LAMPIRAN A

REAKTOR

Jenis : Reaktor *Fixed Bed Multitube*

Fungsi : Tempat berlangsungnya reaksi antara Carbon Dioksida (CO_2) dan Carbon Monoksida (CO) dengan Hidrogen (H_2) menjadi Methanol (CH_3OH)

Kondisi Operasi : Suhu = 200 ^oC

Tekanan = 3 atm

Reaksi = Eksotermis

Fase = Gas

Katalis : $CuO/ZnU/Al_2O_3$ γ-alumina

Reaksi yang terjadi didalam reaktor:

Reaksi 1 : $CO + 2H_2 \longrightarrow CH_3OH$

Reaksi 2 : $CO_2 + 3H_2 \longrightarrow CH_3OH + H_2O$

1. Menentukan jenis reaktor

   Dipilih reaktor fixed bed multitube dengan pertimbangan sebagai berikut:

   a. zat pereaksi berupa fasa gas dengan katalis padat

b. umur katalis panjang 12-15 bulan

c. reaksi eksotermis sehingga diperlukan luas perpindahan panas yang besar agar kontak dengan pendingin berlangsung optimal

d. tidak diperlukan pemisahan katalis dari gas keluaran reaktor

e. pengendalian suhu relatif mudah karena menggunakan tipe shell and tube

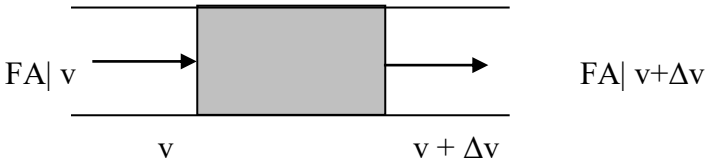
(Hill, hal 425-431)

2. Persamaan – persamaan Matematis Reaktor

a. Neraca massa reaktor

Reaksi berlangsung dalam keadaan steady state dalam reaktor setebal ΔZ dengan konversi X. Neraca massa CH_3OH pada elemen volume :

Input – Output – Yang bereaksi = 0



Keterangan: FA : Kecepatan massa methanol, Kgmol/s

V : Volume reactor

Δv : Penambahan volume, m^3

Rate of input – rate of output – rate of reaction = rate of accumulation

$$FA|v - FA|v+\Delta v - rA\,\Delta v = 0$$

$$FA|v - FA|v+\Delta v = rA * \Delta v$$

$$\frac{Lim}{\Delta v \to 0} \frac{FA|v - FA|v+\Delta v}{\Delta v} = rA$$

$$-\frac{dFA}{dv} = rA \qquad \text{dimana: } v = \frac{\pi Di^2}{4} Z$$

$$dv = \frac{\pi Di^2}{4} dZ$$

$$-\frac{dFA}{dZ} = rA\frac{\pi d^2}{4} \qquad \text{dimana: } FA = FAo(1 - XA)$$

$$dFA = -FAo\ dX$$

$$\frac{FAo\ dX}{dZ} = rA\frac{\pi d^2}{4}$$

$$\frac{dX}{dZ} = -rA\frac{\pi d^2}{4}\frac{1}{FAo}$$

Untuk Nt buah pipa :

$$\frac{dX}{dZ} = -rA\ Nt\frac{\pi d^2}{4}\frac{1}{FAo}$$

dimana : $\frac{dXA}{dz}$ = perubahan konversi persatuan panjang

Nt = Jumlah tube

$(-r_A)$ = kecepatan reaksi = k C_A. C_B

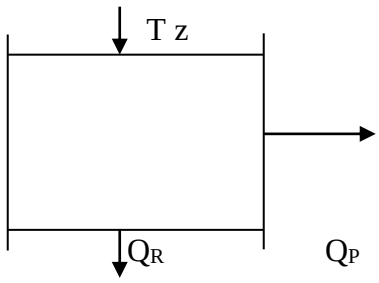
Z = tebal tumpukan katalisator

Di = diameter dalam pipa

Tabel 1 Komposisi Dengan Perhitungan Kapasitas Reaktor

Input	**Massa, Kg/Jam**	**Output**	**Massa, Kg/Jam**
CO	10.663,8060	CO	390,6152
CO2	64.981,9304	CO2	45.933,1317
O2	1.989,5890	O2	1.969,6873
H2O	5.272,3683	H2O	12.746,5028
H2	2.388,1077	H2	574,8852
CH4	600,1927	CH4	600,1927
		CH3OH	25252,5217

b. Neraca panas elemen volume



Q_R = panas reaksi

Q_P = panas yang dibuang, ada pendinginan

Heat of input –Heat of output + Heat of generation - Heat transfer = Acc

$$H|_z - H|_{z+\Delta z} + (-r_A).\Delta H_R.V - Ud.Nt.\Delta z.\pi.OD.(T - T_P) = 0$$

$$H|_z - H|_{z+\Delta z} + (-r_A).\Delta H_R.\frac{\pi}{4}.ID^2.\Delta z.Nt - Ud.Nt.\Delta z.\pi.OD.(T - T_P) = 0$$

$$H|_z - H|_{z+\Delta z} = -(-r_A).\Delta H_R.\frac{\pi}{4}.ID^2.\Delta z.Nt + Ud.Nt.\Delta z.\pi.OD.(T - T_P)$$

$$\frac{H|_z - H|_{z+\Delta z}}{\Delta z} = -(-r_A).\Delta H_R.\frac{\pi}{4}.ID^2.Nt + Ud.Nt.\pi.OD.(T - T_P)$$

$$\lim_{\Delta z \to 0} \frac{H|_z - H|_{z+\Delta z}}{\Delta z} = -(-r_A).\Delta H_R.\frac{\pi}{4}.ID^2.Nt + Ud.Nt.\pi.OD.(T - T_P)$$

$$-\frac{dH}{dz} = -(-r_A).\Delta H_R.\frac{\pi}{4}.ID^2.Nt + Ud.Nt.\pi.OD.(T - T_P)$$

$$\frac{dH}{dz} = (-r_A).\Delta H_R.\frac{\pi}{4}.ID^2.Nt - Ud.Nt.\pi.OD.(T - T_P)$$

Dimana :

H = Q = $\sum$ Fi.Cpi.(T - Tref)

dH = $\sum$ Fi.Cpi. dT

$$\sum Fi.Cpi.\frac{dT}{dz} = (-r_A).\Delta H_R.\frac{\pi}{4}.ID^2.Nt - Ud.Nt.\pi.OD.(T - T_P)$$

$$\frac{dT}{dz} = \frac{F_{A0}.(\Delta H_R).\frac{dx}{dz} - Ud.Nt.\pi.OD.(T - T_P)}{\sum Fi.Cpi}$$

Dimana:

$\frac{dT}{dZ}$ = Perubahan Suhu persatuan panjang katalis

ΔH_R = Panas Reaksi

Ud = Overall heat transfer coefficient

Do = Diameter luar

T = Suhu gas

Ts = Suhu referensi

f. Neraca panas untuk pendingin

Pendingin yang dipakai adalah Dowtherm A yang stabil pada suhu 155 – 255 ^{0}C

Komposisi Dowtherm A : - 73,5 % Diphenyl Oxyde

- 26,5 % Diphenyl

Sifat-sifat fisis Dowtherm A (T dalam K) dari Hidrocarbon Processing.

Cp = 0.1152 + 0.0003402 T.cal/gr.K

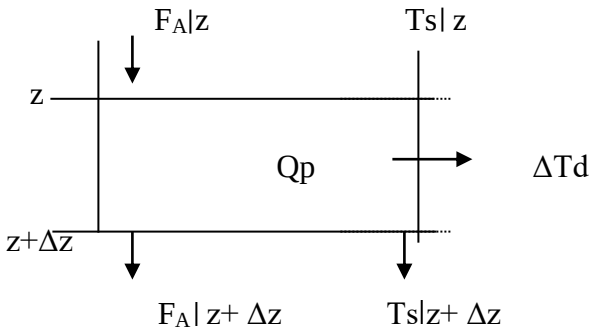
ρ = 1.3644 - 9.7073.10^{-4} T.g/cm3

μ = 35.5898 - 6.04212 T(g/cm.J)

k = 1.512 - 0.0010387 T.cal/g.cm.K1

Aliran pendingin dalam reaktor searah dengan aliran gas

Neraca Panas pada elemen volum



$ms.Cps\ (\ Ts|_Z - T_o\ ) + Qp - ms\ Cps\ (Ts|_{z+\Delta z} - To) = 0$

$ms.Cps\ (Ts|_Z - Ts|_{z+\Delta z}) = -\ Qp$

$$(Ts|_Z - Ts|_{z+\Delta z}) = -\ \frac{U.\pi.Do.Nt.\Delta z.(T - Ts)}{(m.Cp)s}$$

$$(Ts|_Z - Ts|_{z+\Delta z}) / \Delta z = -\ \frac{U.\pi.Do.Nt(T - Ts)}{(m.Cp)s}$$

$$-\ (Ts|_{z+\Delta z} - Ts|_Z) / \Delta z = -\ \frac{U.\pi.Do.Nt(T - Ts)}{(m.Cp)s}$$

$$\frac{\Delta Ts}{\Delta Z} = \frac{U.\pi.Do(T - Ts)}{(m.Cp)s}$$

$\lim \Delta Z \longrightarrow 0$

$$\frac{dTs}{dZ} = \frac{U.\pi.Do(T - Ts)}{(m.Cp)s}$$

g. Penurunan tekanan

Dalam pipa = penurunan tekanan dalam pipa berisi katalisator (Fixed bed) digunakan rumus 11.6 (chapter 11 hal 492 " Chemical Reactor Design For Process Plants".)

$$\frac{dP}{dZ} = \frac{G}{\rho g Dp} \cdot \frac{1-\varepsilon}{\varepsilon^3} \cdot \left[\frac{150(1-\varepsilon)\mu}{Dp} + 1{,}75G\right]$$

Dimana :

G = Kecepatan aliran massa gas dalam pipa, gr/cm^3

ρ = Densitas gas, gr/cm^3

Dp = Densitas pertikel katalisator, cm

G = Gaya Gravitasi, cm/det^2

ε = Porosity tumpukan katalisator

μ = Viskositas gas, gr/cm jam

Data – data sifat fisis bahan

a. Menentukan umpan Yi masuk

Tabel 2 Umpan YI Masuk Reaktor 2

Komponen	BMi (kg/kmol)	Massa (kg/jam)	Mol (kmol/jam)	yi
CO	44	10.663,8061	242,3592	0,0905
CO2	76	64.981,9305	855,0254	0,3195
O2	32	1.989,5830	62,1745	0,0232
H2O	18	5.272,3683	292,9094	0,1094
H2	2	2.188,1078	1094,0539	0,4088
CH4	20	600,1927	30,0096	0,0112
H2	2	200	100	0,0374
Total		85.895,9883	2676,5320	1

b. Menentukan volume gas reaktor

n = 2.676,5320 kmol/jam

R = 0,08206 atm.m^3/Kmol.^{o}K

P = 3 atm

Z = 1

$$V = \frac{nRT}{Z\,P} = 34629{,}3097 \text{ m3/jam}$$

c. Menetukan densitas umpan

$$\rho = \frac{\text{P. BM}}{\text{R. T. Z}} = \frac{(3\ \text{atm})\left(270\frac{\text{kg}}{\text{kmol}}\right)}{\left(0{,}08206\ \text{atm.}\frac{\text{m}^3}{\text{Kmol. K}}\right)(473\text{K})(1)} = 20{,}869\ \frac{\text{kg}}{\text{m}^3}$$

d. Menentukan viskositan umpan

$$\mu_{gas} = A + BT + CT^2$$

Tabel 3 Perhitungan Viskositas Umpan Masuk Reaktor 2

komponen	A	B	C	n gas, micropoise	(Poise=g/cm s)
co	23,811	5,39E-01	-1,54E-04	278,97	0,000278966
co2	11,811	4,98E-01	-1,09E-04	247,54	0,000247545
o2	44,224	5,62E-01	-1,13E-04	310,05	0,00031005
h2o	-36,826	4,29E-01	-1,62E-05	166,09	0,000166091
h2	27,758	2,12E-01	-3,28E-05	128,03	0,000128034
ch4	3,844	4,01E-01	-1,43E-01	193,57	0,000193574
n2	42,606	4,75E-01	-9,88E-05	267,28	0,000267281
h2	27,758	2,12E-01	-3,28E-05	128,03	0,000128034
TOTAL					0,001719575

e. Menentukan konduktivitas gas umpan

$$\text{k}_{\text{gas}} = \text{A} + \text{BT} + \text{CT}^2$$

Tabel 4 Data Konduktivitas Umpan Masuk Reaktor 2

komponen	A	B	C
co	0,00158	8,25E-05	-1,91E-08
co2	-0,012	1,02E-04	-2,24E-08
o2	0,00121	8,62E-05	-1,33E-08
h2o	0,00053	4,71E-05	4,96E-08
h2	0,03951	4,71E-05	-6,49E-08
ch4	-0,00935	1,40E-04	3,32E-08
h2	0,03951	4,71E-05	-6,49E-08

Perhitungan Konduktivitas Umpan Reaktor 2

komponen	fraksi mol	Kgas (W/m K)	Yi . Kgas (W/m K)
co	0,090549723	0,036	0,003
co2	0,319452713	0,031	0,010
o2	0,023229489	0,039	0,001
h2o	0,109436149	0,034	0,004
h2	0,408758012	0,047	0,019
ch4	0,011212134	0,064	0,001
h2	0,.03736178	0,047	0,002
total	1	0,335959422	0,03969947

f. Menentukan kapasitas panas campuran gas

$$\mathrm{Cp} = \mathrm{A} + \mathrm{BT} + \mathrm{CT}^2 + \mathrm{DT}^3 + \mathrm{ET}^4$$

Tabel 7 Data Kapasitas Panas Umpan Reaktor dan perhitungan CP

komponen	A	B	C	D	E
co	29,556	-6,58007E-03	2,0130E-05	-1,2227E-08	2,2617E-12
co2	27,437	4,2315E-02	-1,9555E-05	3,9968E-09	-2,9872E-13
o2	29,526	-8,8999E-03	3,8083E-05	-3,2629E-08	8,8607E-12
h2o	33,933	-8,4186E-03	2,9906E-05	-1,7825E-08	3,6934E-12
h2	25,399	2,0178E-02	-3,8549E-05	3,1880E-08	-8,7585E-12
ch4	34,942	-3,9957E-02	1,9184E-04	-1,5303E-07	3,9321E-11
n2	29,342	-3,5395E-03	1,0076E-05	-4,3116E-09	2,5935E-13
h2	25,399	2,0178E-02	-3,8549E-05	3,1880E-08	-8,7585E-12
ch3oh	40,046	-3,8287E-02	2,4529E-04	-2,1679E-07	5,9909E-11

Komponen	yi	BM	Cp	Cp	Cpi = yi.Cp
		(kg/kmol)	kjoule/kmol.K	kjoule/kg.K	kjoule/kg.K
co	0,090549723	44	4996,231	113,5507	10,282
co2	0,319452713	76	6987,251	91,9375	29,370
o2	0,023229489	32	5120,492	160,0153	3,717
h2o	0,109436149	18	5821,039	323,3910	35,391
h2	0,408758012	2	4941,182	2470,5909	1009,874
ch4	0,011212134	20	6866,389	343,3194	3,849
h2	0.03736178	2	4941,182	2470,5909	92,306

Komponen	Fi	Fi.Cpi	Cp.yi
	(kg/jam)	Kjoule/jam.K	Kjoule/kmol.K
co	10.663,80605	109.645,1021	452,4073
co2	64.981,9304	1.908.498,989	2.232,0962
o2	1.989,5830	7.395,42981	118,9464
h2o	5.272,3683	186.592,669	637,0321
h2	2.188,107779	22.09712,835	2.019,7477
ch4	600,1927028	2.310,3479	76,9868
h2	200	1.8461,13547	184,6113
total	85.895.98834	4.442.616,508	5721,8280

g. Data sifat katalis ($CuO/ZnU/Al_2O_3$ γ-alumina)

Diameter = 0,006 m

Densitas Partikel = 1783,5 kg/m^3

Porositas = 45,53%

3. Dimensi reaktor

a. Menentukan ukuran dan jumlah tube

Diameter pipa reaktor dipilih berdasarkan pertimbangan agar perpindahan panas berjalan dengan baik. Mengingat reaksi yang terjadi

eksotermis, untuk itu dipilih aliran gas dalam pipa turbulen agar koefisien perpindahan panas lebih panas lebih besar.

Pengaruh ratio Dp / Dt terhadap koefisien perpindahan panas dalam pipa yang berisi butir-butir katalisator dibandingkan dengan pipa kosong yaitu hw/h telah diteliti oleh Colburn's (smith hal 571) yaitu :

Dp/Dt	0,05	0,10	0,15	0,20	0,25	0,30
hw/h	5,50	7,00	7,80	7,50	7,00	6,60

(Smith, Chem Kinetik Eng, P.571)

dipilih Dp/Dt = 0,15

dimana

hw = koefisien perpindahan panas dalam pipa berisi katalis

h = koefisien perpindahan panas dalam pipa kosong

Dp = diameter katalisator

Dt = diameter tube

Sehingga :

Dp/Dt = 0,15

Dp = 0,6 cm

Dt = 0,6 / 0,15 = 6,6 cm = 1,575 in

Dari hasil perhitungan tersebut, maka diambil ukuran pipa standar agar koefisien perpindahan panasnnya baik.

Dari table 11 Kern dipilih pipa dengan spesifikasi sebagai berikut :

Nominal pipe size = 2 in

Outside diameter = 2.38 in = 5.08 cm

Schedule number = 40

Inside diameter = 2.067 in = 6.04 cm

Flow area per pipe = 0,533 in^2

Aliran dalam pipa turbule dipilih N_{Re} = 3100

$$N_{Re} = \frac{G_g D_t}{\mu_g}$$

$$G_t = \frac{\mu_g N_{Re}}{D_t}$$

Dalam hubungan ini:

μg = viskositas umpan = 0,000189g/cm.det

Dt = Diameter tube = 5,2502 cm

$$G_t = \frac{\mathrm{Re}.\mu}{Dp}$$

$$\mathrm{G_t} = 54432{,}0583 \frac{\mathrm{kg}}{\mathrm{m^2.jam}}$$

Digunakan 1 buah reaktor :

$$\mathrm{A_t} = \frac{G}{\mathrm{G_t}}$$

$$\mathrm{At} = \frac{1437.7145}{3.5148} = 15.780{,}4042\ \mathrm{cm^2}$$

Luas penampang pipa (Ao) $= \left(\frac{\pi}{4}\right) ID^2 = \left(\frac{3{,}14}{4}\right).(2{,}093\,\text{cm})^2$

$= 21{,}6380\ \text{cm}^2$

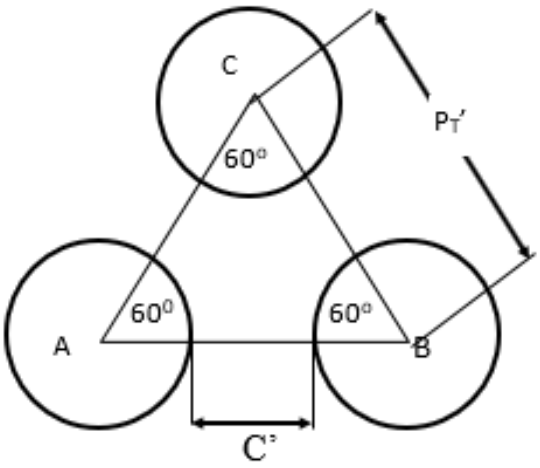
Jumlah pipa dalam reaktor

$$\text{Nt max} = \frac{A_t}{A_0}$$

$= \frac{15.780{,}4042}{21{,}6380} = 729{,}2897$ buah = 730 buah

b. Menghitung diameter dalam reaktor

Direncanakan tube disusun dengan pola triangular pitch.



Pt = 1,25 x ODt

= 1,25 x 2,38 = 2,975 in

C' = P_T – OD

= 2,975 – 0.622 = 2,353 in

untuk menghitung diameter shell, dicari luas penampang shell total (A total)

luas shell = Luas segitiga

A total = 2 .Nt . Luas Segitiga ABC

$$\frac{\pi}{4} x\, IDs^2 = 2\,.Nt\,.(\frac{1}{2}.PT^2.sin\,60\,)$$

Jadi :

$$IDs = \sqrt{\frac{4.\,Nt.\,P_T^2.\,3{,}33}{\pi}}$$

IDs = 290,534 cm

Jadi diameter dalam reaktor = 290,534 = 114,383 in

c. Menghitung tebal dinding reaktor

Tebal dinding reaktor (shell) dihitung dengan persamaan :

$$t_s = \frac{P.r}{f.E - 0{,}6.P} + C \qquad (Brownell\,,\, pers.13-1,\, p.254)$$

Dimana :

t_s = tebal shell, in

E = efisiensi pengelasan

f = maksimum allowable stress bahan yang digunakan

(Brownell,tabel 13-1, p.251)

r = jari-jari dalam shell, in

C = faktor korosi, in

P = tekanan design, Psi

Bahan yang digunakan Stainless Steel SA 240

E = 0,85 (double welded butt joint, tabel 13.2, P.254)

f = 16250 psi

C = 0,125

maka ts = 0,3446 in

dipilih tebal dinding reaktor standar 1/2 in

Diameter luar reaktor = ID + 2 x ts

= 114,3835 in + (2 x 0,3446 in)

= 115,3835 in

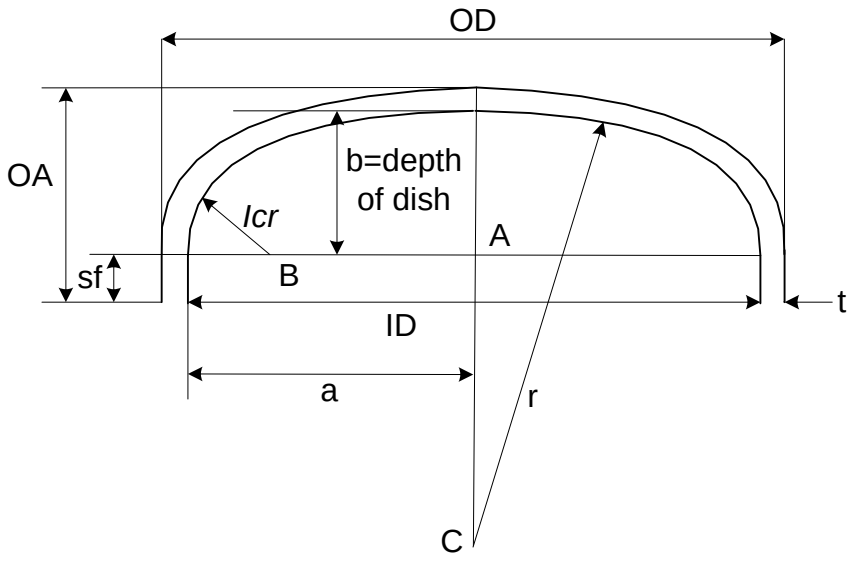
Sehingga dipilih diameter luar reaktor 180 in.

4. Menghitung head reaktor

a. Menghitung tebal head reaktor

Bentuk head : Elipstical Dished Head

Bahan yang digunakan: Low Alloy Steel SA-301 Grade A



Gambar A-1. *Head of reactor*

Keterangan gambar :

ID = diameter dalam head

OD = diameter luar head

a = jari-jari dalam head

t = tebal head

r = jari-jari luar dish

icr = jari-jari dalam sudut icr

b = tinggi head

sf = straight flange

OA = tinggi total head

Tebal head dihitung berdasarkan persamaan :

$$t_h = \frac{P.IDs}{2.f.E - 0{,}2.P} + C$$ (Brownell, 1979)

P = tekanan design, psi = 52,92 psi

IDs = diameter dalam reactor, in = 114,3835 in

F = maksimum allowable stress, psi = 16250 psi

E = efisiensi pengelasan = 0,85

C = faktor korosi, in = 0,125

maka th = 0,3442 in

dipilih tebal head reaktor standar 1/2 in

b. Menghitung tinggi head reaktor

ODs = 180 in

ts = 1/2 in

didapat : irc = 11 in

r = 170 in

a = IDs/2 = 57,1918 in

AB = a – irc = 46,1918 in

BC = r – irc = 159 in

AC = $(BC^2 - AB^2)^{1/2}$ = 152,1424 in

b = r – AC = 17,8576 in

Dari tabel 5.6 Brownell p.88 dengan th 1/2 in didapat sf = 1,5 – 3,5 in perancangan digunakan sf = 3,5 in

Tinggi head reaktor dapat dihitung dengan persamaan :

hH = th + b + sf

= 21,8576m

Menghitung tinggi reaktor

Tinggi reaktor total = panjang tube + tinggi head top

HR = 275,5907 in + (2*21,8576) in

= 297,4483 in = 7,5552 m

c. Volume Reaktor

Volume head = 0,000049 x IDs^2 (Brownell & Young, 1959)

Vh = 0,000049 x $(114,3835\ in)^2$

= 0,0012 m^3

Volume shell = $\pi/4.(IDs)^2.LS$

Vs = $\pi/4.(114,3835)^2.7$

= 46,3847 m^3

Volumer reaktor = Vs + 2Vh

Vr = 46,3847 m^3 + 2 x 0,0012 m^3

= 46,3847 m

Tabel 7 Perhitungan Hasil Simulasi Reaktor

z (m)	x	T (K)	Ts (K)	∫ ΔCP,dT (j/mol)	(-ΔHR)	P (atm)	ra	dx/dz	dT/dz	dTs/dz	dP/dz	Fi,Cpi
0,0000	0,0000	473,0000	303,0000	5.580,8329	2.599.615,1914	3,0000	10,7306	0,0121	27,6646	217,4584	0,0001	2.794.619,4268
0,1000	0,1208	475,7665	324,7458	5.674,8568	2.599.521,1675	3,0000	9,8104	0,0110	23,7504	201,4218	0,0001	2.979.823,9045
0,2000	0,2312	478,1415	344,8880	5.755,6626	2.599.440,3617	3,0000	8,8678	0,0100	20,3308	184,5059	0,0001	3.149.798,1495
0,3000	0,3310	480,1746	363,3386	5.824,8967	2.599.371,1276	3,0000	7,9368	0,0089	17,3626	167,2127	0,0001	3.303.935,6908
0,4000	0,4203	481,9108	380,0599	5.884,0685	2.599.311,9558	3,0000	7,0431	0,0079	14,7991	150,0276	0,0001	3.442.265,2397
0,5000	0,4995	483,3907	395,0626	5.934,5373	2.599.261,4870	3,0001	6,2041	0,0070	12,5943	133,3768	0,0001	3.565297,0855
0,6000	0,5693	484,6502	408,4003	5.977,5112	2.599.218,5131	3,0001	5,4305	0,0061	10,7040	117,6000	0,0001	3.673.879,6419
0,7000	0,6305	485,7206	420,1603	6.014,0527	2.599.181,9716	3,0001	4,7277	0,0053	9,0877	102,9387	0,0001	3.769.075,8475
0,8000	0,6837	486,6294	430,4542	6.045,0891	2.599.150,9352	3,0001	4,0968	0,0046	7,7087	89,5393	0,0001	3.852063,2152
0,9000	0,7298	487,4002	439,4081	6.071,4248	2.599.124,5995	3,0001	3,5360	0,0040	6,5340	77,4647	0,0001	3.924.057,3955
1,0000	0,7696	488,0536	447,1546	6.093,7541	2.599.102,2703	3,0001	3,0418	0,0034	5,5350	66,7124	0,0001	3.986.256,8693
1,1000	0,8038	488,6071	453,8258	6.112,6739	2.599.083,3504	3,0001	2,6091	0,0029	4,6863	57,2315	0,0001	4.039.805,3581
1,2000	0,8332	489,0757	459,5490	6.128,6960	2.599.067,3283	3,0001	2,2325	0,0025	3,9660	48,9399	0,0001	4.085.768,3235
1,3000	0,8583	489,4723	464,4430	6.142,2579	2.599.053,7664	3,0002	1,9064	0,0021	3,3552	41,7372	0,0001	4.125.120,1696
1,4000	0,8797	489,8079	468,6167	6.153,7329	2.599.042,2914	3,0002	1,6250	0,0018	2,8376	35,5151	0,0001	4.158.739,2361
1,5000	0,8980	490,0916	472,1682	6.163,4389	2.599.032,5854	3,0002	1,3831	0,0016	2,3992	30,1646	0,0001	4.187.408,2092
1,6000	0,9136	490,3316	475,1847	6.171,6463	2.599.024,3780	3,0002	1,1758	0,0013	2,0281	25,5808	0,0001	4.211.818,0971
1,7000	0,9268	490,5344	477,7428	6.178,5850	2.599.017,4394	3,0002	0,9984	0,0011	1,7141	21,6661	0,0001	4.232.574,3810

1,8000	0,9380	490,7058	479,9094	6.184,4498	2.599011,5745	3,0002	0,8471	0,0010	1,4485	18,3311	0,0001	4.250.204,3293
1,9000	0,9476	490,8506	481,7425	6.189,4061	2.599.006,6182	3,0002	0,7181	0,0008	1,2239	15,4960	0,0001	4.265.164,7660
2,0000	0,9557	490,9730	483,2921	6.193,5941	2.599.002,4302	3,0002	0,6084	0,0007	1,0340	13,0900	0,0001	4.277.849,8158
2,1000	0,9625	491,0764	484,6011	6.197,1325	2.598.998,8918	3,0003	0,5151	0,0006	0,8735	11,0511	0,0001	4.288.598,3196
2,2000	0,9683	491,1638	485,7062	6.200,1217	2.598.995,9026	3,0003	0,4360	0,0005	0,7378	9,3252	0,0001	4.297.700,7396
2,3000	0,9732	491,2376	486,6387	6.202,6467	2.598.993,3776	3,0003	0,3689	0,0004	0,6232	7,8657	0,0001	4.305.405,4609
2,4000	0,9774	491,2999	487,4253	6.204,7795	2.598.991,2449	3,0003	0,3120	0,0004	0,5263	6,6325	0,0001	4.311.924,4532
2,5000	0,9809	491,3525	488,0885	6.206,5808	2.598.989,4435	3,0003	0,2638	0,0003	0,4445	5,5912	0,0001	4.317.438,3013
2,6000	0,9838	491,3970	488,6476	6.208,1022	2.598.987,9222	3,0003	0,2230	0,0003	0,3754	4,7123	0,0001	4.322.100,6313
2,7000	0,9863	491,4345	489,1189	6.209,3870	2.598.986,6373	3,0003	0,1884	0,0002	0,3170	3,9709	0,0001	4.326.041,9779
2,8000	0,9885	491,4662	489,5160	6.210,4720	2.598.985,5523	3,0003	0,1592	0,0002	0,2677	3,3457	0,0001	4.329.373,1429
2,9000	0,9903	491,4930	489,8505	6.211,3882	2.598.984,6361	3,0004	0,1345	0,0002	0,2261	2,8187	0,0001	4.332.188,0982
3,0000	0,9918	491,5156	490,1324	6.212,1620	2.598.983,8624	3,0004	0,1137	0,0001	0,1909	2,3744	0,0001	4.334.566,4849
3,1000	0,9931	491,5347	490,3699	6.212,8153	2.598.983,2090	3,0004	0,0960	0,0001	0,1612	2,0001	0,0001	4.336.575,7583
3,2000	0,9941	491,5508	490,5699	6.213,3670	2.598.982,6574	3,0004	0,0811	0,0001	0,1361	1,6847	0,0001	4.338.273,0230
3,3000	0,9950	491,5644	490,7383	6.213,8328	2.598.982,1915	3,0004	0,0685	0,0001	0,1149	1,4190	0,0001	4.339.706,6005
3,4000	0,9958	491,5759	490,8802	6.214,2261	2.598.981,7982	3,0004	0,0578	0,0001	0,0970	1,1951	0,0001	4.340.917,3656
3,5000	0,9965	491,5856	490,9997	6.214,5582	2.598.981,4661	3,0004	0,0488	0,0001	0,0819	1,0066	0,0001	4.341.939,8831
3,6000	0,9970	491,5938	491,1004	6.214,8387	2.598.981,1857	3,0004	0,0412	0,0000	0,0692	0,8478	0,0001	4.342.803,3746
3,7000	0,9975	491,6007	491,1852	6.215,0754	2.598.980,9489	3,0005	0,0348	0,0000	0,0584	0,7141	0,0001	4.343.532,5389
3,8000	0,9979	491,6065	491,2566	6.215,2753	2.598.980,7490	3,0005	0,0294	0,0000	0,0493	0,6014	0,0001	4.344.148,2483
3,9000	0,9982	491,6115	491,3167	6.215,4441	2.598.980,5802	3,0005	0,0248	0,0000	0,0416	0,5066	0,0001	4.344.668,1388

4,0000	0,9985	491,6156	491,3674	6.215,5866	2.598.980,4377	3,0005	0,0210	0,0000	0,0352	0,4267	0,0001	4.345.107,1099
4,1000	0,9987	491,6191	491,4101	6.215,7070	2.598.980,3174	3,0005	0,0177	0,0000	0,0297	0,3594	0,0001	4.345.477,7475
4,2000	0,9989	491,6221	491,4460	6.215,8086	2.598.980,2158	3,0005	0,0149	0,0000	0,0251	0,3027	0,0001	4.345.790,6826
4,3000	0,9991	491,6246	491,4763	6.215,8943	2.598.980,1300	3,0005	0,0126	0,0000	0,0212	0,2550	0,0001	4.346.054,8942
4,4000	0,9992	491,6267	491,5018	6.215,9668	2.598.980,0576	3,0005	0,0107	0,0000	0,0179	0,2148	0,0001	4.346.277,9651
4,5000	0,9994	491,6285	491,5233	6.216,0279	2.598.979,9964	3,0006	0,0090	0,0000	0,0151	0,1810	0,0001	4.346.466,2990
4,6000	0,9995	491,6300	491,5414	6.216,0795	2.598.979,9448	3,0006	0,0076	0,0000	0,0127	0,1525	0,0001	4.346.625,3036
4,7000	0,9995	491,6313	491,5566	6.216,1231	2.598.979,9012	3,0006	0,0064	0,0000	0,0108	0,1284	0,0001	4.346.759,5450
4,8000	0,9996	491,6324	491,5694	6.216,1599	2.598.979,8644	3,0006	0,0054	0,0000	0,0091	0,1082	0,0001	4.346.872,8791
4,9000	0,9997	491,6333	491,5803	6.216,1910	2.598.979,8334	3,0006	0,0046	0,0000	0,0077	0,0912	0,0001	4.346.968,5613
5,0000	0,9997	491,6341	491,5894	6.216,2172	2.598.979,8071	3,0006	0,0039	0,0000	0,0065	0,0768	0,0001	4.347.049,3405
5,1000	0,9998	491,6347	491,5971	6.216,2394	2.598.979,7850	3,0006	0,0033	0,0000	0,0055	0,0647	0,0001	4.347.117,5375
5,2000	0,9998	491,6352	491,6035	6.216,2580	2.598.979,7663	3,0006	0,0027	0,0000	0,0046	0,0545	0,0001	4.347.175,1120
5,3000	0,9998	491,6357	491,6090	6.216,2738	2.598.979,7505	3,0007	0,0023	0,0000	0,0039	0,0459	0,0001	4.347.223,7182
5,4000	0,9999	491,6361	491,6136	6.216,2872	2.598.979,7372	3,0007	0,0020	0,0000	0,0033	0,0387	0,0001	4.347.264,7532
5,5000	0,9999	491,6364	491,6175	6.216,2984	2.598.979,7259	3,0007	0,0017	0,0000	0,0028	0,0326	0,0001	4.347.299,3960
5,6000	0,9999	491,6367	491,6207	6.216,3079	2.598.979,7164	3,0007	0,0014	0,0000	0,0023	0,0275	0,0001	4.347.328,6423
5,7000	0,9999	491,6369	491,6235	6.216,3159	2.598.979,7084	3,0007	0,0012	0,0000	0,0020	0,0232	0,0001	4.347.353,3328
5,8000	0,9999	491,6371	491,6258	6.216,3227	2.598.979,7016	3,0007	0,0010	0,0000	0,0017	0,0195	0,0001	4.347.374,1771
5,9000	0,9999	491,6373	491,6277	6.216,3284	2.598.979,6959	3,0007	0,0008	0,0000	0,0014	0,0165	0,0001	4.347.391,7742
6,0000	0,9999	491,6374	491,6294	6.216,3332	2.598.979,6911	3,0007	0,0007	0,0000	0,0012	0,0139	0,0001	4.347.406,6301
6,1000	1,0000	491,6376	491,6308	6.216,3373	2.598.979,6870	3,0007	0,0006	0,0000	0,0010	0,0117	0,0001	4.347.419,1717