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Lampiran 1

Hasil Analisa Proximate Batubara Pada Pemakaian Ketel Uap Sebelum Dibersihkan

[redacted]

Certificate No. 00067/CDDBAG
Date: January 9, 2013

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REPORT OF ANALYSIS

PRINCIPAL	:	PT. INDOFOOD CBP SUKSES MAKMUR Tbk JL. KIMA X KAV. A3 BIRINGKANAYA MAKASSAR
TYPE OF SAMPLE	:	COAL
TESTED FOR	:	Total Moisture, Proximate Analysis, Total Sulfur and Gross Calorific Value
DESCRIPTION OF SAMPLE	:	FORM : Boulder WEIGHT SAMPLE : ± 10.84 KG TOP SIZE : ± 100 mm PACKING : Unsealed Plastic Bag
DATE RECEIVED	:	04/01/2013
DATE OF TESTING	:	04/01/2013 to 09/01/2013
SAMPLE MARK	:	OBBW228122
STANDARD METHOD	:	ASTM STANDARD

Result:

PARAMETER	UNIT	TEST RESULTS	METHODS
• Total Moisture, AR	% wt	12.5	ASTM D – 3302
• Moisture In Analysis the Sample, ADB	% wt	9.2	ASTM D – 3173
• Ash Content, ADB	% wt	10.9	ASTM D – 3174
• Volatile Matter, ADB	% wt	42.8	ISO 562
• Fixed Carbon, ADB	% wt	37.1	By difference
• Total Sulfur, ADB	% wt	3.10	ASTM D – 4239
• Gross Calorific Value, ADB	Kcal/kg	6239	ASTM D – 5865

THE RESULT OF TESTING ANALYSIS ONLY REFERS TO THE SAMPLE SUBMITTED AND DOES NOT REPRESENT ANY CONSIGMENT AS THE SAMPLE WAS NOT TAKEN BY PT SUCOFINDO

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Dept. of Testing

Arie Hartono

MKSOP3201300024

Lampiran 2

Hasil Analisa Cangkang Biji Jambu Mete

03/04/2013 Cashew Nut Shell Cake,Crushed Cash...

Anup Industries
MANUFACTURERS OF CNS LIQUID
S.NO. 757-1p10 PUTTIGE
PERDOOR -576124
PHONE 0820-2542345,2828750
CELL : 94484 09800

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PRODUCTS

- Cashew Nut Shell Liquid
- Cashew Nut Shell Cake

Cashew Nut Shell Cake

Home > Products > Cashew Nut Shell Cake

Empowered with robust infrastructural base and qualified team, we bring forth an ample assortment of high quality **cashew nut shell cake**. We are well reckoned as one of the supreme De-Oiled cashew shell cake exporters and manufacturers in the national and international market. Crushed cashew nut shell cake provided by us is highly acclaimed for quality and performance.

Widely used by tile manufacturing, cashew and many more industries, our cashew nut shell cake is the perfect blend of long lasting shelf life with efficiency. We deliver crushed cashew nut shell cake within the stipulated time frame and that too at very reasonable price.

It is one of the best fuels. It is mainly used by cashew industries, tile manufacturing units and others. The chemical analysis of the cashew shell oil cake is as follows.

1	Gross Calorific Value	5056 Kcal / Kg
2	Proximate analysis (% weight)	
	Moisture	8.85
	Volatile matter	68.03
	Ash	2.00
	Fixed Carbon	21.12
3	Ultimate Analysis	
	Carbon	46.08
	Hydrogen	3.88
	Nitrogen	0.21
	Sulphur	NIL
	Mositure	8.85
	Ash	2.00
	Oxygen	38.98
4	Bulk density	0.4430g/cc
5	Ash Chemical composition (% by weight)	

	Silca (Si02)	61.83
	Iron Oxide (as Fe203)	3.99
	Aluminium Oxide	1.99
	Calcium Oxide (as CaO)	25.64
	Magnesium Oxide (as Mgo)	1.88
	Sodium Oxide (as Na20)	0.65
	Potassium (as P205)	Traces
	Sulphate (as P205)	Traces
	Phosphate (as P205)	Traces
6	Ash Fusion Characteristics	
	Intial defoamation temperature (T1)	840
	Herrisphericla temperature (T2)	920
	Fusion temparature (T3)	1010

Lampiran 3

Hasil Analisa Kimia Abu Batubara

Certificate No. 01655/CDDBAG
Date: May 17, 2013

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REPORT OF ANALYSIS

PRINCIPAL	:	NOVARINI TAMAN BUNGA SUDIANG BLOK B 22 MAKASSAR
TYPE OF SAMPLE	:	COAL
TESTED FOR	:	CaO, MgO, Fe2O3, Na2O, K2O, SiO2, Al2O3 and TiO2
DESCRIPTION OF SAMPLE	:	FORM : Boulder WEIGHT SAMPLE : ± 5.8 KG PACKING : Unsealed Plastic Bag
DATE RECEIVED	:	14/05/2013
DATE OF TESTING	:	14/05/2013 to 17/05/2013
SAMPLE MARK	:	OBBW
STANDARD METHOD	:	ASTM STANDARD

Result:

PARAMETER (DB)	UNIT	TEST RESULTS
• CaO	%	3.48
• MgO	%	1.32
• Fe_2O_3	%	24.50
• Na_2O	%	0.34
• K_2O	%	1.10
• SiO_2	%	41.07
• Al_2O_3	%	25.27
• TiO_2	%	0.97

THE RESULT OF TESTING ANALYSIS ONLY REFERS TO THE SAMPLE SUBMITTED AND DOES NOT REPRESENT ANY CONSIGMENT AS THE SAMPLE WAS NOT TAKEN BY PT SUCOFINDO

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Dept. of Testing

Muhammad Syahrul

MKSOP3201300635

Lampiran 4

Perhitungan Konversi Analisa Proximate ke Ultimate Batubara[3]

$$\text{DMMFC} = \frac{\text{FC}}{(\text{FC} + \text{VOL})} \times 100\% = \frac{37{,}1}{(37{,}1 + 42{,}8)} \times 100\% = 46{,}43$$

$$\text{DMMVOL} = \frac{\text{VOL}}{(\text{FC} + \text{VOL})} \times 100\% = \frac{42{,}8}{(37{,}1 + 42{,}8)} \times 100\% = 53{,}57$$

$$\begin{aligned} \text{C} &= \frac{((\text{DMMFC} + 0{,}9(\text{DMMVOL} - 14)) \times (\text{VOL} + \text{FC})}{100} \\ &= \frac{((46{,}43 + 0{,}9(53{,}57 - 14)) \times (42{,}8 + 37{,}1)}{100} \\ &= 65{,}55 \end{aligned}$$

$$\begin{aligned} \text{N}_2 &= \frac{((2{,}1 - 0{,}012 \times \text{DMMVOL}) \times (\text{VOL} + \text{FC}))}{100} \\ &= \frac{((2{,}1 - 0{,}012 \times 53{,}57) \times (42{,}8 + 37{,}1))}{100} \\ &= 1{,}16 \end{aligned}$$

$$H_2 = \frac{((DMMVOL \times \frac{7,35}{(DMMVOL + 10)} - 0,013) \times (VOL + FC))}{100}$$

$$= \frac{((53,57 \times \frac{7,35}{(53,57 + 10)} - 0,013) \times (42,8 + 37,1))}{100}$$

$$= 4,94$$

O_2 = 100 – Ash – S – H_2 – C – Moisture – N_2

= 100 – 10,9 – 3,10 – 4,94 – 65,55 – 9,20 -1,16

= 5,20

HHV = 6239 Kcal/kg = 11.230 Btu/lb

Lampiran 5

Hasil Analisa Proximate Batubara Pada Pemakaian Ketel Uap
Setelah Dibersihkan

Certificate No. 00328/CDDBAG
Date: February 1, 2013

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REPORT OF ANALYSIS

PRINCIPAL	:	PT. INDOFOOD CBP SUKSES MAKMUR Tbk JL. KIMA X KAV. A3 BIRINGKANAYA MAKASSAR
TYPE OF SAMPLE	:	COAL
TESTED FOR	:	Total Moisture, Proximate Analysis, Total Sulfur and Gross Calorific Value
DESCRIPTION OF SAMPLE	:	FORM : Boulder WEIGHT SAMPLE : ± 9.49 KG TOP SIZE : ± 60 mm PACKING : Unsealed Plastic Bag
DATE RECEIVED	:	29/01/2013
DATE OF TESTING	:	29/01/2013 to 01/02/2013
SAMPLE MARK	:	OBBR119013
STANDARD METHOD	:	ASTM STANDARD

Result:

PARAMETER	UNIT	TEST RESULTS	METHODS
• Total Moisture, AR	% wt	11.6	ASTM D – 3302
• Moisture In Analysis the Sample, ADB	% wt	8.1	ASTM D – 3173
• Ash Content, ADB	% wt	12.7	ASTM D – 3174
• Volatile Matter, ADB	% wt	42.1	ISO 562
• Fixed Carbon, ADB	% wt	37.1	By difference
• Total Sulfur, ADB	% wt	1.16	ASTM D – 4239
• Gross Calorific Value, ADB	Kcal/kg	6216	ASTM D – 5865

THE RESULT OF TESTING ANALYSIS ONLY REFERS TO THE SAMPLE SUBMITTED AND DOES NOT REPRESENT ANY CONSIGMENT AS THE SAMPLE WAS NOT TAKEN BY PT SUCOFINDO

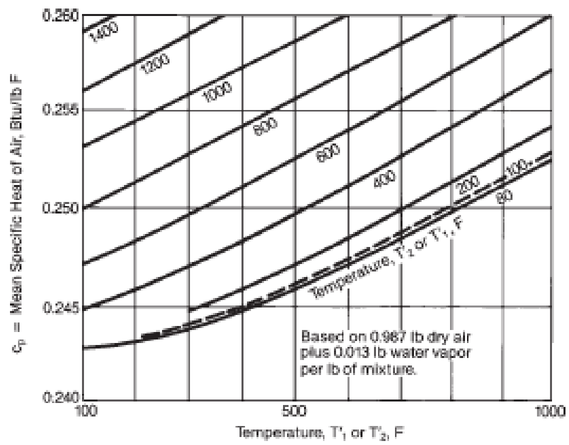
Dept. of Testing

MKSOP3201300150

Arie Hartono

Lampiran 6

Grafik Nilai Kapasitas Panas



Lampiran 7

Tabel Hasil Perhitungan Kesetimbangan Energi dan Prestasi Kerja Ketel Uap Sebelum Dibersihkan Menggunakan Bahan Bakar Campuran 60% Batubara Lignit dan 40% Cangkang Biji Jambu Mete

No	Parameter	Bahan bakar : 60% Batubara Lignite dan 40% cangkang biji jambu mete			
		Hasil Perhitungan	Satuan SI	Hasil Perhitungan	Satuan British
1	Kalor hot product (input), Q_1	16,424 x 10^6	kJ/h	15,577 x 10^6	Btu/h
2	Kalor air umpan ketel (input), Q_6	1,949 x 10^6	kJ/h	1,849 x 10^6	Btu/h
3	Kalor uap/steam yang dibangkitkan (output), Q_4	15,870 x 10^6	kJ/h	15,052 x 10^6	Btu/h
4	Kalor gas buang/flue gas (output), Q_2	0,128 x 10^6	kJ/h	0,121 x 10^6	Btu/h
5	Kalor yang hilang/losses (output), Q_5	2,375 x 10^6	kJ/h	2,253 x 10^6	Btu/h
6	Kalor yang dimanfaatkan, Q_3	16,296 x 10^6	kJ/h	15,456 x 10^6	Btu/h
7	Persentase Kalor yang hilang/losses ,Q5	14,46	%	14,46	%
8	Efisiensi ketel, η	84,76	%	84,76	%
9	Laju aliran uap (m_s)	5.750	kg/h	12.677	lb/h
10	Laju aliran gas (m_g), BTU no 56	7.121	kg/h	15.700	lb/h
11	Temperatur Pembakaran pada ruang bakar	1.543	°C	2.810	°F
12	Temperatur gas keluar ruang bakar/ Temperatur gas masuk pipa api	838	°C	1.540	°F
13	Temperatur gas keluar pipa api	208	°C	406	°F
14	Temperatur air umpan ketel	81	°C	178	°F
15	Konsumsi bahan bakar, BTU no 55	680,388	kg/h	1.500	lb/h
16	Kebutuhan udara pembakaran, BTU no 56	7.121	kg/h	15.700	lb/h
17	Indeks slagging	0,86% (sedang)			
18	Indeks fouling	Na2O = 0,05% (rendah-sedang)			

Lampiran 8

Tabel Kondisi Proses BTU-Method Sebelum Ketel Uap Dibersihkan
Menggunakan Bahan Bakar Batubara Lignit

Kondisi Operasi

Bahan bakar: batubara lignit, Mallawa

(tanggal 11 januari 2013)

Ultimate, % by wt		Proximate, % by wt	
C	65,55	Moisture	9,20
H2	4,94	Volatiles	42,80
S	3,10	Fixed carbon	37,10
O2	5,20	Ash	10,90
N2	1,16		100
H2O	9,20		
Ash	10,90		
	100		

Higher heating value (HHV) : 11.230 Btu/lb

Excess air	31,0	% by wt
Unburned carbon loss	0,23	% by wt
Unaccounted loss	1,5	% by wt
ABMA radiation loss (see Chapter 22)	0,4	% by wt
Furnace exit gas temperature	1.607	F

Lampiran 9

BTU-Method Sebelum Ketel Uap Dibersihkan Menggunakan Bahan Bakar Batubara Lignit

Perhitungan pembakaran - metode BTU batubara lignit Mallawa (11 januari 2013)

No	INPUT CONDITION - BY TEST OR SPESIFICATION	Value		FUEL - Lignite coal,					
				15 Ultimate Analysis		16 Theo air, lb/100 lb fuel		17 H_2O, lb/100 lb fuel	
1	Excess air; at burner/leaving boiler/econ, % by weight	31 31		Constituent	% by weight	K1	[15] x K1	K2	[15] x K2
2	Entering air temperature, F	80							
3	Reference temperature, F	80	A	C	65,55	11,51	754,5		
4	Fuel temperature, F	80	B	S	3,10	4,32	13,4		
5	Air temperature leaving air heater, F		C	H_2	4,94	34,29	169,4	8,94	44,1636
6	Flue gas temperature leaving (excluding leakage), F	518	D	H_2O	9,20			1,00	9,20
7	Moisture in air, lb/lb dry air	0,013	E	N_2	1,16				
8	Additional moisture, lb/100 lb fuel	0	F	O_2	5,20	-4,32	-22,5		
9	Residue leaving boiler/economiser. % total		G	Ash	10,90				
10	Output, 1,000,000 Btu/h	12,6	H	Total	100,05	Air	914,8	H_2O	53,3636

No	Item	Reference	Value	No	Item	Formula	Value
	Corrections for sorbent (from table 14, Chapter 9 if used)						
11	Additional theoretical air, lb/10,000 Btu	Table 14, Item [21]	0	18	Higher heating value (HHV), Btu/lb fuel		11230
12	CO_2 from sorbent, lb/10,000 Btu	Table 14, Item [19]	0	19	Unburned carbon loss, % fuel input		0,23
13	H_2O from sorbent, lb/10,000 Btu	Table 14, Item [20]	0	20	Theoretical air, lb/10,000 Btu	[16H] x 100 / [18]	8,146
14	Spent sorbent. Lb/10,000 Btu	Table 14, Item [24]	0	21	Unburned carbon, % of fuel	[19] x [18] / 14,500	0,18

No	COMBUSTION GAS CALCULATION, Quantity / 10,000 Btu Fuel Input	Formula	A At Burners	B Infiltration	C Leaving Furnace		D Leaving Blr/Econ	
22	Theoretical air (corrected), lb/10,000 Btu	[20] - [21] x 1151 / [18] + [11]						8,128
23	Residue from fuel, lb/10,000 Btu	([15G] + [21]) x 100 / [18]						0,099
24	Total residue, lb/10,000 Btu	[23] + [14]						0,099
25	Excess air, % by weight		31,0	0,0		31,0		31,0
26	Dry air, lb/10,000 Btu	(1 + [25] / 100) x [22]				10,647		10,647
27	H_2O from air, lb/10,000 Btu	[26] x [7]			0,138	0,138	0,138	0,138
28	Additional moisture, lb/10,000 Btu	[8] x 100 / [18]			0,000	0,000	0,000	0,000
29	H_2O from fuel, lb/10,000 Btu	[17H] x 100 / [18]			0,475		0,475	
30	Wet gas from fuel, lb/10,000 Btu	(100 - [15G] - [21]) x 100 / [18]				0,792		0,792
31	CO_2 from sorbent, lb/10,000 Btu	[12]				0,000		0,000
32	H_2O from sorbent, lb/10,000 Btu	[13]			0,000	0,000	0,000	0,000
33	Total wet gas, lb/10,000 Btu	Summation [26] through [32]				11,578		11,578
34	Water in wet gas, lb/10,000 Btu	Summation [27] + [28] + [29] + [32]			0,614	0,614	0,614	0,614
35	Dry gas, lb/10,000 Btu	[33] - [34]				10,964		10,964
36	H_2O in gas, % by weight	100 x [34] / [33]				5,30		5,30
37	Residue, % by weight	[9] x [24] / [33]				0,00		0,00

No	EFFICIENCY CALCULATIONS, % Input from Fuel		Formula		Value
	Losses				
38	Dry gas, %		0.0024 x [35D] x ([6] - [3])		11,53
39	Water from	Enthalpy of steam at 1 psi, T=[6]	H_1 = (3.958E - 5 x T + 0.4329) x T + 1062.2	1297,1	
40	fuel as fired	Enthalpy of water at T=[3]	H2 = [3] - 32	48,0	
41	%		[29] x ([39] - [40]) / 100		5,94
42	Moisture in air, %		0.0045 x [27D] x ([6] - [3])		0,27
43	Unburned carbon, %		[19] or [21] x 14,500 / [18]		0,23
44	Radiation and convection, %		ABMA curve, Chapter 22		0,40
45	Anaccounted for and manufacturers margin, %				1,50
46	Sorbent net losses, % if sorbent in used		From table 14 Item [41, Chapter 9]		0,00
47	Summation of losses, %		Summation [38] through [46]		19,86
	Credits				
48	Heat in dry air, %		0.0024 x [26D] x ([2] - [3])		0,00
49	Heat in moisture in air, %		0.0045 x [27D] x ([2] - [3])		0,00
50	Sensible heat in fuel, %		(H at T[4] - H at T[3]) x 100 / [18]	0,00	0,00
51	Other, %				0,00
52	Summation of credits, %		Summation [48] through [51]		0,00
53	Efficiency, %		100 - [47] + [52]		80,14

No	KEY PERFORMANCE PARAMETERS	Formula	Leaving Furnace	Leaving Blr/Econ
54	Input from fuel, 1,000,000 Btu/h	100 x [10] / [53]		15,7
55	Fuel rate, 1000 lb/h	1000 x [54] / [18]		1,4
56	Wet gas weight, 1000 lb/h	[54] x [33] / 10	18,2	18,2
57	Air to burner (wet), lb/10,000 Btu	(1 + [7]) x (1 + [25A] / 100) x [22]	10,8	
58	Air to burner (wet), 1000 lb/h	[54] x [57] / 10	16,9	
59	Heat available, 1,000,000 Btu/h	[54] x [([18] - 10.30 x [17H]) / [18] - 0.005		
	H_a = 66,0 Btu/lb	x ([44] + [45]) + H_a at T[5] x [57] / 10.000]	13,7	
60	Heat available/lb wet gas, Btu/lb	1000 x [59] / [56]	751,8	
61	Adiabatic flame temperature, F	From fig. 3, Chap. 10 at H = [60], % H2O = [36]	2600	

Lampiran 10

Tabel Hasil Perhitungan Kesetimbangan Energi dan Prestasi Kerja Ketel Uap Sebelum Dibersihkan Menggunakan Bahan Bakar Batubara Lignit

No	Parameter	Bahan bakar : Batubara Lignite			
		Hasil Perhitungan	Satuan SI	Hasil Perhitungan	Satuan British
1	Kalor hot product (input), Q_1	$16{,}588 \times 10^6$	kJ/h	$15{,}733 \times 10^6$	Btu/h
2	Kalor air umpan ketel (input), Q_6	$1{,}762 \times 10^6$	kJ/h	$1{,}671 \times 10^6$	Btu/h
3	Kalor uap/steam yang dibangkitkan (output), Q_4	$15{,}033 \times 10^6$	kJ/h	$14{,}258 \times 10^6$	Btu/h
4	Kalor gas buang/flue gas (output), Q_2	$0{,}167 \times 10^6$	kJ/h	$0{,}158 \times 10^6$	Btu/h
5	Kalor yang hilang/losses (output), Q_5	$3{,}150 \times 10^6$	kJ/h	$2{,}988 \times 10^6$	Btu/h
6	Kalor yang dimanfaatkan, Q_3	$16{,}421 \times 10^6$	kJ/h	$15{,}575 \times 10^6$	Btu/h
7	Persentase Kalor yang hilang/losses ,Q5	18,99	%	18,99	%
8	Efisiensi ketel, η	80	%	80	%
9	Laju aliran uap (m_s)	5.449	kg/h	12.013	lb/h
10	Laju aliran gas (m_g), BTU no 56	8.255	kg/h	18.200	lb/h
11	Temperatur Pembakaran pada ruang bakar	1.427	^oC	2.600	^oF
12	Temperatur gas keluar ruang bakar/ Temperatur gas masuk pipa api	875	^oC	1.607	^oF
13	Temperatur gas keluar pipa api	270	^oC	518	^oF
14	Temperatur air umpan ketel	77	^oC	171	^oF
15	Konsumsi bahan bakar, BTU no 55	635,029	kg/h	1.400	lb/h
16	Kebutuhan udara pembakaran, BTU no 56	8.255	kg/h	18.200	lb/h
17	Indeks slagging	1,42% (sedang)			
18	Indeks fouling	Na2O = 0,34% (rendah-sedang)			

Lampiran 11

Tabel Kondisi Proses BTU-Method Setelah Ketel Uap Dibersihkan Menggunakan Bahan Bakar Batubara Lignit

Kondisi Operasi

Bahan bakar: batubara lignit, Mallawa (tanggal 27 pebruari 2013)

Ultimate, % by wt		Proximate, % by wt	
C	65,01	Moisture	8,10
H2	4,90	Volatiles	42,10
S	1,16	Fixed carbon	37,10
O2	6,97	Ash	12,70
N2	1,16		100
H2O	8,10		
Ash	12,70		
	100		

Higher heating value (HHV) :	11.189	Btu/lb
Excess air	30,0	% by wt
Unburned carbon loss	0,23	% by wt
Unaccounted loss	1,5	% by wt
ABMA radiation loss (see Chapter 22)	0,4	% by wt
Furnace exit gas temperature	1.555	F

Lampiran 12

BTU-Method Setelah Ketel Uap Dibersihkan Menggunakan Bahan Bakar Batubara Lignit

Perhitungan pembakaran - metode BTU batubara lignit Mallawa (tanggal 27 pebruari 2013)

No	INPUT CONDITION - BY TEST OR SPESIFICATION		Value		FUEL - Lignite coal,					
1	Excess air; at burner/leaving boiler/econ, % by weight		30 30		15 Ultimate Analysis		16 Theo air, lb/100 lb fuel		17 H_2O, lb/100 lb fuel	
2	Entering air temperature, F		80		Constituent	% by weight	K1	[15] x K1	K2	[15] x K2
3	Reference temperature, F		80	A	C	65,01	11,51	748,3		
4	Fuel temperature, F		80	B	S	1,16	4,32	5,0		
5	Air temperature leaving air heater, F			C	H_2	4,90	34,29	168,0	8,94	43,806
6	Flue gas temperature leaving (excluding leakage), F		339,269	D	H_2O	8,10			1,00	8,10
7	Moisture in air, lb/lb dry air		0,013	E	N_2	1,16				
8	Additional moisture, lb/100 lb fuel		0	F	O_2	6,97	-4,32	-30,1		
9	Residue leaving boiler/economiser. % total			G	Ash	12,70				
10	Output, 1,000,000 Btu/h		13,4	H	Total	100,00	Air	891,2	H_2O	51,906
	Corrections for sorbent (from table 14, Chapter 9 if used)									
11	Additional theoretical air, lb/10,000 Btu	Table 14, Item [21]	0	18	Higher heating value (HHV), Btu/lb fuel					11189
12	CO_2 from sorbent, lb/10,000 Btu	Table 14, Item [19]	0	19	Unburned carbon loss, % fuel input					0,23
13	H_2O from sorbent, lb/10,000 Btu	Table 14, Item [20]	0	20	Theoretical air, lb/10,000 Btu			[16H] x 100 / [18]		7,965
14	Spent sorbent. Lb/10,000 Btu	Table 14, Item [24]	0	21	Unburned carbon, % of fuel			[19] x [18] / 14,500		0,18

No	COMBUSTION GAS CALCULATION, Quantity / 10,000 Btu Fuel Input	Formula	A At Burners	B Infiltration	C Leaving Furnace		D Leaving Blr/Econ	
22	Theoretical air (corrected), lb/10,000 Btu	[20] - [21] x 1151 / [18] + [11]						7,947
23	Residue from fuel, lb/10,000 Btu	([15G] + [21]) x 100 / [18]						0,115
24	Total residue, lb/10,000 Btu	[23] + [14]						0,115
25	Excess air, % by weight		30,0	0,0		30,0		30,0
26	Dry air, lb/10,000 Btu	(1 + [25] / 100) x [22]				10,331		10,331
27	H_2O from air, lb/10,000 Btu	[26] x [7]			0,134	0,134	0,134	0,134
28	Additional moisture, lb/10,000 Btu	[8] x 100 / [18]			0,000	0,000	0,000	0,000
29	H_2O from fuel, lb/10,000 Btu	[17H] x 100 / [18]			0,464		0,464	
30	Wet gas from fuel, lb/10,000 Btu	(100 - [15G] - [21]) x 100 / [18]				0,779		0,779
31	CO_2 from sorbent, lb/10,000 Btu	[12]				0,000		0,000
32	H_2O from sorbent, lb/10,000 Btu	[13]			0,000	0,000	0,000	0,000
33	Total wet gas, lb/10,000 Btu	Summation [26] through [32]				11,244		11,244
34	Water in wet gas, lb/10,000 Btu	Summation [27] + [28] + [29] + [32]			0,598	0,598	0,598	0,598
35	Dry gas, lb/10,000 Btu	[33] - [34]				10,645		10,645
36	H_2O in gas, % by weight	100 x [34] / [33]				5,32		5,32
37	Residue, % by weight	[9] x [24] / [33]				0,00		0,00

No	EFFICIENCY CALCULATIONS, % Input from Fuel		Formula		Value
	Losses				
38	Dry gas, %		0.0024 x [35D] x ([6] - [3])		6,62
39	Water from fuel as fired %	Enthalpy of steam at 1 psi, T=[6]	H_1 = (3.958E - 5 x T + 0.4329) x T + 1062.2	1213,6	
40		Enthalpy of water at T=[3]	H2 = [3] - 32	48,0	
41			[29] x ([39] - [40]) / 100		5,41
42	Moisture in air, %		0.0045 x [27D] x ([6] - [3])		0,16
43	Unburned carbon, %		[19] or [21] x 14,500 / [18]		0,30
44	Radiation and convection, %		ABMA curve, Chapter 22		0,40
45	Anaccounted for and manufacturers margin, %				1,50
46	Sorbent net losses, % if sorbent in used		From table 14 Item [41, Chapter 9]		0,00
47	Summation of losses, %		Summation [38] through [46]		14,39
	Credits				
48	Heat in dry air, %		0.0024 x [26D] x ([2] - [3])		0,00
49	Heat in moisture in air, %		0.0045 x [27D] x ([2] - [3])		0,00
50	Sensible heat in fuel, %		(H at T[4] - H at T[3]) x 100 / [18]	0,00	0,00
51	Other, %				0,00
52	Summation of credits, %		Summation [48] through [51]		0,00
53	Efficiency, %		100 - [47] + [52]		85,61

No	KEY PERFORMANCE PARAMETERS	Formula	Leaving Furnace	Leaving Blr/Econ
54	Input from fuel, 1,000,000 Btu/h	100 x [10] / [53]		15,7
55	Fuel rate, 1000 lb/h	1000 x [54] / [18]		1,4
56	Wet gas weight, 1000 lb/h	[54] x [33] / 10	17,6	17,6
57	Air to burner (wet), lb/10,000 Btu	(1 + [7]) x (1 + [25A] / 100) x [22]	10,5	
58	Air to burner (wet), 1000 lb/h	[54] x [57] / 10	16,4	
59	Heat available, 1,000,000 Btu/h	[54] x [([18] - 10.30 x [17H]) / [18] - 0.005		
	H_a = 66,0 Btu/lb	x ([44] + [45]) + H_a at T[5] x [57] / 10.000]	13,7	
60	Heat available/lb wet gas, Btu/lb	1000 x [59] / [56]	777,0	
61	Adiabatic flame temperature, F	From fig. 3, Chap. 10 at H = [60], % H2O = [36]	2480	

Lampiran 13

Tabel Hasil Perhitungan Kesetimbangan Energi dan Prestasi Kerja Ketel Uap Setelah Dibersihkan Menggunakan Bahan Bakar Batubara Lignit

No	Parameter	Bahan bakar : Batubara Lignite			
		Hasil Perhitungan	Satuan SI	Hasil Perhitungan	Satuan British
1	Kalor hot product (input), Q_1	16,527 x 10^6	kJ/h	15,675 x 10^6	Btu/h
2	Kalor air umpan ketel (input), Q_6	1,801 x 10^6	kJ/h	1,708 x 10^6	Btu/h
3	Kalor uap/steam yang dibangkitkan (output), Q_4	15,938 x 10^6	kJ/h	15,115 x 10^6	Btu/h
4	Kalor gas buang/flue gas (output), Q_2	0,096 x 10^6	kJ/h	0,093 x 10^6	Btu/h
5	Kalor yang hilang/losses (output), Q_5	2,294 x 10^6	kJ/h	2,175 x 10^6	Btu/h
6	Kalor yang dimanfaatkan, Q_3	16,431 x 10^6	kJ/h	15,584 x 10^6	Btu/h
7	Persentase Kalor yang hilang/losses ,Q5	13,88	%	13,88	%
8	Efisiensi ketel, η	85,54	%	85,54	%
9	Laju aliran uap (m_s)	5.800	kg/h	12.787	lb/h
10	Laju aliran gas (m_g), BTU no 56	7.983	kg/h	17.600	lb/h
11	Temperatur Pembakaran pada ruang bakar	1.360	°C	2.480	°F
12	Temperatur gas keluar ruang bakar/ Temperatur gas masuk pipa api	846	°C	1.555	°F
13	Temperatur gas keluar pipa api	171	°C	339	°F
14	Temperatur air umpan ketel	74,2	°C	166	°F
15	Konsumsi bahan bakar, BTU no 55	635,029	kg/h	1.400	lb/h
16	Kebutuhan udara pembakaran, BTU no 56	7.983	kg/h	17.600	lb/h
17	Indeks slagging	1,42% (sedang)			
18	Indeks fouling	Na2O = 0,34% (rendah-sedang)			

Lampiran 14

Tabel Hasil Perhitungan Kesetimbangan Energi dan Prestasi Kerja Ketel Uap Sebelum dan Setelah Dibersihkan

No	Parameter	Menggunakan 60% batubara lignit dan 40% cangkang biji jambu mete sebelum ketel uap dibersihkan	Menggunakan batubara lignit sebelum ketel uap dibersihkan	Menggunakan batubara lignit setelah ketel uap dibersihkan
1	Temperatur pembakaran (°C)	1.543	1.427	1.360
2	Temperatur gas keluar ruang bakar (°C)	838	875	846
3	Temperatur gas keluar pipa api (°C)	208	270	171
4	Laju alir massa uap/steam (kg/h)	5.750	5.449	5.800
5	Efisiensi ketel uap (%)	84,76	80	85,54
6	Kalor hot product (input), Q_1 (kJ/h)	$16,424 \times 10^6$	$16,588 \times 10^6$	$16,527 \times 10^6$
7	Kalor air umpan ketel (input), $Q_{6,}$ (kJ/h)	$1,949 \times 10^6$	$1,762 \times 10^6$	$1,801 \times 10^6$
8	Kalor uap/steam yang dibangkitkan (output), $Q_{4,}$ (kJ/h)	$15,870 \times 10^6$	$15,033 \times 10^6$	$15,938 \times 10^6$
9	Kalor gas buang/flue gas (output), $Q_{2,}$ (kJ/h)	$0,128 \times 10^6$	$0,167 \times 10^6$	$0,096 \times 10^6$
10	Kalor yang hilang/losses (output), $Q_{5,}$ (kJ/h)	$2,375 \times 10^6$	$3,150 \times 10^6$	$2,294 \times 10^6$
11	Kalor yang dimanfaatkan, $Q_{3,}$ (kJ/h)	$16,296 \times 10^6$	$16,421 \times 10^6$	$16,431 \times 10^6$
12	Indeks slagging (%)	0,86%	1,42%	1,42%
13	Indeks fouling Na_2O (%)	0,05%	0,34%	0,34%

Lampiran 15

Hasil Perhitungan Indeks Slagging dan Fouling

No	Bahan Bakar yang Digunakan	Indeks slagging	Kategori	Indeks fouling	Kategori
1	Batubara	1,42%	sedang	$CaO + MgO + Fe_2O_3 > 20\%$ $Na_2O = 0,34\%$ $Na_2O < 3$	rendah - sedang
2	60% batubara dan 40% cangkang biji jambu mete	0,86%	sedang	$CaO + MgO + Fe_2O_3 > 20\%$ $Na_2O = 0,05\%$ $Na_2O < 3$	rendah - sedang

Lampiran 16

Perhitungan Ekonomi

Data pembiayaan :
- Harga batubara = Rp. 650/kg
- Harga cangkang biji jambu mete = Rp. 700/kg
- Biaya transport bahan bakar yg tidak terbakar ke PPLI = Rp. 1.520/kg
- Biaya pengemasan bahan bakar yg tidak terbakar = Rp. 30/kg

<u>Bila menggunakan batubara lignit</u>
- Uap yang dihasilkan = 5.449 kg/h
- Bahan bakar yang digunakan = 635,029 kg/h
- Bahan bakar yang tidak terbakar = 0,23%

Biaya harga bahan bakar perjam = 635,029 kg x Rp. 700/kg
= Rp. 444.520,3

Biaya penanganan bahan bakar yang tidak terbakar :
- Jh bahan bakar yang tidak terbakar perjam = 0,23% x 635,029 kg = 1,46 kg

- Biaya transport bahan bakar yg tidak terbakar ke PPLI =1,46kg x Rp.1.520/kg
= Rp. 2.219,2

-Biaya pengemasan bahan bakar yang tidak terbakar = 1,46 kg x Rp.30/kg
= Rp. 43,8

Total biaya penanganan bahan bakar yg tidak terbakar = Rp.2.219,2 + Rp.43,8
= Rp. 2.263

Biaya perjam bila menggunakan batubara lignit = Rp. 444.520,3 + Rp. 2.263
= Rp. 446.783,3

<u>Bila menggunakan campuran 60% batubara lignit dan 40% cangkang biji jambu mete</u>
- Uap yang dihasilkan = 5.750 kg/h
- Bahan bakar yang digunakan = 680,338 kg/h
- Bahan bakar yang tidak terbakar = 0,14%

Biaya harga bahan bakar perjam :

$$\text{Jumlah bahan bakar perjam} = \frac{5.449\text{kg}}{5.750\text{kg}} \times 635{,}029\text{kg} = 601{,}787\text{kg}$$

$$\text{Jumlah batubara lignit perjam} = \frac{60}{100} \times 601{,}787\text{kg} = 361{,}072\text{ kg}$$

$$\text{Jumlah cangkang biji jambu mete perjam} = \frac{40}{100} \times 601{,}787\text{kg} = 240{,}715\text{ kg}$$

Biaya harga batubara lignit perjam = 361,072 kg x Rp. 700/kg = Rp. 252.750,54

Biaya harga cangkang biji jambu mete perjam = 240,715 kg x Rp. 650/kg
= Rp. 156.464,62

Biaya harga bahan bakar perjam = Rp. 252.750,54 + Rp. 156.464,62
= Rp. 409.215,16

Biaya penanganan bahan bakar yang tidak terbakar :
- Jh bahan bakar yang tidak terbakar perjam = 0,14% x 601,787 kg = 0,84 kg

- Biaya transport bahan bakar yg tidak terbakar ke PPLI =0,84 kg x Rp.1.520/kg
= Rp. 1.276,8

-Biaya pengemasan bahan bakar yang tidak terbakar = 0,84 kg x Rp.30/kg
= Rp. 25,2

Total biaya penanganan bahan bakar yg tidak terbakar = Rp.1.276,8 + Rp.25,2
= Rp. 1.302

Biaya perjam bila menggunakan batubara lignit = Rp. 409.215,16 + Rp. 1.302
= Rp. 410.517,16

Penghematan yang didapat perjam = Rp. 446.783,3 – Rp. 410.517,16
= ***Rp. 36.266,14***

Penghematan yang didapat untuk 1 ketel uap perhari = Rp. 36.266,14 x 24
= ***Rp. 870.387,36***

Penghematan yang didapat untuk 3 ketel uap perhari = Rp. 870.387,36 x 3
= ***Rp. 2.611.162,08***

Penghematan perbulan yang didapat untuk ketiga ketel uap
= Rp. 2.611.162,08 x 25
= ***Rp. 65.279.052***