cdot 10^{-6} (T^3 - T_{\text{ref}}^3) - 1,298 \cdot 10^{-9} (T^4 - T_{\text{ref}}^4)) \text{ J/mol} \end{aligned}$$

KECEPATAN MASSA MASUK REAKTOR

Komponen	Kgmol /jam	Kg / jam
C8H16	593.6423	66487.9375
H2	1187.2845	2374.5691
CH4	50.2177	803.4832
C8H18	11.3996	1299.5544

Total 1842.5441 70965.5391

Kecepatan massa = 70965.5391 Kg/j
 = 19712.6504 g/dt
 BM rata-rata = 38.51
 Suhu Umpan (T) = 573 oK
 Tekanan Umpan (P) = 2 atm
 Densitas gas (rho) = 0.001802 g/cm³
 Viskositas gas = 0.000539 g/cm dt

Digunakan pipa Standard
 ID pipa = 1.049 in = 2.664 cm
 OD pipa = 1.320 in = 3.353 cm
 BWG = 16 in

A. Jumlah pipa maximum :

1. Menghitung Gt :

$$4100 = \frac{Fre \cdot Dp \cdot Gt}{u}$$

$$= \frac{50.5 \cdot 0.3635 \text{ cm} \cdot Gt}{0.0005390 \text{ (g / cm dt)}}$$

$$= 34057.05 \text{ Gt}$$

$$Gt = 0.120386 \text{ g/cm}^2 \text{ dt}$$

2. Menghitung Luas penampang pipa :

$$Ao = \frac{3.14 \cdot DI^2 \cdot e}{4}$$

$$= \frac{3.14 \cdot (2.6645 \text{ cm})^2 \cdot 0.36}{4}$$

$$= 2.0063 \text{ cm}^2$$

3. Menghitung Luas penampang total :

$$\begin{aligned}
 A_t &= \frac{G}{G_t} \\
 &= \frac{19712.6504 \text{ g/dt}}{0.1204 \text{ g/cm}^2 \text{ dt}} \\
 &= 163745.0625 \text{ cm}^2
 \end{aligned}$$

Menghitung Jumlah pipa maximum :

$$\begin{aligned}
 N_t \text{ max} &= \frac{A_t}{A_o} \\
 &= \frac{163745.0625 \text{ cm}^2}{2.0063 \text{ cm}^2} \\
 &= 81616.4297 \text{ pipa}
 \end{aligned}$$

B. Jumlah pipa minimum :

1. Menghitung Kecepatan maximum :

$$\begin{aligned}
 v \text{ max} &= \left[\frac{4 \cdot (r_b - r_g) \cdot g \cdot D_p}{3 \cdot r_g \cdot f_D} \right]^{1/2} \\
 &= \left[\frac{4 \cdot (1.1940 - 0.001802) \cdot 981 \cdot 0.3635}{3 \cdot 0.0018020 \cdot 1} \right]^{1/2} \\
 &= 560.8506 \text{ cm/dt}
 \end{aligned}$$

2. Menghitung Kecepatan Volume Umpan :

$$\begin{aligned}
 F_v &= \frac{G}{r_g} \\
 &= \frac{19712.6504 \text{ g/dt}}{0.0018 \text{ g/cm}^3} \\
 &= 10939030.0000 \text{ cm}^3/\text{dt}
 \end{aligned}$$

3. Menghitung Luas penampang total :

$$At = \frac{Fv}{v \max}$$

$$= \frac{10939030.0000 \text{ cm}^3/\text{dt}}{560.8506 \text{ cm}/\text{dt}}$$

$$= 19504.3574 \text{ cm}^2$$

Menghitung Jumlah pipa minimum :

$$Nt \text{ min} = \frac{At}{Ao}$$

$$= \frac{19504.3574 \text{ cm}^2}{2.0063 \text{ cm}^2}$$

$$= 9721.6738 \text{ pipa}$$

C. Jumlah pipa :

1. Menghitung Gt :

diambil bilangan Reynold (Re) = 30000

$$Re = \frac{Fre \cdot Dp \cdot Gt}{u}$$

$$= \frac{50.5 \cdot 0.3635 \text{ cm} \cdot Gt}{0.0005390 \text{ (g / cm dt)}}$$

$$= 34057.05 \text{ Gt}$$

$$Gt = \frac{30000}{34057.05} \text{ g/cm}^2 \text{ dt}$$

$$= 0.880875 \text{ g/cm}^2 \text{ dt}$$

2. Menghitung Luas penampang pipa :

$$Ao = \frac{3.14 \cdot DI^2 \cdot e}{4}$$

$$= \frac{3.14 \cdot (2.6645 \text{ cm})^2 \cdot 0.36}{4}$$

$$= 2.0063 \text{ cm}^2$$

3. Menghitung Luas penampang total :

$$At = \frac{G}{Gt}$$

$$= \frac{19712.6504 \text{ g/dt}}{0.8809 \text{ g/cm}^2 \text{ dt}}$$

$$= 22378.4922 \text{ cm}^2$$

Menghitung Jumlah pipa :

$$Nt = \frac{At}{Ao}$$

$$= \frac{22378.4922 \text{ cm}^2}{2.0063 \text{ cm}^2}$$

$$= 11154 \text{ pipa}$$

REAKTOR FIXBED MULTITUBE

Jumlah pipa = 11154 pipa
 Diameter luar pipa = 3.353 cm
 Diameter dalam pipa = 2.664 cm
 Pitch = 4.191 cm
 Diameter Shell = 5.357 m
 Jumlah pendingin = 722779.188 Kg/j

KECEPATAN MASSA MASUK REAKTOR

Komponen	Kgmol /jam	Kg / jam
C8H16	593.6423	66487.9375
H2	1187.2845	2374.5691
CH4	50.2177	803.4832
C8H18	11.3996	1299.5544

Total 1842.5441 70965.5391

Enthalpi Umpan Masuk Reaktor :

Suhu operasi = 300.00 C
 Suhu refferensi = 25 C

Komponen	Kgmol /jam	Cp dT	Qs = m Cp dT
H2	1187.2845	1916.57	2275516.7500
CH4	50.2177	2842.10	142723.7656
C8H16	593.6423	15324.45	9097242.0000
C8H18	11.3996	16790.80	191408.4063

Total 1842.5441 11706891.0000

KONDISI AWAL

Suhu gas masuk	= 300.0 °C
Suhu pendingin keluar	= 230.0 °C
Tekanan awal	= 3.2 atm
Increment tebal katalis	= 1.00 cm

L (cm)	Xa	T (c)	Td (c)	P (atm)
0	0.0000	300.00	230.0	3.200
10	0.0900	308.59	229.4	3.198
20	0.1819	316.79	228.6	3.197
30	0.2727	324.24	227.8	3.195
40	0.3596	330.55	227.0	3.194
50	0.4399	335.42	226.0	3.192
60	0.5118	338.69	225.1	3.191
70	0.5743	340.33	224.1	3.189
80	0.6275	340.45	223.0	3.188
90	0.6721	339.23	222.0	3.186
100	0.7090	336.91	221.0	3.185
110	0.7395	333.71	220.0	3.184
120	0.7647	329.86	219.0	3.182
130	0.7854	325.52	218.1	3.181
140	0.8026	320.86	217.2	3.180
150	0.8169	315.99	216.3	3.178
160	0.8288	311.02	215.5	3.177
170	0.8388	306.00	214.6	3.176
180	0.8473	301.02	213.9	3.175
190	0.8545	296.10	213.1	3.174
200	0.8607	291.29	212.4	3.172
210	0.8661	286.61	211.8	3.171
220	0.8707	282.07	211.1	3.170
230	0.8747	277.69	210.5	3.169
240	0.8783	273.48	210.0	3.168
250	0.8814	269.45	209.4	3.167
260	0.8842	265.59	208.9	3.165
270	0.8866	261.91	208.4	3.164
280	0.8888	258.40	208.0	3.163
290	0.8908	255.06	207.6	3.162
300	0.8926	251.89	207.2	3.161
310	0.8943	248.89	206.8	3.160
320	0.8958	246.04	206.4	3.159
330	0.8971	243.35	206.1	3.158

340	0.8984	240.81	205.8	3.157
350	0.8996	238.40	205.5	3.156
360	0.9007	236.14	205.2	3.155
370	0.9017	234.00	205.0	3.154
380	0.9026	231.98	204.7	3.153
390	0.9035	230.09	204.5	3.151
400	0.9043	228.30	204.3	3.150
410	0.9051	226.63	204.1	3.149
420	0.9059	225.05	203.9	3.148
430	0.9066	223.57	203.7	3.147
440	0.9072	222.18	203.5	3.146
450	0.9079	220.87	203.4	3.145
460	0.9085	219.64	203.2	3.144
470	0.9091	218.49	203.1	3.143
480	0.9096	217.41	203.0	3.142
490	0.9102	216.40	202.8	3.141
500	0.9107	215.46	202.7	3.140
510	0.9112	214.57	202.6	3.139
520	0.9117	213.74	202.5	3.138
530	0.9122	212.96	202.4	3.137
540	0.9127	212.23	202.3	3.136
550	0.9131	211.54	202.3	3.135
560	0.9136	210.90	202.2	3.134
570	0.9140	210.30	202.1	3.133
580	0.9144	209.74	202.0	3.132
590	0.9148	209.22	202.0	3.131
600	0.9152	208.73	201.9	3.130
610	0.9156	208.27	201.9	3.129
620	0.9160	207.84	201.8	3.128
630	0.9164	207.44	201.7	3.127
640	0.9168	207.06	201.7	3.126
650	0.9171	206.71	201.7	3.125
660	0.9175	206.38	201.6	3.124
670	0.9179	206.07	201.6	3.123
680	0.9182	205.78	201.5	3.122
690	0.9186	205.51	201.5	3.121
700	0.9189	205.26	201.5	3.120
710	0.9192	205.02	201.4	3.119
713	0.9193	204.95	201.4	3.119

KECEPATAN MASSA GAS KELUAR REAKTOR

Komponen	Kgmol /jam	Kg / jam
C8H16	47.9069	5365.5752
H2	641.5492	1283.0984
CH4	50.2177	803.4832
C8H18	557.1349	63513.3867
Total	1296.8088	70965.5469

Enthalpi Hasil reaksi :

Suhu operasi = 204.95 C

Suhu refferensi = 25 C

Komponen	Kgmol /jam	Cp dT	Qs = m Cp dT
H2	641.5492	1250.89	802506.0000
CH4	50.2177	1745.55	87657.5000
C8H16	47.9069	9010.79	431678.9688
C8H18	557.1349	10070.41	5610576.0000
Total	1296.8088		6932418.5000

NERACA PANAS :

MASUK :

1. Enthalpi Umpan Masuk Reaktor

Qs1 = 11706891.0000 Kcal/j

2. Panas Reaksi

Qr=7310473.0000 Kcal/j

Kcal/j

=604247.3125Kcal/j

--

19017364.0000 Kcal/jam

KELUAR :

1. Enthalpi hasil reaksi:

Qs2 =6932418.5000Kcal/j

2. Panas dibawa pendingin

Qp = 11480699.0000

3. Panas Hilang

Qloss

19017364.0000 Kcal/jam

Dari hasil perhitungan Reaktor diperoleh :

Jumlah pipa = 11154 pipa

Diameter Shell = 5.357 m

Jumlah pendingin = 722779 Kg/j

Panjang katalis = 7.1 m

= 23.4 ft

Panjang Pipa = 7.3 m

= 24.0 ft

Menghitung Tebal Shell

Digunakan bahan Stainless Steel SA 167 grade 3

Tekanan design (p) = 36,75 psi

Allowable stress = 15100 psi

efisiensi sambungan = 0,85

faktor korosi = 0,125 in

Jari-jari tangki = 421,64 in

Tebal Shell :

$$\begin{aligned}t_{\text{shell}} &= \frac{p \cdot r_i}{S \cdot e - 0,4 \cdot p} + c \\&= \frac{36,75 \cdot 421,64}{15100,00 \cdot 0,85 - 0,4 \cdot 36,75} + 0,125 \\&= 1,334 \text{ in}\end{aligned}$$

Dipakai tebal shell 1 6/16 in

Menghitung tebal head

Bentuk head : Elliptical Dished Head

Digunakan bahan Stainless steel SA 167 grade 3

Tekanan design (p) = 36.30 psi

Allowable stress = 15100 psi

efisiensi sambungan = 0.85

faktor korosi = 0.125 in

Jari-jari tangki = 421.64 in

Tebal Head :

$$\begin{aligned}t \text{ head} &= \frac{0,885 \cdot p \cdot d}{2 \cdot S \cdot e - 0,2 \cdot p} + c \\&= \frac{0,885 \cdot 36,30 \cdot 843,28}{2 \cdot 15100,00 \cdot 0,85 - 0,2 \cdot 36,30} + 0,125 \\&= 1,181 \text{ in}\end{aligned}$$

Dipilih tebal head 1 3/16 in

Menghitung ukuran pipa

Diameter Optimum pipa berdasarkan Pers. 15 Peters, hal.525

a. Pipa pemasukan Umpan Reaktor :

$$\text{Kecepatan Umpan} = 469060,281 \text{ lb/j}$$

$$\text{Densitas Umpan} = 0,1363 \text{ lb/ft}^3$$

$$\begin{aligned}D_i &= 2,2 \cdot (G/1000)^{0,45} \cdot \rho^{(-0,31)} \\&= 2,2 \cdot (469060,281 / 1000)^{0,45} \cdot 0,1363^{(-0,31)} \\&= 64,981 \text{ in}\end{aligned}$$

Dipakai pipa dengan ukuran : 65,00 in

b. Pipa pengeluaran hasil Reaktor :

$$\text{Kecepatan hasil} = 469060,281 \text{ lb/j}$$

$$\text{Densitas hasil} = 0,1329 \text{ lb/ft}^3$$

$$\begin{aligned}D_i &= 2,2 \cdot (G/1000)^{0,45} \cdot \rho^{(-0,31)} \\&= 2,2 \cdot (469060,281 / 1000)^{0,45} \cdot 0,1329^{(-0,31)} \\&= 65,497 \text{ in}\end{aligned}$$

Dipakai pipa dengan ukuran : 65,50 in

c. Pipa pemasukan dan pengeluaran Hi-Tech :

$$\text{Kecepatan Hi-Tech} = 110000,0078 \text{ lb/j}$$

$$\text{Densitas Hi-Tech} = 55.9728 \text{ lb/Ft}^3$$

$$D_i = 2,2 \cdot (L/1000)^{0,45} \cdot \rho^{(-0,31)}$$

$$= 2,2 \cdot (110000,008 / 1000)^{0,45} \cdot 55,9728^{(-0,31)}$$

$$= 5,238 \text{ in}$$

Dipakai pipa dengan ukuran : 5,25 in

Menghitung tebal Isolasi

$$\text{Diameter shell} = 10,89 \text{ ft}$$

$$\text{Tinggi shell} = 32,00 \text{ ft}$$

$$\text{Tebal shell} = 0,111 \text{ ft}$$

$$\text{Luas permukaan head} = 223,53 \text{ ft}^2$$

$$\text{Luas permukaan shell} = 1094,47 \text{ ft}^2$$

$$\text{Total luas permukaan} = 1317,99 \text{ ft}^2$$

$$\text{Suhu permukaan isolasi} = 167,00 \text{ }^\circ\text{F} = 707,00 \text{ }^\circ\text{R}$$

$$\text{Suhu dalam reaktor} = 644,90 \text{ }^\circ\text{F} = 1184,90 \text{ }^\circ\text{R}$$

$$\text{Suhu udara lingkungan} = 86,00 \text{ }^\circ\text{F} = 626,00 \text{ }^\circ\text{R}$$

$$\text{Konduktifitas thermal dinding shell} = 26,0000 \text{ Btu ft/(j ft}^2 \text{ F)}$$

Digunakan Isolasi Fine Diatomaceous earth powder

$$\text{Konduktifitas thermal isolasi} = 0,1400 \text{ Btu ft/(j ft}^2 \text{ F)}$$

Koeffisien transfer panas konveksi (hc) :

$$\begin{aligned}
 h_c &= 0,19 \left[T_w - T_u \right]^{1/3} \\
 &= 0,19 \left[707,00 - 626,00 \right]^{1/3} \\
 &= 0,8220822 \text{ Btu/j ft}^2 \text{ F}
 \end{aligned}$$

Panas yang hilang bila digunakan tebal isolasi = 0 in

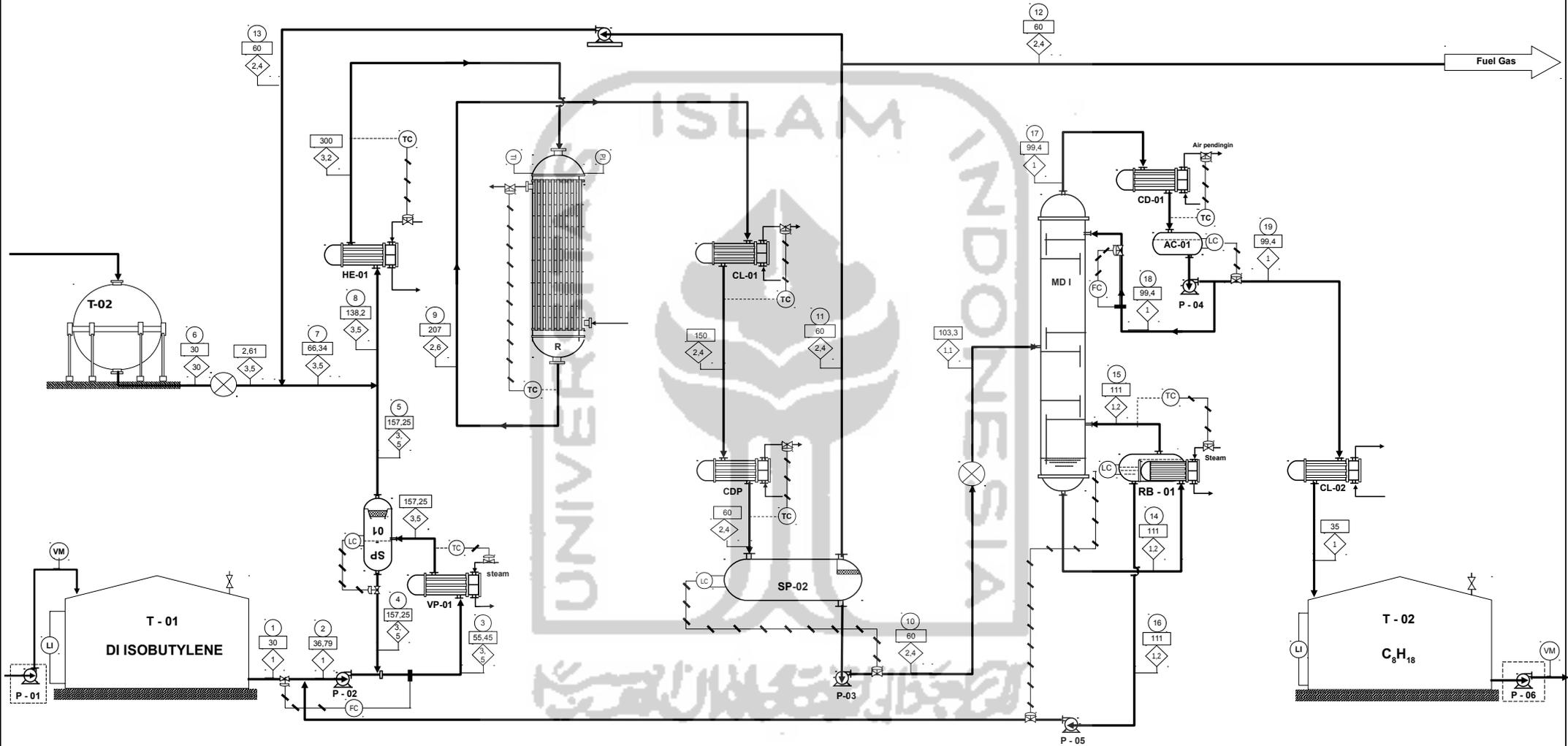
$$\begin{aligned}
 Q_{\text{loss}} &= \frac{A \cdot (T_1 - T_u)}{\left[\frac{t_1}{k_1} + \frac{t_2}{k_2} + \frac{1}{(h_r + h_c)} \right]} \\
 &= \frac{1317,993 \cdot (644,90 - 86,00)}{\left[\frac{0,111}{26,00} + \frac{T_{\text{is}}}{0,140} + \frac{1}{0,8221} \right]} = \frac{1239567,125}{\left[\frac{0,111}{26,00} + \frac{T_{\text{is}}}{0,140} + \frac{1}{0,8221} \right]} = 1317,993 (644,90 - 86,00) \\
 &= 1,683 \\
 \left[\frac{0,00428}{0,1400} + \frac{T_{\text{is}}}{0,1400} + \frac{1,21642}{0,1400} \right] &= 1,683 \\
 \left[\frac{T_{\text{is}}}{0,1400} \right] &= 0,462
 \end{aligned}$$

$$\begin{aligned}
 T_{\text{isolasi}} &= 0,065 \text{ ft} \\
 &= 0,776 \text{ in}
 \end{aligned}$$

Digunakan tebal isolasi = 1 in

PROCESS ENGINEERING FLOW DIAGRAM PRARANCANGAN PABRIK ISO OKTANA DARI DI ISOBUTILENA

KAPASITAS PRODUKSI : 500.000 TON / TAHUN



ARUS MASSA (Kg/Jam)

NO	KOMPONEN	NOMOR ARUS																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	H ₂						1476.40	2374.57	2374.57	1283.10		1283.10	384.93	898.17						
2	CH ₄						241.04	803.48	803.48	803.48		803.48	241.04	562.44						
3	C ₄ H ₁₀	620.60	1255.10	1568.87	313.77	1255.10		44.46	1299.56	63513.39	63449.87	63.51	19.05	44.46	9474.97	8840.47	634.50	84680.06	21864.69	62815.37
4	C ₈ H ₁₈	61439.39	66484.73	83105.91	16621.18	66484.73		3.21	66487.93	5365.58	5361.00	4.58	1.37	3.21	75342.09	70296.75	5045.34	425.53	109.87	315.66
Jumlah		62059.99	67739.83	84674.78	16934.96	67739.83	1717.45	3225.72	70965.54	70965.54	68810.87	2154.68	646.40	1508.27	84817.06	79137.22	5679.84	85105.59	21974.56	63131.03

KETERANGAN	
AC	Accumulator
C	Compressor
CD	Condenser
CL	Cooler
EV	Expantion Valve
IC	Inter Cooler
HE	Heater
MD	Menara Distilasi
P	Pompa
R	Reaktor
RB	Reboiler
SP	Separator
T	Tangki
LC	Level Controller
LI	Level Indicator
PI	Pressure Indicator
TC	Temp. Controller
TV	Temp. Controller
VM	Volume Meter
FC	Flow Controller
N	Nomor Arus
°C	Temperatur (°C)
atm	Tekanan (Atm.)
—	Pipa
—	Udara Tekan
—	Sambungan Listrik



UNIVERSITAS ISLAM INDONESIA

JURUSAN TEKNIK KIMIA
FAKULTAS TEKNOLOGI INDUSTRI
UNIVERSITAS ISLAM INDONESIA
YOGYAKARTA

PROCESS ENGINEERING FLOW DIAGRAM
PRARANCANGAN PABRIK ISO OKTANA DARI DI ISOBUTILENA
KAPASITAS PRODUKSI : 500.000 TON / TAHUN

Dikerjakan oleh :

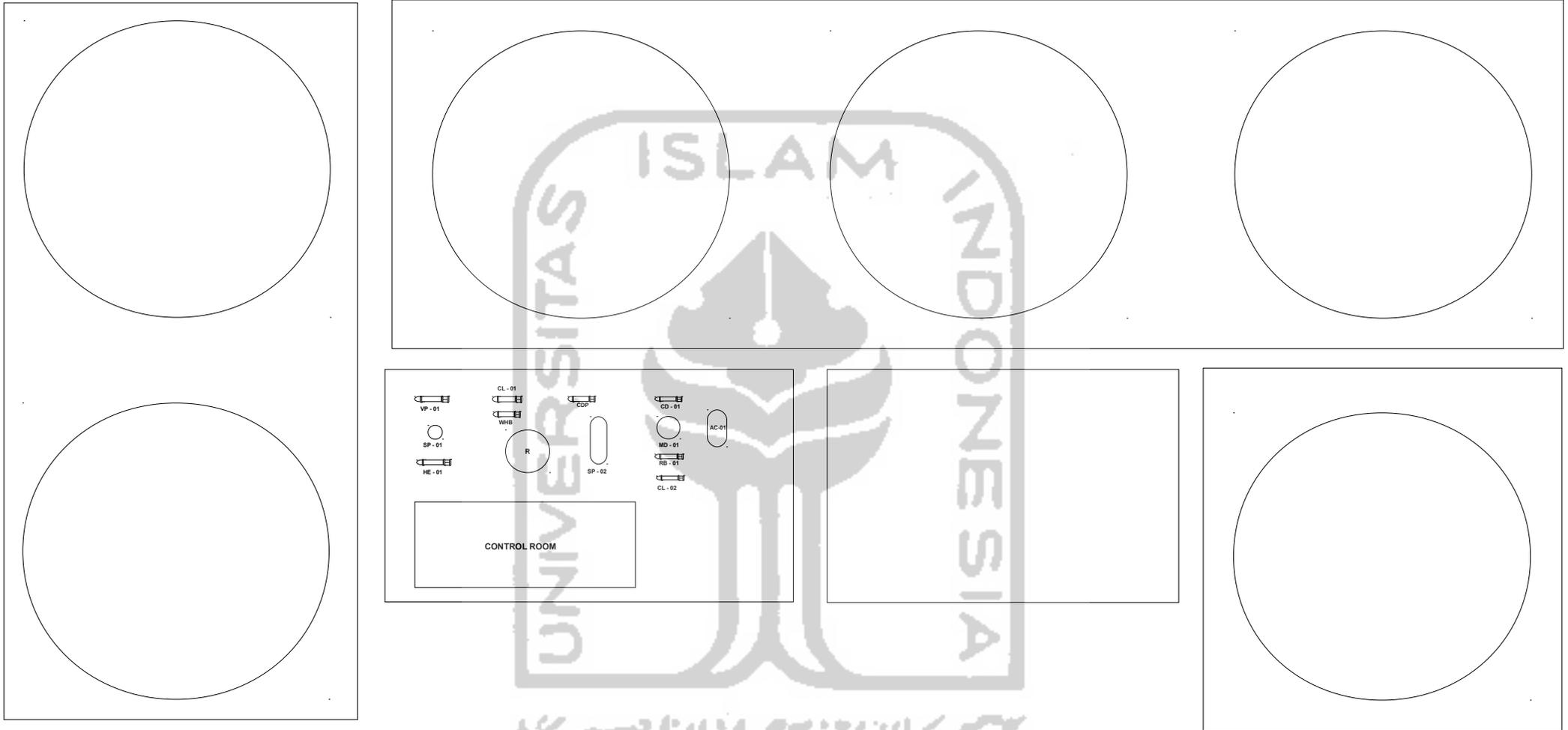
N A M A : 1.

DOSEN PEMBIMBING : 2.

2.

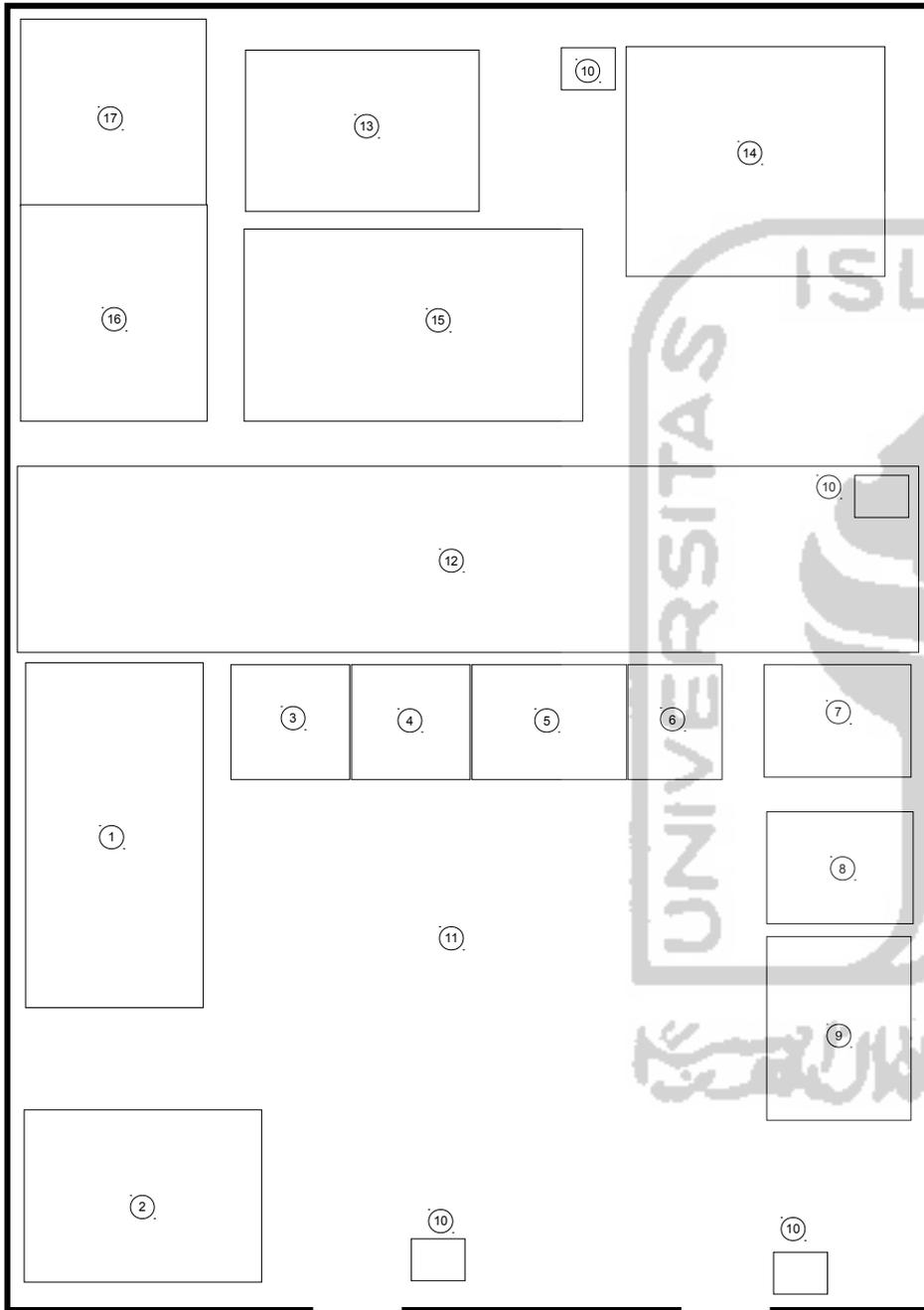
H2
CH4
C8H18
C8H16





SKALA 1 : 100

TATA LETAK ALAT



KETERANGAN :

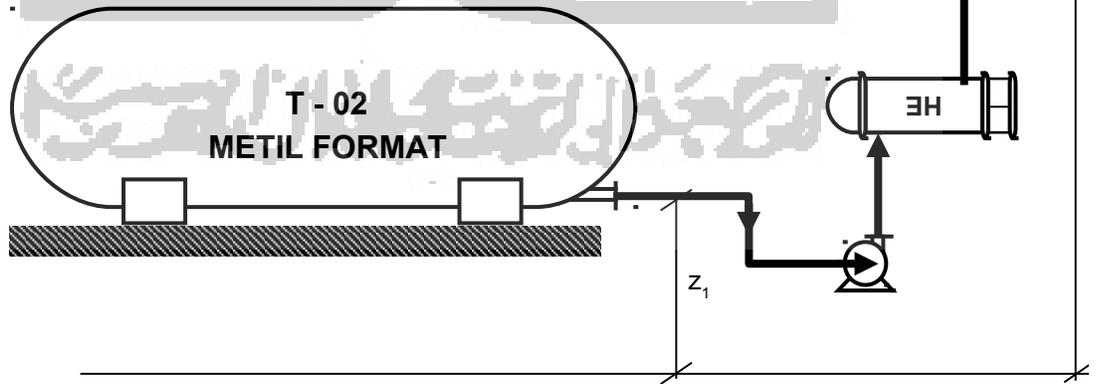
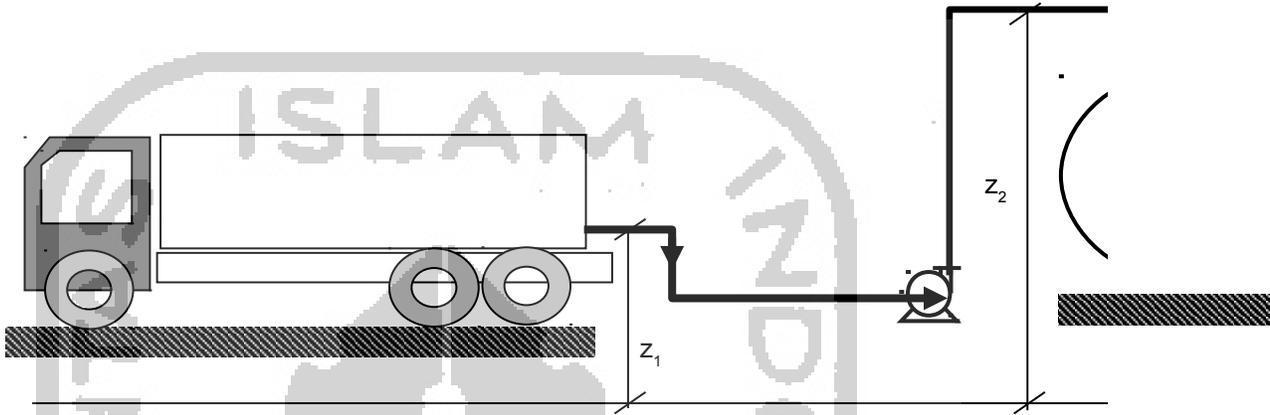
1. Gedung Pertemuan
2. Gedung Kantor utama
3. Gedung Tempat Ibadah
4. Gedung Klinik
5. Gedung Kantin
6. Gedung Laboratorium
7. Gedung Bengkel
8. Gedung Logistik I
9. Gedung Logistik II
10. Pos jaga
11. Area Parkir dan taman
12. Area Parkir Utama
13. Area Tangki I
14. Area Tangki II
15. Area Proses
16. Area Utilitas
17. Area UPL
18. Area Perluasan Pabrik

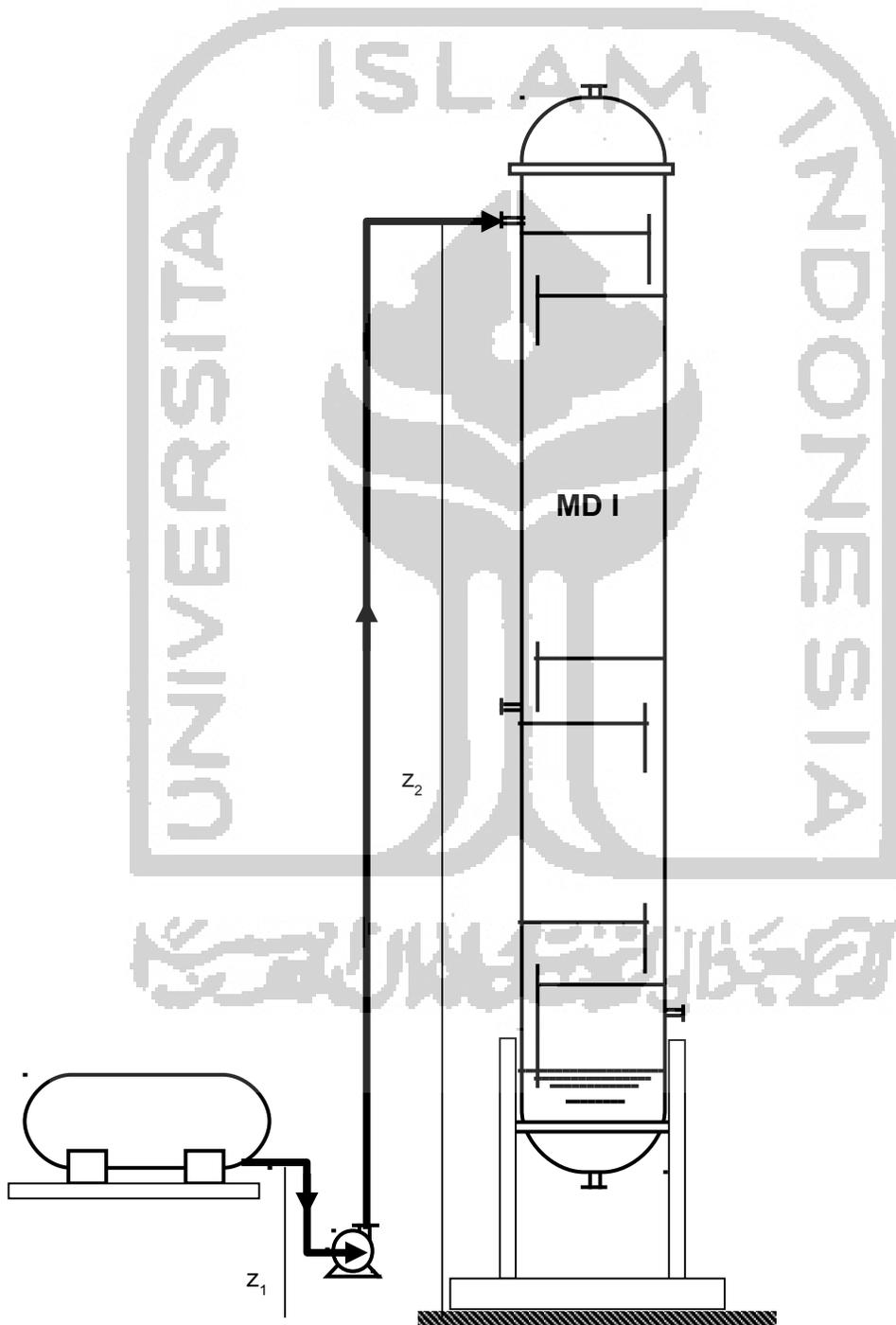
SKALA 1 : 200

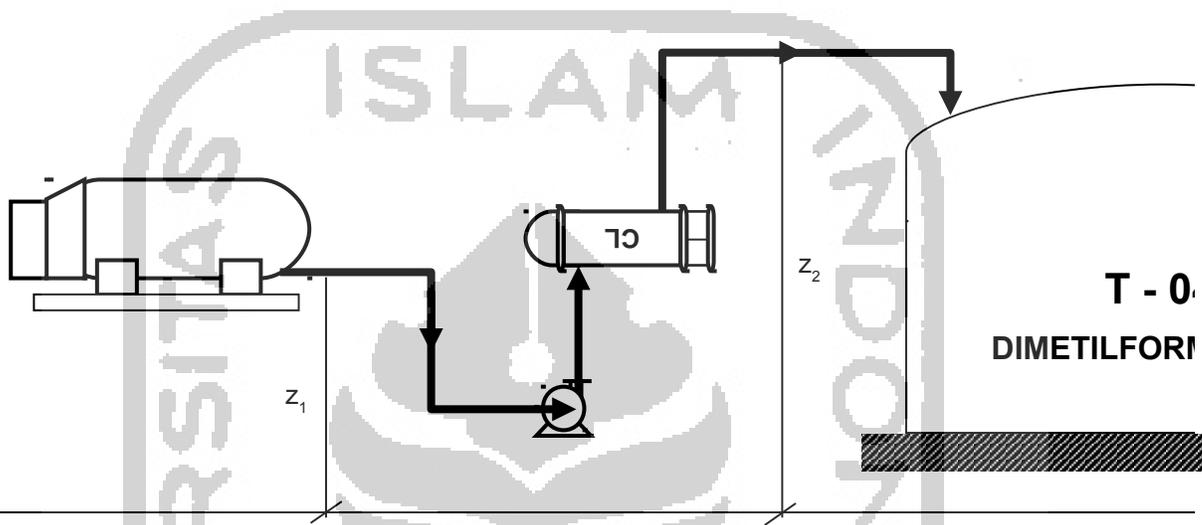
JALAN RAYA



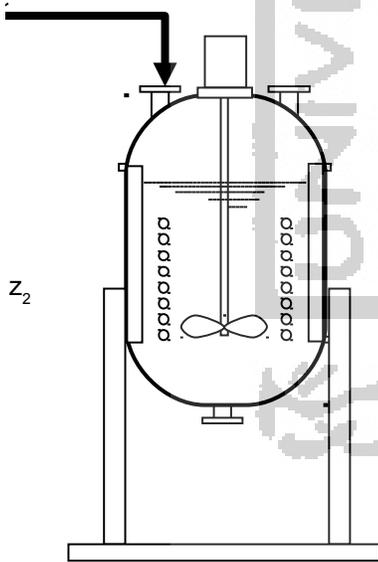
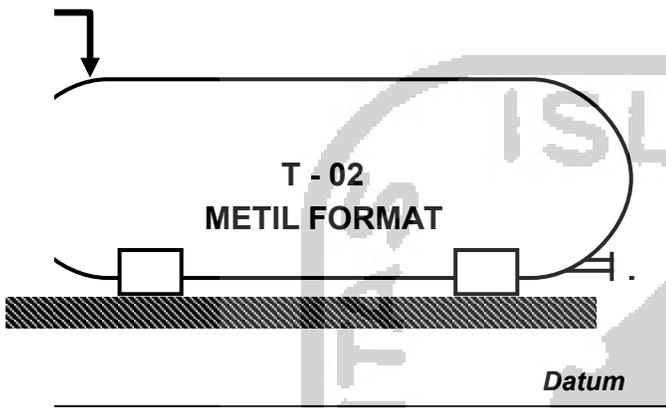
جامعة الإسلام في إندونيسيا

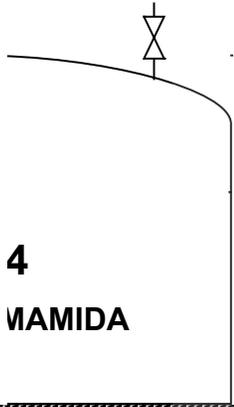






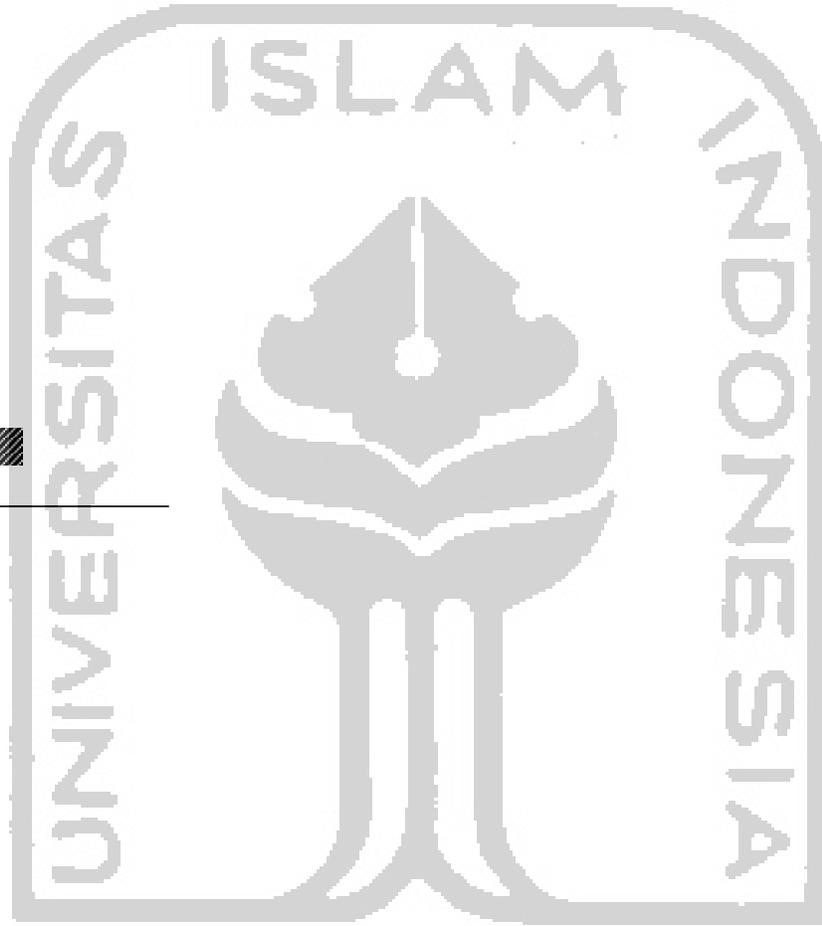
UNIVERSITAS ISLAM INDONESIA





4

MAMIDA



جامعة الإسلام في إندونيسيا

T1 8 2 4 0.8 10

T2 15 2 7.5

16.77 2 8.385
28.52 2 14.26

MD1 1.06 1 1.06 3.5 0.302857
MD2 1.099 1 1.099
R 1.32 1 1.32
SP1 1.093927 1 1.093927

1 0
1 0

AC-01 1.2 1 1.2
2.24 1 2.24

AC-02 0.91 1 0.91
1.83 1 1.83

VP 1.5 0
HE 1.5 0
CL-01 1.5 0
CL-02 1.5 0
CL-03 1.5 0
CL-04 1.5 0

Panjang 15 1.5 10
Lebar 10 1.5 6.666667

16.77 1 16.77
28.52 1 28.52

1.176528
3.944112

