LAMPIRAN

NERACA MASSA

A. REAKTOR

Compon	Input						Output					
	Arus 1			Arus 2			Arus 3			Arus 4		
	kmol	xi	kg/jam	kmol	xi	kg/jam	kmol	xi	kg/jam	kmol	xi	kg/j
C	5,6434	0,334	67,7									
H	7,7562	0,038	7,7									
S	0,0101	0,001	0,3									
N	0,0738	0,005	1,0									
O	3,6895	0,291	59,0									
Moisture	3,3752	0,30	60,7				3,3752	0,122	60,7			
Ash		0,029	5,8					0,004	22,1		0,540	3,7
CO							3,5857	0,201	100,			
H2							2,3094	0,009	4,6			
CH4							0,7840	0,025	12,5			
CO2							0,8557	0,075	37,6			
N2				8,5345	0,790	238,	8,5340	0,479	238,			
Tar						0,0		0,078	39,1			
Unburn						0,0		0,003	61,7		0,459	3,2
O2				1,9851	0,210	63,5						
Total		1	202,			302,		1	498,		1	6,9
	202,5130			302,4870			498,0081			6,9919		
	505,0000						505,0001					

NERACA MASSA

Kapasitas	=	3.999.600	kg/Tahun
Operasi per tahun	=	330	hari/tahun
Operasi per hari	=	24	jam/hari
Basis Perhitungan	=	1	jam operasi
Kapasitas per jam	=	505,0000	kg/jam

Jumlah Carbon = Xc * feed

67,7203 58 kg/jam

92,6% C terkonversi, sisa 7,4 % menjadi arang

Jadi arang	5,0113	kg/jam	
Bereaksi	62,7091	kg/jam	5,225754 311 kgmol (massa/Mr)
Total	67,7204	kg/jam	

Carbon balance

Sumber : https://www.researchgate.net/post/How_can_I_calculate_the_carbon_conversion_of_biomass_gasification

% mol C (CO) = CompositionCO*Atom C/BM CO	0,0940
% mol C(CH4) =	0,0206
% mol C (CO2) =	0,0224
% mol C product =	0,1370

1. Boudouard (Reaksi C untuk CO2) (mol yang dibutuhkan = jumlah Creaksi * konversi Cke CO2)

0,855679069

C + CO2 <> 2CO

0,8557 0,8557 1,7114

2. water gas or steam (Reaksi C ke CO) (mol yang dibutuhkan = jumlah Creaksi * konversi Cke CO)

3,585702763

C	+	H2O	<>	CO	+	H2	
3,5857		3,5857		3,5857		3,5857	

3. Hydrogasification (Reaksi C untuk CH4) (mol yang dibutuhkan = jumlah Creaksi * konversi Cke CH4)

0,784372479

C	+	2H2	<>	CH4
0,7844		1,5687		0,7844

4. Sisa C

C	+	0,5 O2	>	CO		0,4176
0,4176		0,2088		0,4176		

TOTAL5,643363187

Perhitungan Output

1. CO2 = mol CO2 reaksi *BM CO2			37,64987902
2. CH4			12,54995967
3. CO			100,3996774
4. H2	H2 mula2	H2 terpakai	4,618759247
	3,878124583	1,5687	

arus 1 + arus 2 = arus 3 + arus 4

505 = (458,8494+Tar)+6,9919

Tar 39,1587

A. CYCLONE

Component	Input			Output					
	Arus 3			Arus 5			Arus 6		
	kmol	xi	kg/jam	kmol	xi	kg/jam	kmol	xi	kg/jam
C									
H									
S									
N									
O									
Moisture		0,1220	60,7539		0,1228	60,7539			
Ash		0,0042	2,1145		0,0009	0,4229		0,5404	1,6916
CO		0,2016	100,3997		0,2029	100,3997			
H2		0,0093	4,6188		0,0093	4,6188			
CH4		0,0252	12,5500		0,0254	12,5500			
CO2		0,0756	37,6499		0,0761	37,6499			
N2		0,4798	238,9647		0,4829	238,9647			
Tar		0,0786	39,1587		0,0791	39,1587			
Unburn		0,0036	1,7981		0,0007	0,3596		0,4596	1,4384
O2									
Total		1	498,008		1	494,878		1	3,1300
		498,0081			494,8781			3,1300	
		498,0081			498,0081				

Operating condition and efficiency of some particle removal equipment (GUAN et al 2008

Dust separator	Temperature range (C)	De dusting efficiency	Pressure drop (Kpa)
Cyclone	100-900	Dust > 5 mic -80%	<10
Fabric bag filter	60-250	Dust >0.3 mic -99-99.8%	1-2.5
Wet scrubber (venture)	20-100	Dust >0.1-1 mic 85-95% Otherwise 90-99%	5-20
Fibrous ceramic filter	200-800	Dust >0.3 mic -99-99.8%	1-2.5
Rigid ceramic filter	200-800	Dust >0.1 mic -99.5-99.99%	1-5
Metallic foam filter	200-800	Dust >0.1 mic -99-99.5%	<1
Granular bed filter	200-800	Highly depend on regime and surface cake filtration	<10

Particle remove

Removal 80% ash and unburn	0,8
Ash	1,6916
Unburn	1,4384

B. FABRIC FILTER 1

Component	Input			Output					
	Arus 5			Arus 7			Arus 8		
	kmol	xi	kg/jam	kmol	xi	kg/jam	kmol	xi	kg/jam
C									
H									
S									
N									
O									
Moisture		0,1228	60,7539		0,1280	60,7539			
Ash		0,0009	0,4229		0,0000	0,0042		0,0206	0,4187
CO		0,2029	100,3997		0,2116	100,3997			
H2		0,0093	4,6188		0,0097	4,6188			
CH4		0,0254	12,5500		0,0264	12,5500			
CO2		0,0761	37,6499		0,0793	37,6499			
N2		0,4829	238,9647		0,5036	238,9647			
Tar		0,0791	39,1587		0,0413	19,5794		0,9619	19,5794
Unburn		0,0007	0,3596		0,0000	0,0036		0,0175	0,3560
O2									
Total		1	494,8781		1	474,5241		1	20,3540
		494,8781			474,5241			20,3540	
		494,8781			494,8781				

Operating condition and efficiency of some particle removal equipment (GUAN et al 2008

Dust separator	Temperature range (C)	De dusting efficiency	Pressure drop (Kpa)
Cyclone	100-900	Dust > 5 mic -80%	<10
Fabric bag filter	60-250	Dust >0.3 mic -99-99.8%	1-2.5
Wet scrubber (venture)	20-100	Dust >0.1-1 mic 85-95% Otherwise 90-99%	5-20
Fibrous ceramic filter	200-800	Dust >0.3 mic -99-99.8%	1-2.5
Rigid ceramic filter	200-800	Dust >0.1 mic -99.5-99.99%	1-5
Metallic foam filter	200-800	Dust >0.1 mic -99-99.5%	<1
Granular bed filter	200-800	Highly depend on regime and surface cake filtration	<10

Particle remove

Removal 99% Ash and Unburn 0,99

Ash 0,4187

Unburn 0,3560

Tar Remove

Removal 50% Tar 0,5

Tar 19,57935

C. DEMISTER

Component	Input			Output					
	Arus 7			Arus 9			Arus 10		
	kmol	xi	kg/jam	kmol	xi	kg/jam	kmol	xi	kg/jam
C									
H									
S									
N									
O									
Moisture		0,1280	60,7539		0,0000	0,0061		1,0000	60,7478
Ash		0,0000	0,0042		0,0000	0,0042			
CO		0,2116	100,3997		0,2426	100,3997			
H2		0,0097	4,6188		0,0112	4,6188			
CH4		0,0264	12,5500		0,0303	12,5500			
CO2		0,0793	37,6499		0,0910	37,6499			
N2		0,5036	238,9647		0,5775	238,9647			
Tar		0,0413	19,5794		0,0473	19,5794			
Unburn		0,0000	0,0036		0,0000	0,0036			
O2									
		1	474,5241		1	413,7762		1	60,7478
Total	474,5241			413,7762			60,7478		
	474,5241			474,5241					

Moisture Remove

Removal 99,99% Moisture 0,9999

Moisture 60,7478

D. FABRIC FILTER 2

Component	Input			Output					
	Arus 9			Arus 11			Arus 12		
	kmol	xi	kg/jam	kmol	xi	kg/jam	kmol	xi	kg/jam
C									
H									
S									
N									
O									
Moisture		0,0000	0,0061		0,0000	0,0061			
Ash		0,0000	0,0042		0,0000	0,0000		0,0002	0,0042
CO		0,2426	100,3997		0,2547	100,3997			
H2		0,0112	4,6188		0,0117	4,6188			
CH4		0,0303	12,5500		0,0318	12,5500			
CO2		0,0910	37,6499		0,0955	37,6499			
N2		0,5775	238,9647		0,6062	238,9647			
Tar		0,0473	19,5794		0,0000	0,0000		0,9996	19,5794
Unburn		0,0000	0,0036		0,0000	0,0000		0,0002	0,0036
O2									
Total		1	413,7762		1	394,1891		1	19,5871
	413,7762			394,1891			19,5871		
	413,7762			413,7762					

Particle remove	
Removal 99% ash and unburn	0,99
Ash	0,0042
Unburn	0,0036
Tar Remove	
Removal 50% Tar	0,5
Tar	19,579 35

NERACA PANAS

A. REAKTOR

Panas Umpan Masuk Reaktor

Component	nF(kmol)	F1(kg/jam)	F2(kg/jam)	$\int_{298,15}^{303,15} Cp.dT(J/mol)(kJ/kg)$	$Q1 = m\int_{298,15}^{303,15} Cp.dT(kJ/jam)$
CKS		202,5130		6287,550639	1273310,95
Component	**nF(kmol)**	**F1(kg/jam)**	**F2(kg/jam)**	$\int_{298,15}^{303,15} Cp.dT(J/mol)(kJ/kg)$	$Q2 = m\int_{298,15}^{303,15} Cp.dT(kJ/jam)$
O2	1,9851		63,5223	4605,982105	292582,5771
N2	8,5345		238,9647	4542,747481	1085556,289
Total					1378138,866

Panas Reaksi di Reaktor

Reaksi	n(kmol)	ΔHreaksi°298 (kj/kmol)		Q Reaksi (kj/jam)
C + CO2 <> 2CO	0,855679069	+	172000,0000	147176,7998
C + H2O <> CO + H2	3,585702763	+	131000,0000	469727,062
C + 2H2 <> CH4	0,784372479	-	89500,0000	70201,33691
C + 0,5O2 > CO	0,4176	-	111900,0000	46730,43321
Total				733835,6319

Panas Gas Keluar Reaktor

Component	nF3(kmol)	F3(kg/jam)	$\int_{298,15}^{673,15} Cp.dT(J/mol)(kJ/kg)$	$Q3 = m\int_{298,15}^{673,15} Cp.dT(kJ/jam)$
CO	2,2818	100,3997	11211,8848	1125669,6188
H2	2,3094	4,6188	10956,0041	50603,1452
CH4	0,7844	12,5500	17152,2760	215260,3726
CO2	0,8557	37,6499	372,0201	14006,5120
N2	8,5345	238,9647	396,0123	94632,9553
Moisture	3,3752	60,7539	732,7290	44516,1512
Tar		39,1587		
Unburn		1,7981	68,4695	123,1120
Ash		2,1145	821,6335	1737,3069
Total		498,0081007	41711,02931	1546549,1740

Panas Padatan Keluar reaktor

Component	nF4(kmol)	F4(kg/jam)	$\int_{298,15}^{673,15} Cp.dT(J/mol)(kJ/kg)$	$Q4 = m\int_{298,15}^{673,15} Cp.dT(kJ/jam)$
CO				
H2				
CH4				
CO2				
N2				
Moisture				
Tar				
Unburn		3,2132	68,46946042	220,0060702
Ash		3,7787	821,6335251	3104,706601
Total		6,9919	890,1029855	3324,712671

Qreaktan+Qreaksi+Qproduk+
Q=0

Q1+Q2+Qreaksi+Q3+Q4+Q=0

Q -4935159,335 kJ/jam

B. CYCLONE

Panas Gas Masuk Cyclone

Component	nF3(kmol)	F3(kg/jam)	$\int_{298,15}^{673,15} Cp.dT(J/mol)(kJ/kg) Q3 = m\int_{298,15}^{673,15} Cp.dT(kJ/jam)$	
CO	2,2818	100,3997	11211,88482	1125669,6188
H2	2,3094	4,6188	10956,0041	50603,1452
CH4	0,7844	12,5500	17152,27604	215260,3726
CO2	0,8557	37,6499	372,0201068	14006,5120
N2	8,5345	238,9647	396,0122719	94632,9553
Moisture	3,3752	60,7539	732,7289933	44516,1512
Tar		39,1587		
Unburn		1,7981	68,46946042	123,1120

Ash		2,1145	821,6335251	1737,3069
Total		498,0081007	41711,02931	1546549,1740

T	673,15	K	400	oC
Tref	298,15	K	25	oC

Panas Gas Keluar Cyclone

Component	nF5(kmol)	F5(kg/jam)	$\int_{298,15}^{673,15} Cp.dT(J/mol)(kJ/kg) Q5 = m\int_{298,15}^{673,15} Cp.dT(kJ/jam)$	
CO	2,2818	100,3997	11211,88482	1125669,6188
H2	2,309379624	4,6188	10956,0041	50603,1452
CH4	0,784372479	12,5500	17152,27604	215260,3726
CO2	0,855679069	37,6499	372,0201068	14006,5120
N2	8,534453711	238,9647	396,0122719	94632,9553
Moisture	3,375217217	60,7539	732,7289933	44516,1512
Tar		39,1587		
Unburn		1,7981	68,46946042	123,1120
Ash		2,1145	821,6335251	1737,3069
Total		498,0081007	41711,02931	1546549,1740

Panas Padatan Keluar Cyclone

Component	nF6(kmol)	F6(kg/jam)	$\int_{298,15}^{673,15} Cp.dT(J/mol)(kJ/kg) Q6 = m\int_{298,15}^{673,15} Cp.dT(kJ/jam)$	
CO				
H2				
CH4				
CO2				
N2				
Moisture				
Tar				
Unburn		1,7981	68,46946042	123,1120
Ash		2,1145	821,6335251	1737,3069
Total		3,912511	890,1029855	1860,4189

C. HEAT EXCHANGER

Panas Gas Masuk HE-01

Component	nF5(kmol)	F5(kg/jam)	$\int_{298,15}^{673,15} CpdT(J/mol)(kJ/kg)$	$Q5 = m\int_{298,15}^{948,15} Cp.dT(kJ/jam)$
CO	2,281810849	100,399677	11211,88482	1125669,619
H2	2,309379624	4,61875925	10956,0041	50603,14524
CH4	0,784372479	12,5499597	17152,27604	215260,3726
CO2	0,855679069	37,649879	372,0201068	14006,51201

N2	8,534453711	238,964704	396,0122719	94632,95529
Moisture	3,375217217	60,7539099	732,7289933	44516,15125
Tar		39,1587	0	
Unburn		1,79805678	68,46946042	123,1119773
Ash		2,11445478	821,6335251	1737,306934
Total		498,008101	41711,02931	1546549,1740

Panas Gas Keluar HE-01

Component	nF5(kmol)	F5(kg/jam)	$\int_{298,15}^{313,15} CpdT(J/mol)(kJ/kg)$	$Q5 = m\int_{298,15}^{313,15} Cp.dT(kJ/jam)$
CO	2,281810849	100,399677	15,58713637	1564,943463
H2	2,309379624	4,61875925	215,9901803	997,6066425
CH4	0,784372479	12,5499597	34,33695237	430,9273674
CO2	0,855679069	37,649879	13,17781777	496,1432446
N2	8,534453711	238,964704	15,57896623	3722,823052
Moisture	3,375217217	60,7539099	28,06490639	1705,052795
Tar		39,1587		
Unburn		1,79805678	2,244187917	4,03517729
Ash		2,11445478	26,930255	56,94280639
Total		498,008101	351,9104023	8978,474548

Kebutuhan Air

Tcwin	303,15	K	30	oC
Thwout	323,15	K	50	oC
Tref	298	K	25	oC
Qcwout-Qcwin=Qin-Qout				
Qhwout-Qcwin	1537570,699	kJ/jam		

Qhwout-Qcwin=F*(Cphwout-Cpcwin)

1537570,6995	kJ/jam	Fcw	kg/jam		84,8614	kJ/kg
		18118,6053	kg/jam			

Panas Air Masuk HE-01

Component	nF(kmol)	F(kg/jam)	$\int_{298,15}^{303,15} Cp.dT(J/mol)(kJ/kg)$	$Q5 = m\int_{298,15}^{303,15} Cp.dT(kJ/jam)$
H2O(l)		18118,6053	21,8908	396630,1468

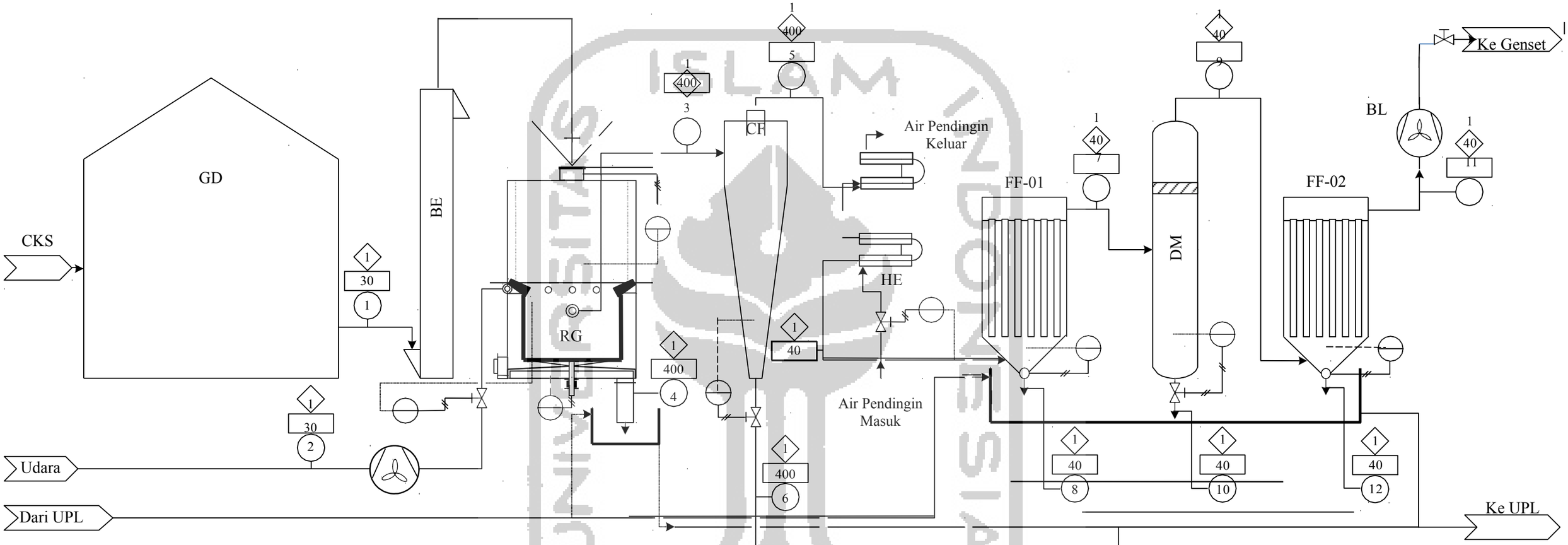
Panas Air Keluar HE-01

Component	nF(kmol)	F(kg/jam)	$\int_{298,15}^{323,15} Cp.dT(J/mol)(kJ/kg)$	$Q5 = m\int_{298,15}^{323,15} Cp.dT(kJ/jam)$
H2O(l)		18118,6053	106,7522	1934200,846

	Aliran Panas Masuk (kJ/jam)		Aliran Panas Keluar (kJ/jam)	
Qin	1546549,1740	**Qout**		8978,474548
Qcwin	396630,1468	**Qhwout**		1934200,846
Total	1943179,321		1943179,321	

PROCESS ENGINEERING FLOW DIAGRAM

PRA RANCANGAN PABRIK PRODUSER GAS
DARI GASIFIKASI CANGKANG SAWIT DENGAN
KAPASITAS MASUK 4000 TON/TAHUN



PROGRAM STUDI TEKNIK KIMIA FAKULTAS TEKNOLOGI INDUSTRI UNIVERSITAS ISLAM INDONESIA YOGYAKARTA	
GAMBAR: PROCESS ENGINEERING FLOW DIAGRAM PRA RANCANGAN PABRIK PRODUSER GAS DARI GASIFIKASI CANGKANG SAWIT DAN UDARA KAPASITAS 3.000 TON/TAHUN	
DISUSUN OLEH: NUGROHO JANUARI PRATOMO MUHAMMAD NOVIANSYAH	(12521085) (12521164)
DOSEN PEMBIMBING: FARHAM H. M. SALEH, Ir., MSIE, Dr.	

Komponen	kg/jam											
	1	2	3	4	5	6	7	8	9	10	11	12
CKS												
C	67,7200											
H	7,0000											
S	0,3240											
N	1,0328											
O	59,0325											
Moisture	60,7539		60,7539		60,7539		60,7539		60,7539	60,7478	0,0061	
Ash	5,8931		2,1145	3,7787	0,4229	1,6916	0,0042	0,4189	0,0042		0,0000	0,0042
Udara												
N2		238,9647	238,9647		238,9647		238,9647		238,9647		394,1891	
O2		63,5223										
Produser Gas												
CO			100,3997		100,3997		100,3997		100,3997		100,3997	
H2			4,6188		4,6188		4,6188		4,6188		4,6188	
CH4			12,5500		12,5500		12,5500		12,5500		12,5500	
CO2			37,6499		37,6499		37,6499		37,6499		37,6499	
Tar			39,1587		39,1587		19,5794	19,5794	19,5794		0,0000	44,8469
Unburn			1,7981	3,2132	1,7981	1,4384	0,0036	0,3560	0,0036		0,0000	0,0036
Total	202,5130	302,4870	498,0081	6,9919	494,8781	3,1300	474,5241	20,3540	413,7763	60,7478	394,1891	44,8546

Simbol	Keterangan
O	Nomor Arus
□	Suhu (°C)
◇	Tekanan (atm)
≠	Elektrik
———	Pneumatik
GD	Gedung
BE	Bucket Elevator
RG	Reactor Gasifier
CF	Cyclone Filter
HE	Heat Exchanger
FF	Fabric Filter
DM	Demister
BL	Blower
WP	Water Pump

PRA RANCANGAN PARBRIK PRODUSER GAS DARI GASIFIKASI CANGKANG KELAPA SAWIT DENAGN KAPASITAS MASUK 4000 TON/TAHUN

FAIZAL FURQON PRATAMA (12521131)

AGUS TAUFIQ Ir . M.Sc.

Lucky Wahyu Nuzulia S S.T., M.Eng