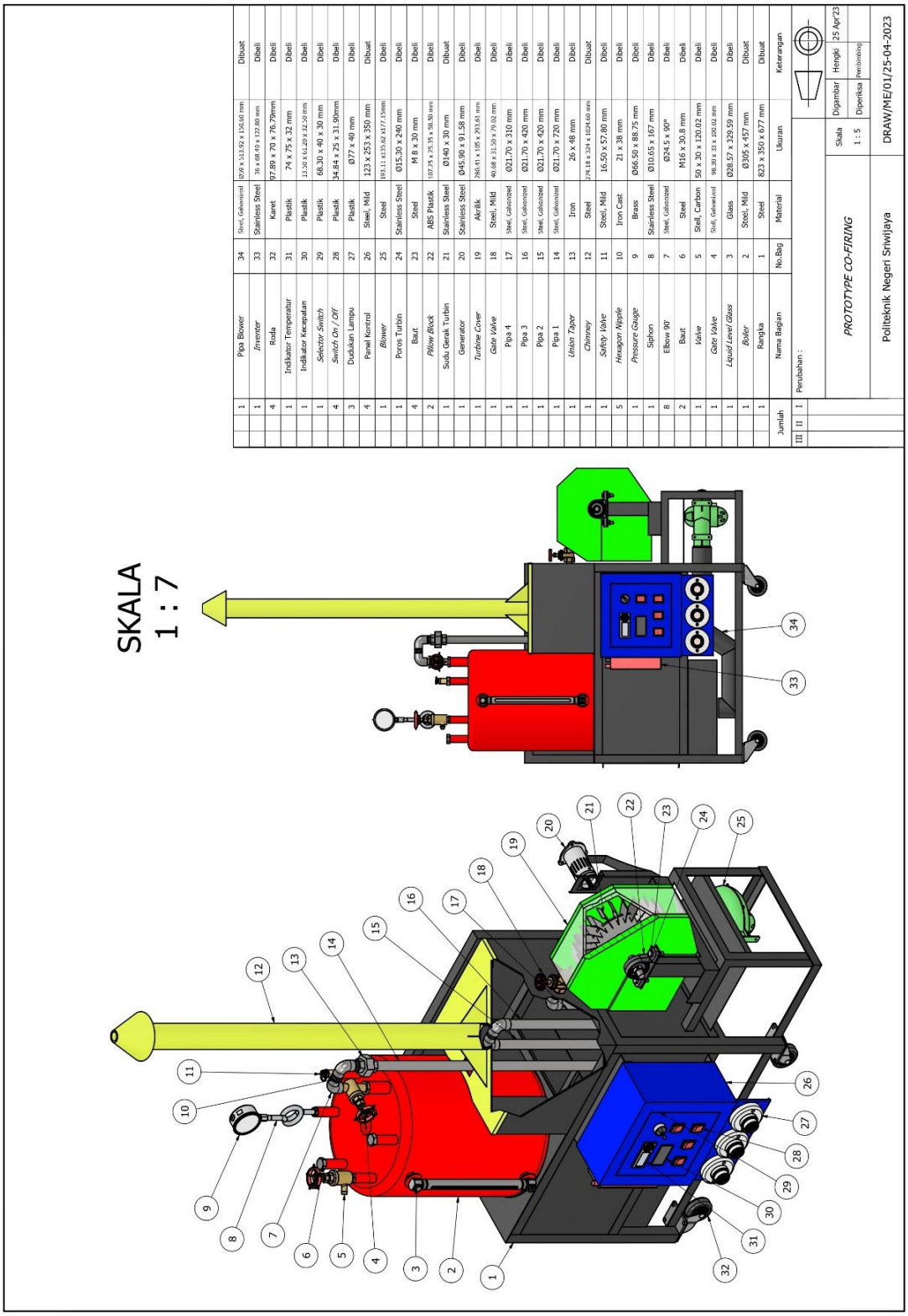
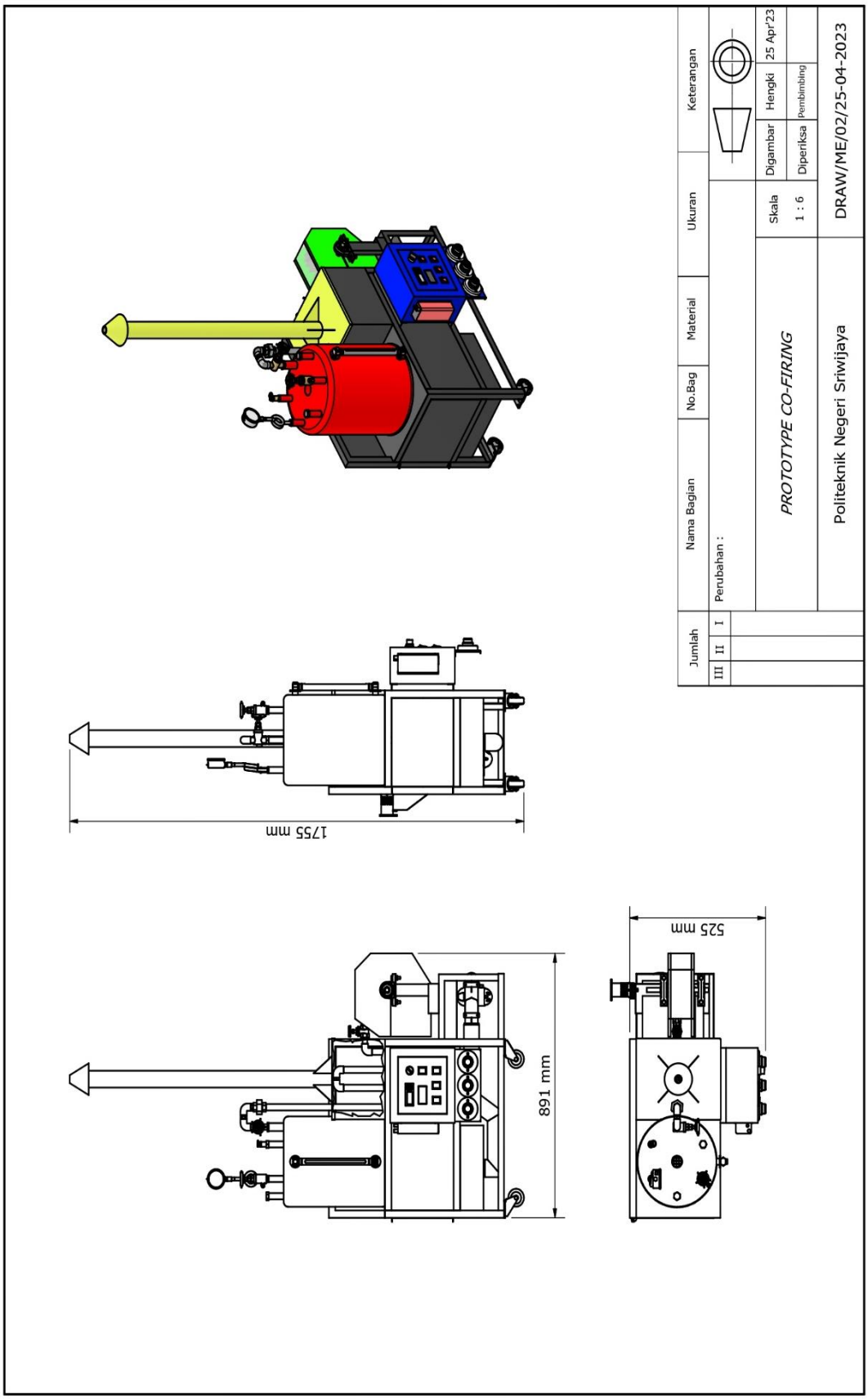
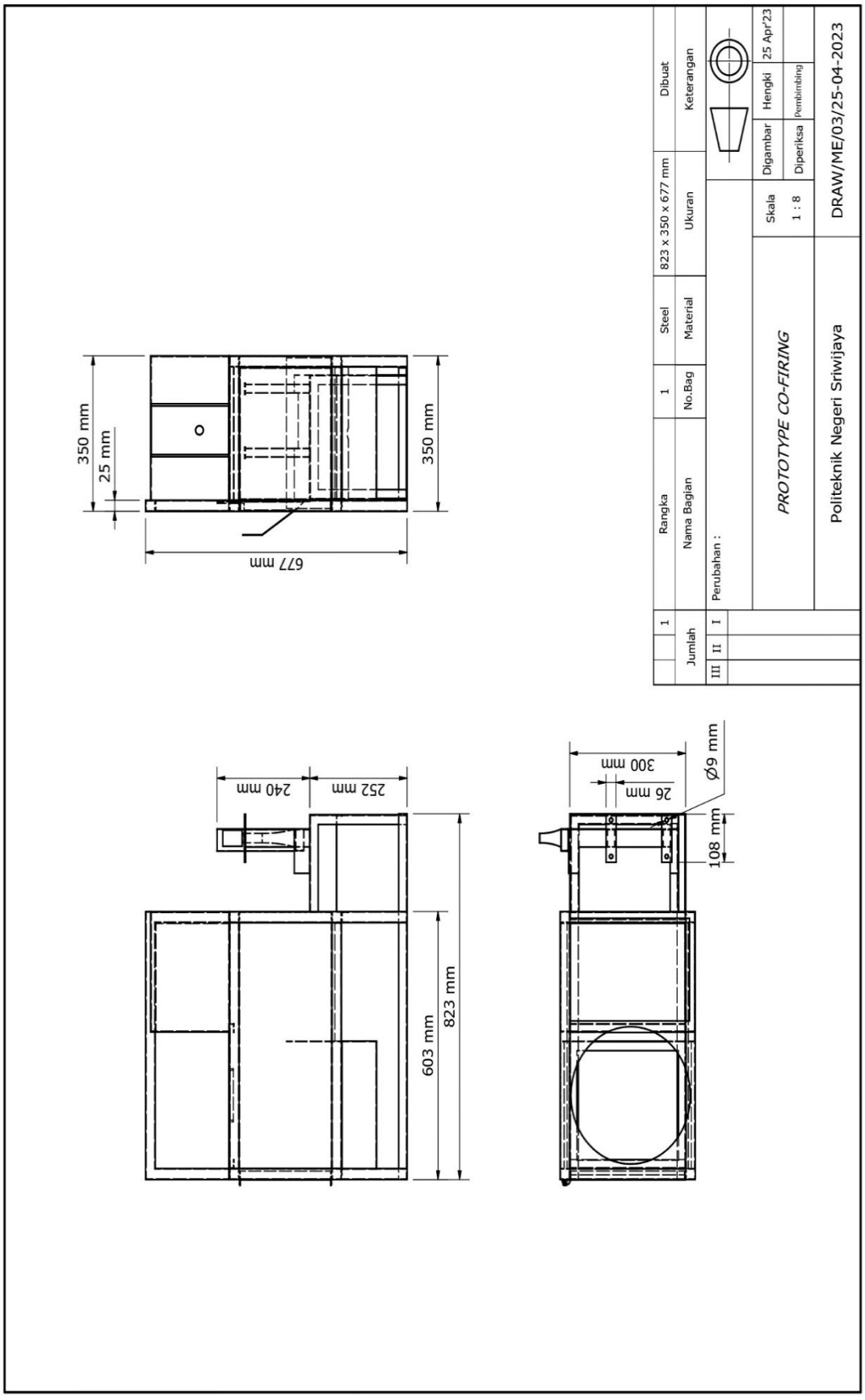
L A M P I R A N 1

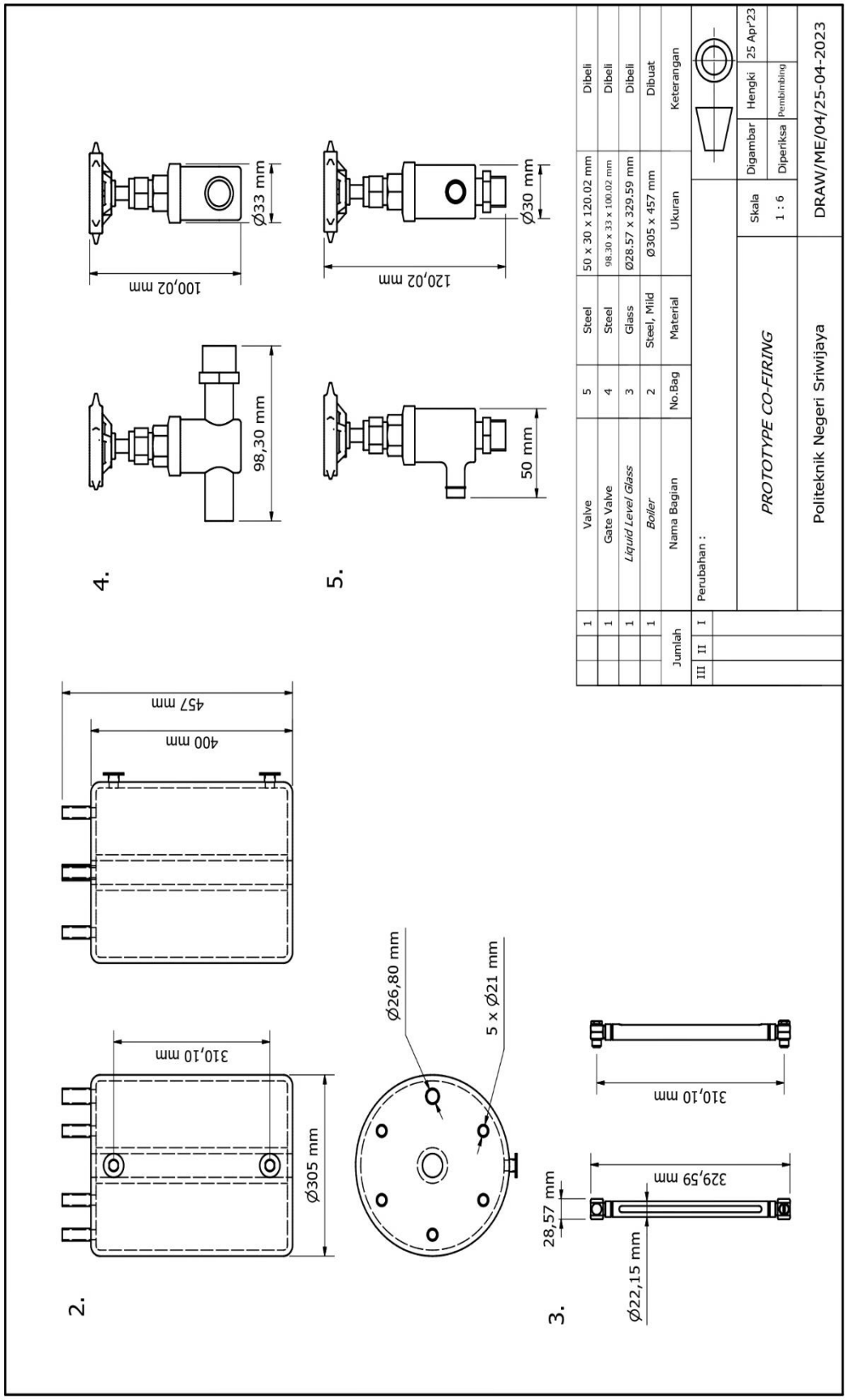
DESIGN BOILER PORTABEL

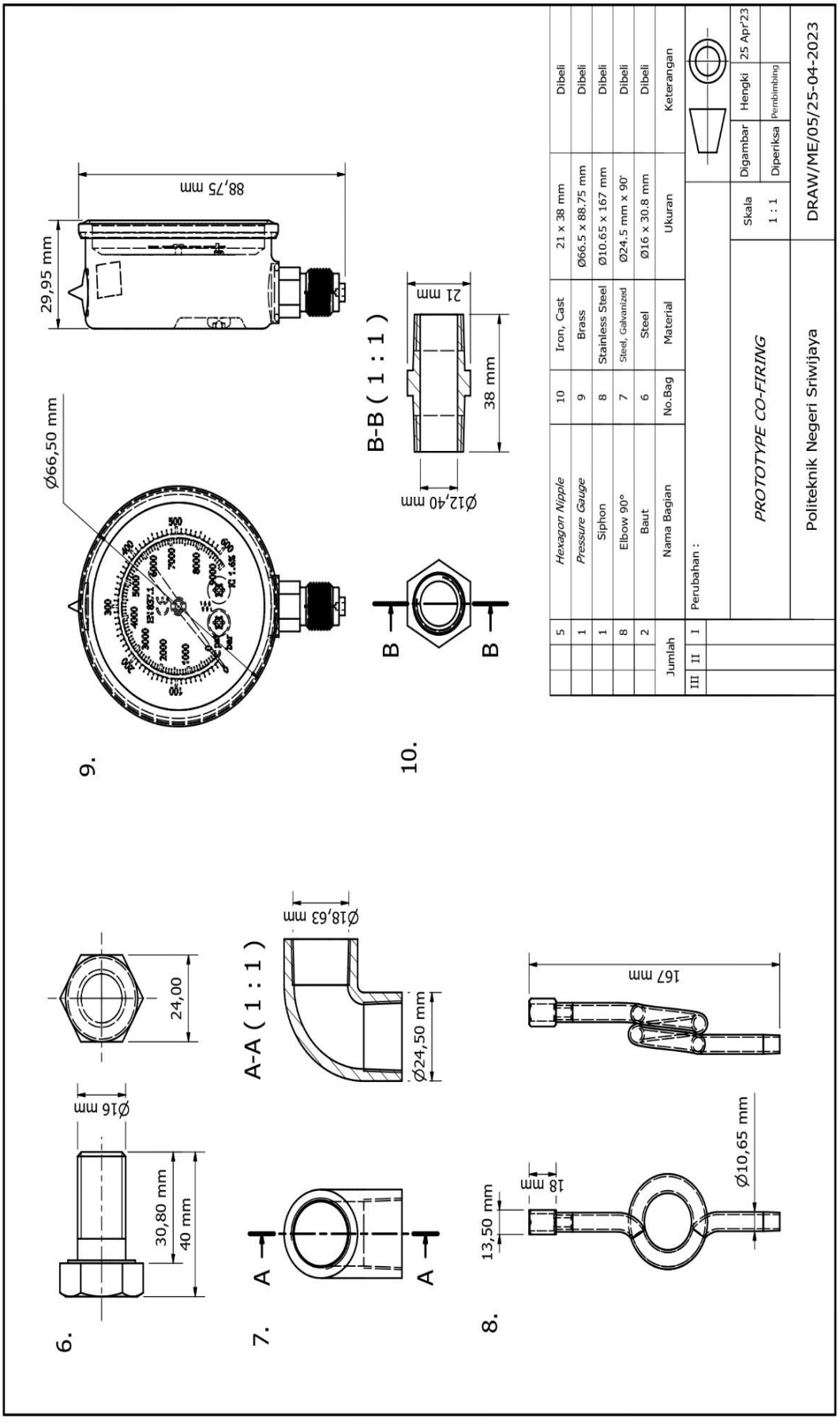
LAMPIRAN
BOILER PORTABEL

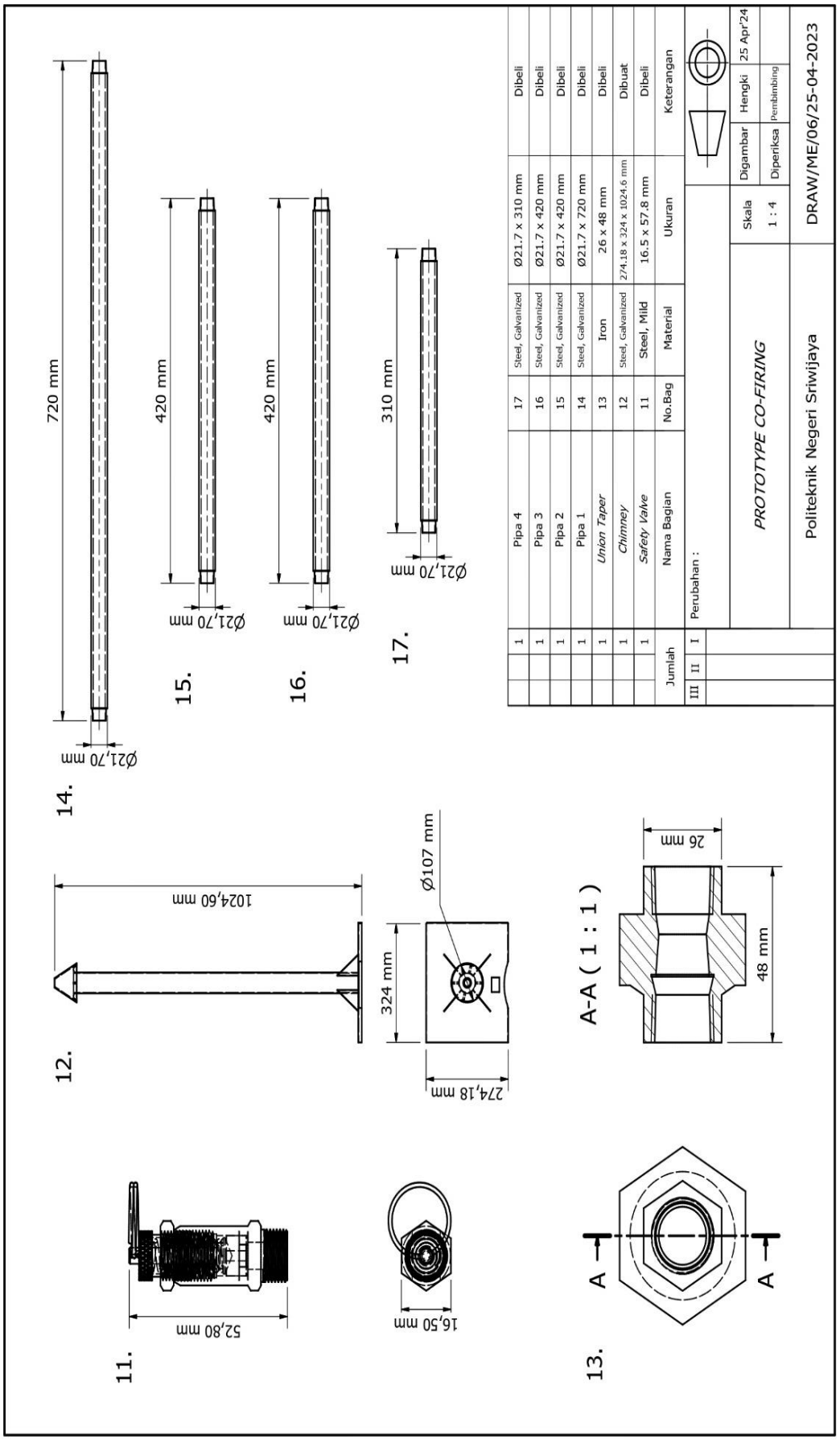


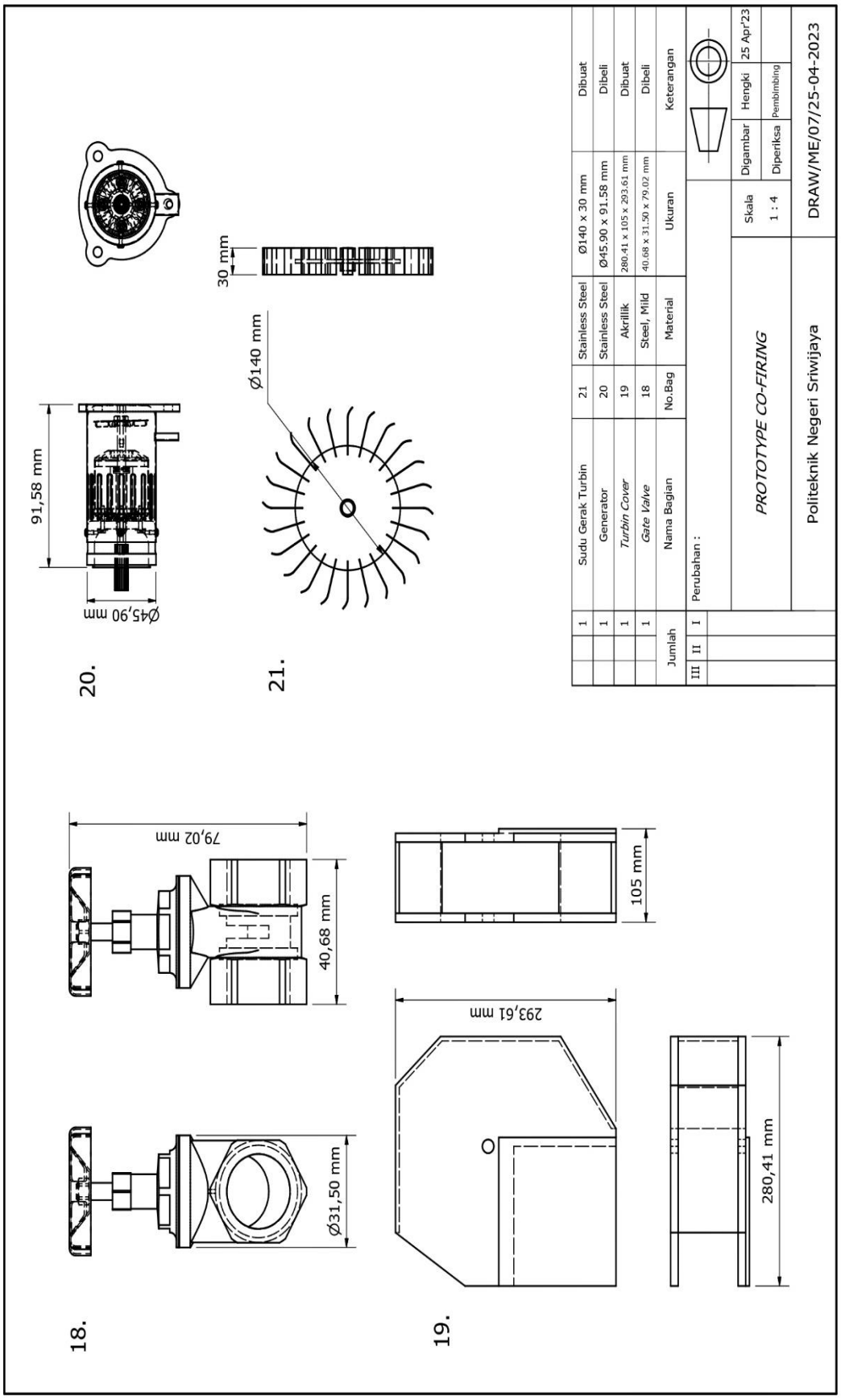

Jumlah
I
II
III
Nama Bagian
Perubahan :
No.Bag
Material
Ukuran
Keterangan
PROTOTYPE CO-FIRING
Skala
1 : 6
Digambar
Hengki
25 Apr'23
Diperiksa
Pembimbing
Politeknik Negeri Sriwijaya
DRAW/ME/02/25-04-2023
1755 mm
891 mm
525 mm

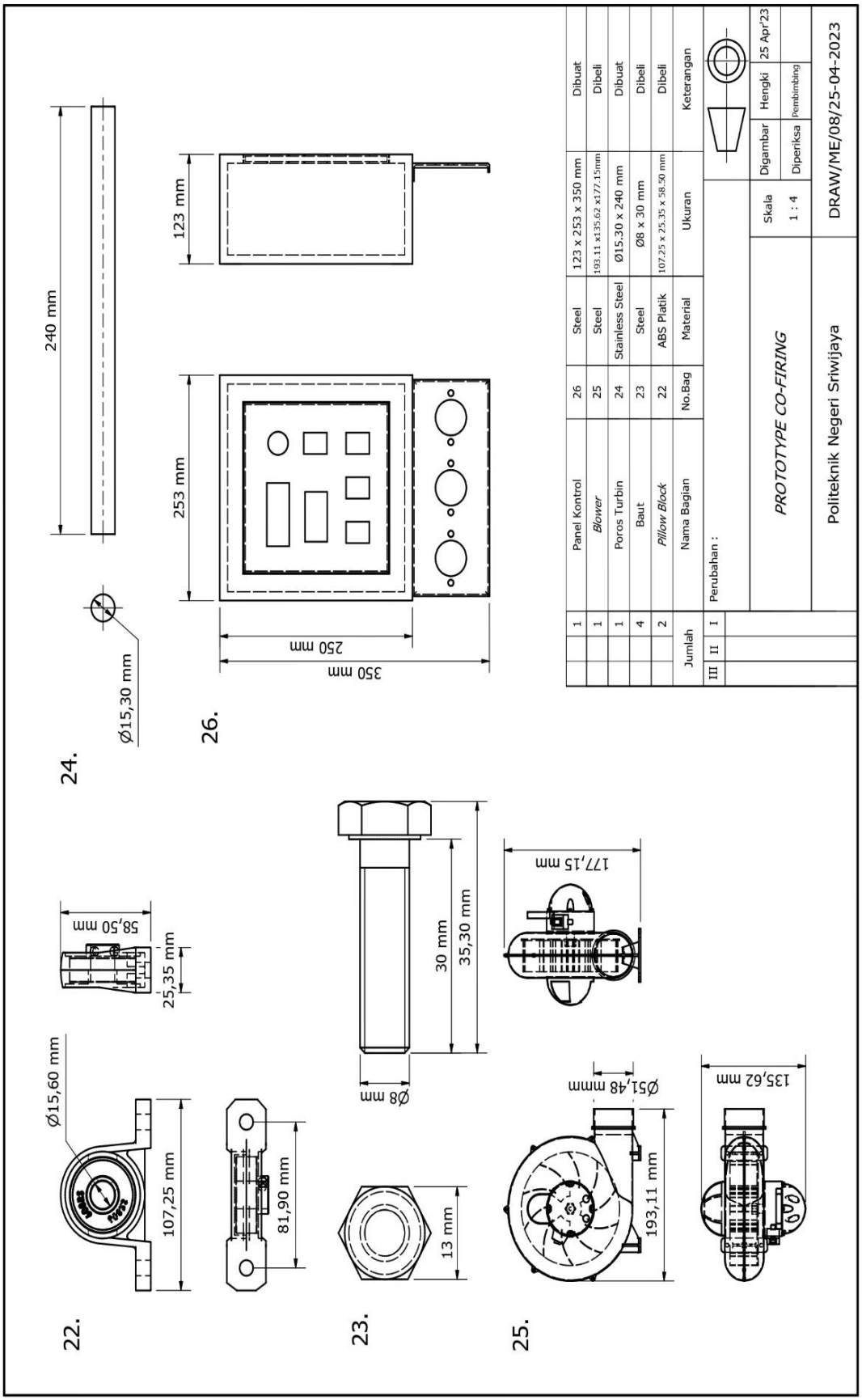

350 mm
25 mm
350 mm
677 mm
240 mm
252 mm
603 mm
823 mm
300 mm
26 mm
Ø9 mm
108 mm
Rangka
1
Steel
823 x 350 x 677 mm
Dibuat
Nama Bagian
No.Bag
Material
Ukuran
Keterangan
Perubahan :
PROTOTYPE CO-FIRING
Skala
1 : 8
Digambar
Hengki
25 Apr'23
Diperiksa
Pembimbing
Politeknik Negeri Sriwijaya
DRAW/ME/03/25-04-2023
Jumlah
1
III II I

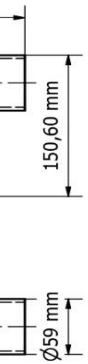

4.
Ø33 mm
100,02 mm
98,30 mm
5.
Ø30 mm
120,02 mm
50 mm
2.
457 mm
400 mm
310,10 mm
Ø305 mm
Ø26,80 mm
5 x Ø21 mm
3.
310,10 mm
329,59 mm
28,57 mm
Ø22,15 mm
1 Valve 5 Steel 50 x 30 x 120.02 mm Dibeli
1 Gate Valve 4 Steel 98.30 x 33 x 100.02 mm Dibeli
1 Liquid Level Glass 3 Glass Ø28.57 x 329.59 mm Dibeli
1 Boiler 2 Steel, Mild Ø305 x 457 mm Dibuat
Jumlah Nama Bagian No.Bag Material Ukuran Keterangan
III II I Perubahan :
PROTOTYPE CO-FIRING
Skala 1 : 6
Digambar Hengki 25 Apr'23
Diperiksa Pembimbing
Politeknik Negeri Sriwijaya
DRAW/ME/04/25-04-2023


6.
Ø16 mm
30,80 mm
40 mm
24,00
7.
A-A (1 : 1)
Ø18,63 mm
Ø24,50 mm
A
A
8.
167 mm
13,50 mm
18 mm
Ø10,65 mm
9.
Ø66,50 mm
29,95 mm
88,75 mm
10.
B-B (1 : 1)
21 mm
38 mm
Ø12,40 mm
B
B
5 Hexagon Nipple 10 Iron, Cast 21 x 38 mm Dibeli
1 Pressure Gauge 9 Brass Ø66.5 x 88.75 mm Dibeli
1 Siphon 8 Stainless Steel Ø10.65 x 167 mm Dibeli
8 Elbow 90° 7 Steel, Galvanized Ø24.5 mm x 90° Dibeli
2 Baut 6 Steel Ø16 x 30.8 mm Dibeli
Jumlah Nama Bagian No.Bag Material Ukuran Keterangan
III II I Perubahan :
PROTOTYPE CO-FIRING
Skala 1 : 1
Digambar Hengki 25 Apr'23
Diperiksa Pembimbing
Politeknik Negeri Sriwijaya
DRAW/ME/05/25-04-2023


720 mm
Ø21,70 mm
14.
420 mm
Ø21,70 mm
15.
420 mm
Ø21,70 mm
16.
310 mm
Ø21,70 mm
17.
1024,60 mm
324 mm
Ø107 mm
274,18 mm
12.
A-A (1 : 1)
26 mm
48 mm
52,80 mm
11.
16,50 mm
A
A
13.
Politeknik Negeri Sriwijaya
DRAW/ME/06/25-04-2023
PROTOTYPE CO-FIRING
Skala 1 : 4
Digambar Hengki 25 Apr'24
Diperiksa Pembimbing
Perubahan :
Jumlah
Nama Bagian
No.Bag
Material
Ukuran
Keterangan
Pipa 4 17 Steel, Galvanized Ø21.7 x 310 mm Dibeli
Pipa 3 16 Steel, Galvanized Ø21.7 x 420 mm Dibeli
Pipa 2 15 Steel, Galvanized Ø21.7 x 720 mm Dibeli
Pipa 1 14 Steel, Galvanized Ø21.7 x 720 mm Dibeli
Union Taper 13 Iron 26 x 48 mm Dibeli
Chimney 12 Steel, Galvanized 274.18 x 324 x 1024.6 mm Dibuat
Safety Valve 11 Steel, Mild 16.5 x 57.8 mm Dibeli


18.
Ø31,50 mm
79,02 mm
40,68 mm
19.
293,61 mm
105 mm
280,41 mm
20.
91,58 mm
Ø45,90 mm
21.
Ø140 mm
30 mm
1 Sudu Gerak Turbin 21 Stainless Steel Ø140 x 30 mm Dibuat
1 Generator 20 Stainless Steel Ø45.90 x 91.58 mm Dibeli
1 Turbin Cover 19 Akrillik 280.41 x 105 x 293.61 mm Dibuat
1 Gate Valve 18 Steel, Mild 40.68 x 31.50 x 79.02 mm Dibeli
Jumlah Nama Bagian No.Bag Material Ukuran Keterangan
III II I Perubahan :
PROTOTYPE CO-FIRING
Skala 1 : 4
Digambar Hengki 25 Apr'23
Diperiksa Pembimbing
Politeknik Negeri Sriwijaya
DRAW/ME/07/25-04-2023


22.
Ø15,60 mm
107,25 mm
81,90 mm
58,50 mm
25,35 mm
23.
Ø8 mm
30 mm
35,30 mm
13 mm
25.
177,15 mm
Ø51,48 mmm
193,11 mm
135,62 mm
24.
240 mm
Ø15,30 mm
26.
123 mm
253 mm
250 mm
350 mm
1 Panel Kontrol 26 Steel 123 x 253 x 350 mm Dibuat
1 Blower 25 Steel 193.11 x135.62 x177.15mm Dibeli
1 Poros Turbin 24 Stainless Steel Ø15.30 x 240 mm Dibuat
4 Baut 23 Steel Ø8 x 30 mm Dibeli
2 Pillow Block 22 ABS Platik 107.25 x 25.35 x 58.50 mm Dibeli
Jumlah Nama Bagian No.Bag Material Ukuran Keterangan
III II I Perubahan :
PROTOTYPE CO-FIRING
Skala 1 : 4
Digambar Hengki 25 Apr'23
Diperiksa Pembimbing
Politeknik Negeri Sriwijaya
DRAW/ME/08/25-04-2023

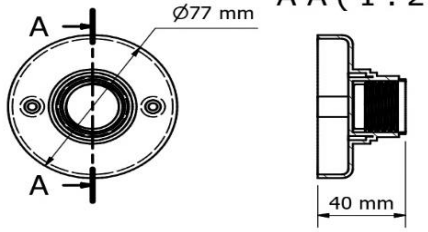


3.92 x 150.60 mm	Dibuat
40 x 122.80 mm	Dibeli
Ukuran	Keterangan

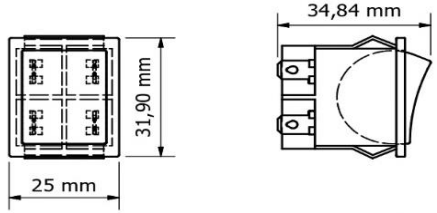
Skala 1 : 4	Digambar	Hengki	25 Apr23
	Diperiksa	Pembimbing	

DRAW/ME/10/25-04-2023

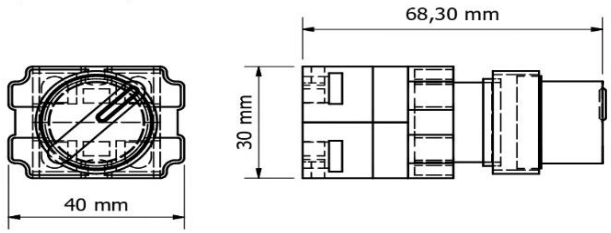
27.



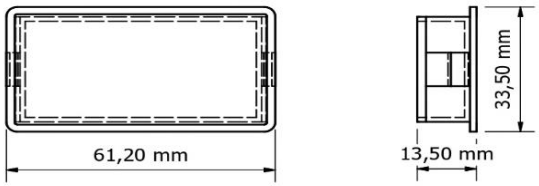
28.



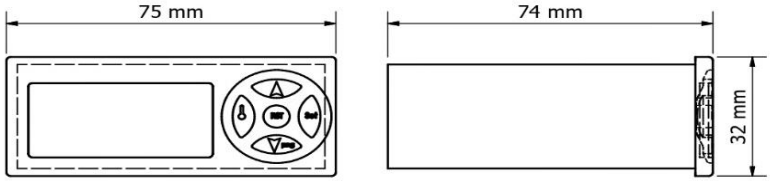
29.



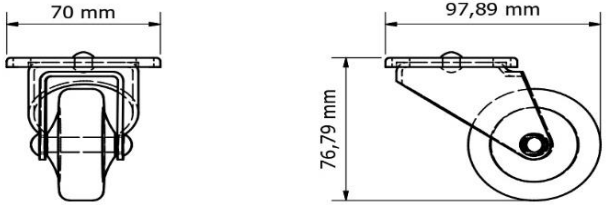
30.



31.



32.



		4	Roda	32	Karet	97.89 x 70 x 76.79mm	Dibeli
		1	Indikator Temperatur	31	Plastik	74 x 75 x 32 mm	Dibeli
		1	Indikator Kecepatan	30	Plastik	13.50 x 61.20 x 33.50 mm	Dibeli
		1	*Selector Switch*	29	Plastik	68.30 x 40 x 30 mm	Dibeli
		4	*Switch On /Off*	28	Plastik	34.84 x 25 x 31.90mm	Dibeli
		3	Dudukan Lampu	27	Plastik	Ø77 x 40 mm	Dibeli
Jumlah			Nama Bagian	No.Bag	Material	Ukuran	Keterangan

III	II	I

Perubahan :

PROTOTYPE CO-FIRING	Skala 1 : 1	Digambar	Hengki	25 Apr'23
		Diperiksa	Pembimbing	
Politeknik Negeri Sriwijaya	DRAW/ME/09/25-04-2023			

L A M P I R A N 2

SERTIFIKAT HASIL PENGUJIAN

LAMPIRAN
SERTIFIKAT

PT. BUKIT ASAM, Tbk
LABORATORIUM PAB PTBA TANJUNG ENIM
Jalan Parigi No.01 Tanjung Enim 31716
Telp. (0734) 451202/451206 Fax. (0734) 451095

LP-073-IDN

SERTIFIKAT ANALISIS

Nomor : T / 350 /255300000G/PR.01.09/IX/2022

Nama Pelanggan : **Hengky Saputra**
Nomor Order : -
Komoditi : **Batubara**
Tanggal Terima : **01 September 2022**
Tanggal Pengujian : **01 September 2022**
Kondisi Contoh : **Baik**

Identitas Contoh	Parameter										
	Mad	Ash		VM		FC		TS		GCV Cal/Gr	
	% Adb	% Adb	% Db	% Adb	% Db	% Adb	% Db	% Adb	% Db	Adb	Db
93. 094. 09 .2022	7,47	20,38	22,02	58,61	63,33	13,56	14,65	0,05	0,05	3.354	3.624
Metode	BS ISO 11722:2013	BS/ISO 1171:2010		BS/ISO 562:2010		By Difference		BS/ISO 19579:2006		BS/ISO 1928:2009	

Keterangan:

Semua parameter diatas sudah terakreditasi KAN

Tanjung Enim, 02 September 2022
Manajer Laboratorium

Karmain

Sertifikat analisis ini tidak boleh digandakan sebagian/sepotong-sepotong, kecuali penggandaan secara lengkap dan harus persetujuan tertulis dari pihak Laboratorium PTBA Tanjung Enim. Sertifikat ini hanya melaporkan keadaan pada saat pengujian dilakukan dan diterbitkan dengan itikad baik tanpa prasangka

QF:LBTE:5.10:01:00:11,Rev : 0,Hal : 1 dari 1

PT. BUKIT ASAM, Tbk
LABORATORIUM PAB PTBA TANJUNG ENIM
Jalan Parigi No.01 Tanjung Enim 31716
Telp. (0734) 451202/451206 Fax. (0734) 451095

KAN Komite Akreditasi Nasional LP-073-IDN

SERTIFIKAT ANALISIS

Nomor : T / 351 /255300000G/PR.01.09/IX/2022

Nama Pelanggan : **Hengky Saputra**
Nomor Order : **-**
Komoditi : **Batubara**
Tanggal Terima : **19 Agustus 2022**
Tanggal Pengujian : **01 September 2022**
Kondisi Contoh : **Baik**

Identitas Contoh	Parameter									
	TS		GCV Cal/Gr		Carbon (C)		Hidrogen (H)		Nitrogen (N)	
	% Adb	% Db	% Adb	% Db	% Adb	% Db	% Adb	% Db	% Adb	% Db
93. 092. 09.2022	0,07	-	984	-	34,76	-	5,59	-	0,38	-
Metode	BS/ISO 19579:2006		BS/ISO 1928:2009		ASTM D5373-21		ASTM D5373-21		ASTM D5373-21	

Keterangan:

Semua parameter diatas sudah terakreditasi KAN

Tanjung Enim, 02 September 2022
Manajer Laboratorium

Karmain

QF:LBTE:5.10:01:00:11,Rev : 0,Hal : 1 dari 1

BukitAsam / KAN	PT. BUKIT ASAM,TBK LABORATORIUM PENGUJI BATUBARA JL. Parigi No. 01 Tanjung Enim 31716 Telp. (0734) 451202/451206 Ext. 2924, 2925, Fax.(0734) 451095/451099	No. Dok : QF : LBTE : 5.10 : 01 : 00 : 05 Revisi : 0 Halaman : 1 dari 1

LAPORAN PENGUJIAN BATUBARA

No. Laporan : 7536 / T / 252231000L / PR.01.09 / X / 2022
Nama Pelanggan : PT BEST - BSI
Alamat : Tanjung Enim

Tanggal : 22 Oktober 2022

No. Laporan : 094 / VIII / 23160 / PLTU - TE / III / 2022
Tanggal : 21 Oktober 2022

No. Urut	IDENTITAS CONTOH	TANGGAL			HASIL PENGUJIAN												KETERANGAN **)
		PENGAMBILAN	TERIMA	PENGUJIAN	TM *)	M *)	Ash *)		VM *)		FC		TS *)		GCV *) (Cal/gr)		
					% (ar)	% (adb)	%(adb)	% (ar)	%(adb)	% (ar)	%(adb)	% (ar)	%(adb)	% (ar)	(adb)	(ar)	
1	63. 162. 10. 2022	1 s/d 21 Oktober 2022	21-Oct-22 Jam : 09.00 Wib	22-Oct-22	20.60	14.29	6.80	6.30	40.30	37.33	38.61	35.77	0.33	0.31	5.631	5.216	PLTU / Tanjung Enim 3x10 MW Coal Feeder Jam : 09.00 Wib

Catatan :
- Hasil Analisis *Normal Test*
- Parameter Mad : *Analisis Moisture Air Dry , Acuan : (BS ISO 11722:2013)*
- Parameter ASH : *Analisis Ash Content , Acuan : (BS ISO 1171:2010 / ~~ASTM-D7582-15~~)*
- Parameter VM : *Analisis Volatile Matter, Acuan : (BS ISO 562:2010 / ~~ASTM-D7582-15~~)*
- Parameter GCV : *Analisis Nilai Kalori Gross , Acuan : (BS/ISO 1928:2009 / ~~ASTM-D5865--13~~)*
- Parameter TM : *Analisis Total Moisture , Acuan : (BS.1016 part 1.1973 / ~~ASTM-D3302--07~~)*
- Parameter TS : *Analisis Total Sulfur , Acuan : (BS/ ISO 19579:2006 / ~~ASTM-D4239--14~~)*
- Parameter FC : *Analisis Fixed Carbon , Acuan : Perhitungan*
- Laporan Pengujian ini dinyatakan telah divalidasi secara memadai oleh personel yang berwenang pada saat didistribusikan melalui trtansmisi *e-Mail*.
- User name personel pengirim sama dengan personel yang memvalidasi laporan ini.
- Laporan pengujian dan/atau sertifikat ini hanya melaporkan keadaan pada saat pengujian dilakukan dan diterbitkan dengan itikad baik tanpa prasangka.
- Laporan pengujian ini tidak boleh digandakan sebagian/sepotong-sepotong, kecuali penggandaan secara lengkap dengan persetujuan secara tertulis oleh Laboratorium Pengujian PTBA Tanjung Enim.
- Ketidaksesuaian mengenai hasil analisis ini dapat menghubungi Laboratorium Pengujian pada kesempatan pertama.

*) Parameter yang sudah diakreditasi
**) Lokasi pengambilan contoh dan Subkontraktor yang berkompeten, dll.

Telah divalidasi oleh :

Kadri. (Spv. Preparasi & Analisis Batubara A-D)

PT. BUKIT ASAM, Tbk
LABORATORIUM PAB PTBA TANJUNG ENIM
Jalan Parigi No.01 Tanjung Enim 31716
Telp. (0734) 451202/451206 Fax. (0734) 451095
Komite Akreditasi Nasional
LP-073-IDN

SERTIFIKAT ANALISIS

Nomor: T/ 034 /252230000L/PR.01.09/I/2023

Nama Pelanggan : **Hengky Saputra**
Nomor Order : **177/Eks-BEST/PLTU-TE-017/I/2023**
Komoditi : **Batubara**
Tanggal Terima : **18 Januari 2023**
Tanggal Pengujian : **24 Januari 2023**
Kondisi Contoh : **Baik**

No	Identitas Contoh	Parameter						
		Mad %(Adb)	Carbon		Hydrogen		Nitrogen	
			%(Adb)	%(Db)	%(Adb)	%(Db)	%(Adb)	%(Db)
1	63.012.1.2023	14,5	59,35	69,41	5,92	5,03	0,99	1,16
Metode		BS ISO 11722:2013	ASTM D5373-21					

Tanjung Enim, 25 Januari 2023

AVP Laboratorium

PT BUKIT ASAM Tbk BukitAsam

Karmain

Sertifikat analisis ini tidak boleh digandakan sebagian/sepotong-sepotong, kecuali penggandaan secara lengkap dan harus persetujuan tertulis dari pihak Laboratorium PTBA Tanjung Enim. Sertifikat ini hanya melaporkan keadaan pada saat pengujian dilakukan dan diterbitkan dengan itikad baik tanpa prasangka

QF:LBTE:5.10:01:00:11,Rev : 0,Hal : 1 dari 1

PENELITIAN KERJASAMA
PROGRAM STUDI TEKNIK ENERGI TERBARUKAN POLITEKNIK NEGERI SRIWIJAYA
DENGAN PT PLN (PERSERO) UIW S2JB
PADA PROGRAM TANGGUNG JAWAB SOSIAL DAN LINGKUNGAN (TJSL)
***RESEARCH WASTE TO ENERGY:* BIOPELET UNTUK *CO-FIRING* PLTU**

PELAKSANA PENELITIAN
Penanggung jawab:
Direktur Politeknik Negeri Sriwijaya
Wakil Penanggung Jawab:
Wakil Direktur Bidang Kerjasama
Ketua Tim Peneliti: Prof. Rusdianasari

Anggota Peneliti:
Dr. Ir. Leila Kalsum, M.T.
Dr. Ir. Aida Syarif, M.T.
Dr. Yohandri Bow, M.S.
Fatahul Arifin, Ph.D.
Teknisi: Widodo

TUJUAN PENELITIAN

1. Memperoleh biopelet dari biomassa limbah pertanian sebagai co-firing pada pembangkit-pembangkit PLN di Sumatera Selatan dan sekitarnya
2. Menganalisis biopelet yang dihasilkan sesuai dengan SNI 8951: 2020 (Biopelet untuk pembangkit listrik)
3. Memberikan rekomendasi untuk jenis biopelet yang sesuai dengan pembangkit-pembangkit PLN di Sumatera Selatan dan sekitarnya dalam penyediaan listrik oleh PT PLN (Persero) UIW S2JB.

HASIL PENELITIAN

HASIL ANALISA BIOPELET

Sample	Proximate Analysis, Weight %						Gross Calorific Value, kcal/kg ASTM D 5865 – 19		
	Moisture in the Analysis Sample ASTM D 3173/D 3173M-17a	Ash Content ASTM D 5142 – 12 (2018)		Volatile Matter ASTM D 5115 – 20		Fixed Carbon ASTM D 3172 – 13 (2021)e1			
	adb	adb	db	adb	db	adb	db	ar	db
Cangkang Kelapa Sawit	8,89	5,44	5,92	70,99	76,26	16,38	17,82	4.582	4.104	4.985
TKKS	11,98	6,33	7,42	65,95	73,90	16,41	18,68	4.034	3.773	4.583
Ampas Tebu	9,90	1,25		76,95		10,81		2.612		
Sekam padi	7,88	10,95		57,42		44,59		3.216		
Sabut kelapa	3,56	3,78		67,46		25,6		3.931		
Ampas kelapa	10,24	0,16		79,17		10,43		1.893		
Serbuk kayu	8,16	3,04		74,85		18,95		4.121		

Sample	Ultimate Analysis, Weight %						Total Sulfur, Weight %	
	Carbon (C) ASTM D5373-21		Hydrogen (H) ASTM D5373-21		Nitrogen (N) ASTM D5373-21		ASTM D4239-18e1	
	adb	db	adb	db	adb	db	adb	db
Cangkang Kelapa Sawit	47,11	51,26	6,40	5,98	0,34	0,37	0,17	0,18
TKKS	42,63	48,43	6,05	5,35	0,32	0,36	0,08	0,09
Sekam Padi	38,37	43,28	5,92	5,24	0,48	0,54	0,08	0,09
Sabut Kelapa	24,86	50,30	2,05	4,15	0,06	0,12	0,09	0,18
Serbuk Kayu	48,53	54,28	5,70	6,38	0,08	0,09	0,12	0,13
Ampas Kelapa	48,23	50,21	6,09	6,34	0,28	0,29	0,14	0,14
Ampas Tebu	53,20	55,72	7,63	7,99	0,85	0,89	0,12	0,12

Kesimpulan:

Bahan biomassa yang sesuai untuk co-firing pada pembangkit-pembangkit PLN yang ada di Sumatera Selatan dan sekitarnya dari beberapa produk biopelet yang dihasilkan berdasarkan nilai kalor adalah biopelet dari cangkang kelapa sawit (4.582 kcal/kg, serbuk kayu (4.121 kcal/kg), TKKS (4.034 kcal/kg), sabut kelapa (3.931 kcal/kg), sekam padi (3.216 kcal/kg) dan ampas tebu (2.612 kcal/kg). Dari segi kimia, kandungan abu yang memenuhi syarat di antaranya ampas tebu 1,25%, ampas kelapa 0,16%, dan serbuk kayu 3,16%.

PLN Peduli

Peneliti Mahasiswa
Riztamala Diana, Hengky Saputra, Akhmad Rizal, Joko Triatmoko

CARSURIN
1968

REPORT OF LABORATORY ANALYSIS

Subject : Rice Husk Pellet
Date Received : September 19, 2022
Tested for : Ultimate Analysis
Description of Sample : Sample Code : **Pelet Sekam Padi**
Packing : Unsealed Plastic Bag
Weight : 250 gr
Your Reference : **Verbal Dated September 19, 2022**
Date of Report : September 20, 2022
No. of Pages Including Cover : 1 Page

THIS IS TO REPORT that upon the request of the principal, the sample received wa analyzed in the laboratory in accordance with ASTM method.
The results are as follows:

PARAMETER	STANDARD	RESULTS		
		adb	ar	db
A. Ultimate Analysis, Weight %				
Carbon (C)	ASTM D5373-21	38.37	-	43.28
Hydrogen (H)	ASTM D5373-21	5.92	-	5.24
Nitrogen (N)	ASTM D5373-21	0.48	-	0.54

Note: adb = Air Dried Basis ; Arb = Air Received Basis ; db = Dry Basis

Remarks : - This report refers to the tested sample only
This Report reflects our findings at time and place of analysis only and does not certify (or report) any other matters.
This Report is issued without prejudice and our responsibility is limited to the exercise of reasonable care and due diligence.

Palembang, September 20, 2022
PT. CARSURIN

e: palembang@carsurin.com

PT. BUKIT ASAM, Tbk
LABORATORIUM PAB PTBA TANJUNG ENIM
Jalan Parigi No.01 Tanjung Enim 31716
Telp. (0734) 451202/451206 Fax. (0734) 451095

KAN Komite Akreditasi Nasional LP-073-IDN

SERTIFIKAT ANALISIS

Nomor: T/376/252230000L/PR.01.09/VI/2023

Nama Pelanggan : **Hengky Saputra**
Nomor Order : -
Komoditi : **Batubara**
Tanggal Terima : **16 Juni 2023**
Tanggal Pengujian : **16 Juni 2023**
Kondisi Contoh : **Baik**

No	Identitas Contoh	Hasil Pengujian											Lokasi	Keterangan
		Mad %(Adb)	Ash		VM		FC		TS		GCV (Cal/gr)			
			%(Adb)	%(Db)	%(Adb)	%(Db)	%(Adb)	%(Db)	%(Adb)	%(Db)	%(Adb)	%(Db)		
1	93.033.06.23	25,7	6,3	8,5	38,5	51,8	29,5	39,7	0,41	0,55	4.528	6.092	Tanjung Enim	Penelitian Thesis
2	93.034.06.23	24,4	7,2	9,5	40,7	53,8	27,7	36,6	0,38	0,50	4.428	5.858		
Metode		BS ISO 11722 : 2013	BS/ISO 1171 : 2010		BS/ISO 562 : 2010		By Different		BS/ISO 9579:2006		BS/ISO 1928:2009			

Tanjung Enim, 06 Juli 2023
Pgs AVP Laboratorium

PT BUKIT ASAM Tbk BukitAsam

Syahrial Hamiki

Sertifikat analisis ini tidak boleh digandakan sebagian/sepotong-sepotong, kecuali penggandaan secara lengkap dan harus persetujuan tertulis dari pihak Laboratorium PTBA Tanjung Enim.
Sertifikat ini hanya melaporkan keadaan pada saat pengujian dilakukan dan diterbitkan dengan itikad baik tanpa prasangka

QF:LBTE:5.10:01:00:11,Rev : 0,Hal : 1 dari 1

PT. BUKIT ASAM, Tbk
LABORATORIUM PAB PTBA TANJUNG ENIM
Jalan Parigi No.01 Tanjung Enim 31716
Telp. (0734) 451202/451206 Fax. (0734) 451095

KAN Komite Akreditasi Nasional LP-073-IDN

SERTIFIKAT ANALISIS

Nomor: T/ 382 /252230000L/PR.01.09/VII/2023

No	Identitas Contoh	Hasil Pengujian								Lokasi	Keterangan
		Karbon		Hidrogen		Nitrogen		Oksigen			
		(%Adb)	(%Db)	(%Adb)	(%Db)	(%Adb)	(%Db)	(%Adb)	(%Db)		
1	93.033.06.23	48,66	65,48	6,14	4,39	0,66	0,89	37,84	20,21	Tanjung Enim	Penelitian Thesis
2	93.034.06.23	46,98	62,14	5,98	4,30	0,60	0,80	38,86	22,73		
Metode		ASTM D5373-21									

Tanjung Enim, 06 Juli 2023
Pgs AVP Laboratorium

PT BUKIT ASAM Tbk BukitAsam

Syahrial Hamiki

Sertifikat analisis ini tidak boleh digandakan sebagian/sepotong-sepotong, kecuali penggandaan secara lengkap dan harus persetujuan tertulis dari pihak Laboratorium PTBA Tanjung Enim.
Sertifikat ini hanya melaporkan keadaan pada saat pengujian dilakukan dan diterbitkan dengan itikad baik tanpa prasangka

QF:LBTE:5.10:01:00:11,Rev : 0,Hal : 1 dari 1

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN, RISET DAN TEKNOLOGI
POLITEKNIK NEGERI SRIWIJAYA
LABORATORIUM TEKNIK KIMIA
Jalan Srijaya Negara, PALEMBANG 30139
Telp.0711-353414 ekt. 113 Fax. 0711-355918. E-mail : kimia@polsri.ac.id.

SURAT TANDA UJI

Nomor : 058 /PL6.I.14.1/A/2023

Nama Pelanggan	:	Hengky Saputra
NIP	:	062150443032
Perusahaan/ Instansi	:	Politeknik Negeri Sriwijaya
Nama Sampel	:	Emisi Gas Pembakaran Co-Firing
Jumlah Sampel	:	4 jenis
Tanggal Diterima	:	15 Mei 2023
Status Contoh	:	Sesuai dengan yang diterima

No	Kode	Jenis Sampel/Perlakuan	Metode Uji	Hasil Pemeriksaan (% Vol)			
				CO (ppm)	NO (ppm)	CO_2 (%)	NO_x (ppm)
1	1	Batubara 100% : Biopelet Sekam Padi 0%	Multi Gas Detector Analyzer	8615	7	5,51	7
2	2	Batubara 95% : Biopelet Sekam Padi 5%		4967	8	4,76	8
3	3	Batubara 90% : Biopelet Sekam Padi 10%		5264	7	4,07	7
4	4	Batubara 85% : Biopelet Sekam Padi 15%		2835	7	2,82	7

Nomor contoh : 058/06-23/Lab.TK

Palembang, 06 Juni 2023
Kepala Laboratorium Analisa

Adi Syakdani, S.T., M.T.
NIP. 196904011992031001

POLSRI

CARSURIN
1968

Report No. : 231922.0152
Page : 1 of 1

REPORT OF LABORATORY ANALYSIS

Principal	:	**MR. HENGKY SAPUTRA**
Subject	:	Sampel Abu Pembakaran dari Co-Firing Boiler (Batubara dan Biopelet Sekam Padi)
Date Received	:	June 3, 2023
Tested For	:	Ash Analysis
Description of Sample	:	Sample Code : **SAMPLE ABU**
	:	Packing : Unsealed Plastic Bag
	:	Weight : 469.80 gram
You Reference	:	**By Verbal Mr. Hengky Saputra Dated June 03, 2023**
Order Number	:	PLB/0193/H/06/23
Date of Report	:	June 06, 2023
No. of Pages Including Cover	:	1 Page

THIS IS TO REPORT that upon the request of the principal, the sample received was analyzed in the laboratory in accordance with ASTM method.
The results are as follows:

PARAMETER	STANDARD	RESULTS		
		UNITS	BASIS	VALUE
Ash Analysis				
Silicon Dioxide (SiO_2)	ASTM D 3682-21	%	DB	59.95
Alumunium Oxide (Al_2O_3)	ASTM D 3682-21	%	DB	16.78
Ferric Oxide (Fe_2O_3)	ASTM D 3682-21	%	DB	6.51
Calcium Oxide (CaO)	ASTM D 3682-21	%	DB	4.08
Magnesium Oxide (MgO)	ASTM D 3682-21	%	DB	1.65
Sodium Oxide (Na_2O)	ASTM D 3682-21	%	DB	3.41
Potassium Oxide (K_2O)	ASTM D 3682-21	%	DB	1.82
Titanium Oxide (TiO_2)	ASTM D 3682-21	%	DB	0.70
Manganese (Mn_3O_4)	ASTM D 3682-21	%	DB	0.06
Sulphur Trioxide (SO_3)	ASTM D 5016-16	%	DB	4.30
Phosporous Pentoxide (P_2O_5)	AS 1038 part 9.3:2013 (Reconfirmed 2018)	%	DB	0.36

Note: adb = Air Dried Basis ; Arb = Air Received Basis ; db = Dry Basis ; daf = Dry Ash Free

Remarks : - This report refers to the tested sample only
This Report reflects our findings at time and place of analysis only and does not certify (or report) any other matters.
This Report is issued without prejudice and our responsibility is limited to the exercise of reasonable care and due diligence.

Palembang, June 6, 2023
PT. CARSURIN

CARSURIN 1968

Doan Yuditiansyah
Head of Laboratory

For verification of authenticity of certificate or reports, scan the secure QR code using the validator App or visit verify.carsurin.com

SOHO Capital 28th Floor, Jl. Letjen S. Parman Kav. 28, Grogol Petamburan, Jakarta Barat 11470, Indonesia
p +62.21.5022.6868 | e headoffice@carsurin.com | w carsurin.com

RA 15077

L A M P I R A N 3

MANUAL BY DESIGN

LAMPIRAN
MANUAL BY DESIGN

江西江联能源环保股份有限公司
Jiangxi Jianglian Energy & Enviornment Co., Ltd.

JG-56/5.4-M 型锅炉
JG-56/5.4-M Type Boiler

热力计算汇总表
Summary List of Thermal Calculation

F5601-JW$_1$

江西江联能源环保股份有限公司
Jiangxi Jiang Energy & Environment Co., Ltd.
2009.7

＊＊＊＊锅 炉 热 力 计 算 汇 总 表＊ ＊ ＊ ＊ ＊

Summary List of Thermal Calculation For Boiler

＊ 江 西 锅 炉 厂 江 西 锅 炉 研 究 所 ＊

Jiangxi Boiler Works, Jiangxi Boiler Research Institute

＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊＊

1. 锅 炉 规 范 Boiler Specifications

额定蒸发量 Rated Capacity	D	t/h	56
过热蒸汽压力 Superheating steam pressure	P	Mpa	5.3
过热蒸汽温度 Superheating steam temperature	t_{gr}	℃	485
锅炉给水温度 Boiler feedwater temperature	t_{gs}	℃	150
冷风温度 Cold air temperature	t_k	℃	20

2. 设 计 燃 料 Designed fuel

序号 SN	项目 Item	基准 Base	单位 Unit	最小 Min.	最大 Max.	平均/设计 Average/ Designed
A	工业分析 Industrial analysis					
1	水份 Moisture	a.r	%	23.6	30.5	28.8
2	灰份 Ash content	a.r	%	2.7	17.2	6.7
3	挥发份 Volatile matter	a.r	%	31.1	34.7	32.9
4	固定炭 Fixed carbon	a.r	%	31.7	36.7	31.5
5	热值 Heat value	a.d.b	kcal/kg	4500	5000	4750

B	元素分析 Elemental analysis					
1	C	adb	%	47.5	53.1	50.3
2	H	adb	%	3.0	3.8	3.6
3	N	adb	%	0.7	0.9	0.8
4	O	adb	%	29.0	33.1	32.96
5	S	adb	%	0.16	0.83	0.6
6	A	adb	%			9.94

3. 锅 炉 热 平 衡 Boiler heat balance：

1	排烟热损失 Fuel gas loss	q_2	%	6.76
2	化学热损失 Chemical heat loss	q_3	%	0
3	机械热损失 Mechanical heat loss	q_4	%	1.64
4	散热热损失 Heat radiation loss	q_5	%	1.26
5	灰渣热损失 Ash and slag heat loss	q_6	%	0.07
6	锅炉效率 Boiler efficiency	η	%	90.27
7	计算燃料量 Calculated fuel consumption	Bj	kg/h	8289.4
8	燃料消耗量 Fuel consumption	B	kg/h	8444.31

4. 热 力 计 算 综 合 表：（JG-56/5.3-M）

序号 SN	名 称 Name	符号 Symbol	单位 Unit	沸腾层埋管 Embeded pipe in fluid bed	悬浮段 Suspend section	高过 HT superheater	低过 LT superheater	省煤器 Economizer	二次风空预器 Secondary air preheater	一次风空预器 Primary air preheater
1	进口烟温 Inlet gas temperature	T'	℃		895.3	795.1	721.5	580.2	242	177.8
2	出口烟温 Outlet gas temperature	T"	℃	895.3	795.1	721	580.2	242	177.8	140
3	工质进口 Working medium inlet	t'	℃	274.8	274.8	329.6	274.8	150	20	20
4	工质出口 Working medium outlet	t"	℃	274.8	274.8	485	380.7	282.9	131	94
6	烟气速度 Flue gas velocity	Wy	m/s	2.8	4.5	5.2	6.4	5.6	9.7	9.5
7	工质速度 Working medium velocity	Wg	m/s	/	/	20.6	19.1	/	5.3	5.5
8	受热面积 Heating surface area	H	m2	45	175	208	236	1100	560	455
9	传热量 Heat tran	Q	KJ/kg	2856.3	5105.3	2194.9	1815	3365.8	592.1	320.7
计算误 差 Calculation error		$\Delta Q=Q*\eta/100-\sum Qi*(1-q4)/100=-0.32KJ/Kg$								
比 值 Specific value		$\lvert \Delta Q/Q \rvert *100=0.32/18200*100=0<0.5\%$								

L A M P I R A N 4

PROSES PENELITIAN

LAMPIRAN
DOKUMENTASI PEMBUATAN

Sekam Padi

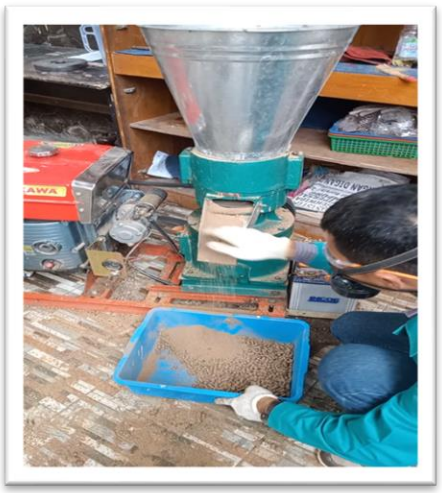
Pencacahan

Pengayakan

Hasil Pengayakan

Pengadukan

Peletisasi



Pengeluaran Biopelet

Produk Biopelet

Pengukuran panjang biopelet

Pengukuran diameter biopelet

Portabel Boiler

Persiapan Batubara

Pembakaran Batubara

Temp dan RPM (17watt)

Arus 1,17 (17 watt)

Tegangan 265 V (17 watt)

Rasio Pembakaran 95%:5%

Temp dan RPM (95%:5%)

Tegangan 257 (95%:5%)

Pengambilan emisi gas pembakaran

Pengujian emisi gas

Hasil abu Pembakaran

L A M P I R A N 5

REKOMENDASI SIDANG

LAMPIRAN
REKOMENDASI SIDANG

No. Dok. F-PBM-62 | Tgl. Berlaku : 01 Juli 2016 | No. Rev. 00

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN,
RISET, DAN TEKNOLOGI
POLITEKNIK NEGERI SRIWIJAYA
Jalan Srijaya Negara, Palembang 30139
Telp. 0711-353414 Fax. 0711-355918
Website : www.polsri.ac.id E-mail : info@polsri.ac.id

REKOMENDASI UJIAN TESIS

Pembimbing Tesis memberikan rekomendasi kepada:

Nama	: Hengky Saputra
NPM	: 062150443032
Program Studi	: Teknik Energi Terbarukan
Judul Tesis	: Analisis Energi Dari Proses Co-Firing Antara Batubara Sub-Bituminus Dan Biopelet Sekam Padi Di Pembangkit Listrik

Mahasiswa tersebut telah memenuhi persyaratan dan dapat mengikuti Ujian Tesis pada Tahun Akademik 2023

Palembang, Juli 2023

Pembimbing I,

Prof. Dr. Ir. Rusdianasari, M.Si.
NIDN 0019116705

Pembimbing II,

Dr. Ir. Abu Hasan, M.Si
NIDN 0023106402

L A M P I R A N 6

JURNAL

Rice Husk with Subbituminous Coal as biopellets for Power Plants Co-firing

Hengky Saputra[1,2], Rusdianasari[3,*] and Abu Hasan[3]

[1] Applied Master of Renewable Energy Engineering, Politeknik Negeri Sriwijaya, Jalan Srijaya Negara, Palembang, 30139 Indonesia
[2] PT. Bukit Energi Servis Terpadu, PLTU TE 3x10 MW, Tanjung Enim, Indonesia
[3] Renewable Energy Engineering Department, Politeknik Negeri Sriwijaya, Jalan Srijaya Negara, Palembang, 30139 Indonesia
*Corresponding author: rusdianasari@polsri.ac.id

Abstract. It is necessary to enhance the usage of renewable energy sources in the form of biofuels. Given that the demand for fossil fuels is increasing every year and the fuel is finite and expensive, it supports research and development aimed at obtaining renewable, environmentally friendly fuels at a lower cost. Rice husks, considered industrial waste, have not been appropriately utilized and frequently contribute to environmental contamination. Therefore, efforts must be made to transform rice husk waste into a more valuable commodity. Carbon from rice hulls has the potential to be transformed into biopellets for use as fuel. These biopellets are created by crushing raw materials and combining them with plant-based adhesives. In the co-firing process of the boiler, each biopellet will be combined with coal in proportions of 100%:0%, 99%:1%, 97%:3%, and 96%:4%. The boiler's performance is determined by testing the quality of the bottom ash using both ultimate and proximate analyses. The boiler's energy output is maximized by decreasing its coal consumption.

1. Introduction

Along with the country's and the world's rapid economic growth, the use of coal as the primary energy source is expanding in various countries, particularly as a fuel in power plants. Following government policy, particularly on conserving countermeasures and stages for environmentally friendly coal, ecologically sound co-firing technology applies to the energy sector's sustainable development. The Ministry of Energy and Mineral Resources (ESDM) recorded a nationwide energy consumption of 245,518.57 GWh at the end of 2019. The installed capacity of power plants in Indonesia increased to 69,678.85 MW from 64,924.80 MW in 2018.

Plan initiatives linked to decreasing GHG emissions from coal-fired power plants include a moratorium on coal-fired power plant construction, the phase-out of coal-fired power plants by 2050, and the installation of low-carbon technology to increase the efficiency of coal-fired power plants. The adoption of co-firing is the quickest to implement of the three alternatives. Currently, a subsidiary of PT PLN, PT PJB (Java Bali Power Plant), operates the Paiton (2x400 MW) PLTU with co-firing, using a biomass fuel ratio of 1% of the coal energy supply. PT IP (Indonesia Power) operates the Jeranjang power plant using organic waste pellets and other biomass waste for a co-firing mixture of up to 3% of the coal energy supply.

Another benefit of biomass is its ability to minimize greenhouse gas emissions, making it one of the answers to global warming. Biomass has a low bulk density and calorific value when burned directly

without processing and high amounts of pollutant emissions. To achieve optimal results when processing biomass, you must consider the components influencing the combustion aspect. The raw material composition has a significant impact on the combustion properties of biomass.

Numerous researchers focus on the conversion of organic and inorganic waste into fuel. Generally, the distance between biomass production sites, such as forests and agricultural land, and industrial sites or residential areas is considerable, necessitating skilled logistics for delivery and storage. Therefore, pelletization is an improved way of effective and efficient biomass energy consumption.

To attain the national energy mix by 2025, it must accelerate capacity growth in new and renewable energy, including biomass co-firing development. Co-firing is the combustion of biomass in the boiler furnace of a PLTU. Co-firing is an effective means of decreasing emissions without sacrificing efficiency. This study examines the energy analysis of co-firing subbituminous coal and rice husk biopellets in power plants. The standard parameters for biopellets used in power plants are displayed in Table 1.

Table 1. Standard specification of biomass pellets for power plants (SNI 8951:2020)

Test Parameters	Unit min/max	Quality		
		Premium	Standard	Utility
Moisture Content	%wt, max	9,5	10	12
Ash Content	%wt, max	1,3	3	4
Volatile Content	%, max	72	71	70
Fixed Carbon	%, min	17	16	14
Color Value	Kcal/kg, min	4.300	4.300	4.040

2. Research Methodology

The raw materials used in this study were sub-bituminous coal and rice husk biopellets with ratios of 100:0, 99:1, 97:3, and 96:4, respectively. Coal raw materials are obtained from PTBA, and rice husks from collecting agricultural waste in the Muara Enim District of South Sumatra.

2.1. Research Procedure

The research procedure starts with preparing the raw materials and tools used in the study, including preparing rice husks that have been dried in advance to be ground. Rice husks are smoothed through a pulverizer machine up to a size of 50 mesh which is then carried out ultima and proximate testing first before making biopellets

Fig. 1. Preparation of ultimate and proximate testing of rice husks (A) Rice husks material, (B) Pulverizer (C) Sifting (D) Rice husks size reduction

2.2. The analysis method

The analysis method carried out is a proximate analysis of water content (BS / ISO 11722: 2013), ash content (BS / ISO 11711: 2010), volatile content (BS / ISO 562: 2010), and fixed carbon content (By

Difference). For the ultimate analysis, namely carbon (ASTM D 5373-21), Hydrogen (ASTM D 5373-21), Nitrogen (ASTM 5373-21), and sulfur values based on BS / (ISO 19579: 2006).

3. Result and Discussion

3.1. Experimental setup

This investigation began with the choice of raw materials for rice husks and coal. Utilizing rice husks as raw material, a drying process is conducted. The raw materials for rice husks are dried in the sun for eight hours to minimize the moisture in the rice husks' raw material before being crushed to reduce the particle size. The following phase involves producing rice husk biopellets using a pelletizing machine, followed by ultimate and proximate testing to determine the quality of the biopellets.

Fig. 2. *Experimental setup*

Figure 2 shows the stages of the biopellets manufacturing process from the beginning of the raw material preparation to the stage of the biopellets manufacturing process and the quality analysis of the biopellets produced from the rice husk biomass raw material. The biopellets produced after analysis of the chemical composition of raw materials The first selection process, the calorific value of the raw materials tested using a calorimeter bomb.

3.2. Result and Discussion

3.2.1. Rice Husk Proximate Analysis

Proximate analysis is carried out to determine the characteristics of the rice husk raw materials, including moisture content, ash content, and volatile matter. Figure 3 shows that the rice husks used in this study have a moisture content of 7.47%.

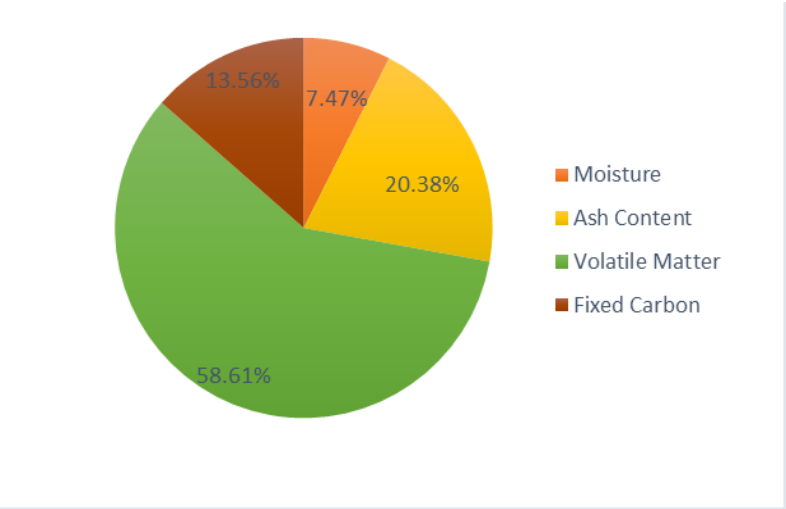


Fig. 3. Rice Husk Proximate Analysis Results

This product has a high moisture content. This is due to the inefficient drying of rice husks. Because of the water content in the raw material, high water content might impede the combustion process and diminish the calorific value of the fuel. In this investigation, rice husks had a high ash concentration of 20.38%. Ash can produce rust in the combustion process, making it an impediment when burning in the boiler. Meanwhile, the content of Volatile Matter / flying substances in rice husks was 58.61% in this study, and the carbon content value in rice husks was 13.56%. A high ash content might also accelerate the filling of the furnace. As a result, when utilizing rice husk biopellets as fuel, the boiler's operation must be adjusted.

3.2.2. Rice Husk Ultimat Analysis

The ultimate analysis is carried out to determine the characteristics of the content of rice husk raw materials, which include carbon, hydrogen, and nitrogen.

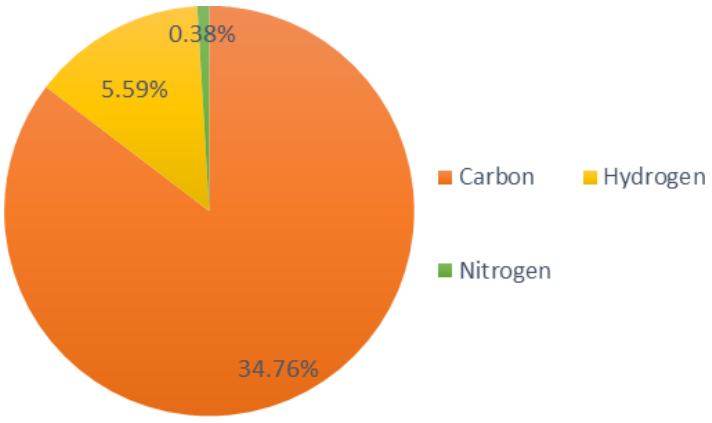


Fig. 4. Rice Husk Ultimate Analysis Results

Rice husks have a Carbon content of 34.76 percent, a Hydrogen content of 5.59 percent, and a Nitrogen content of 0.3 percent, as depicted in Figure 4 of the final test findings. This demonstrates that rice husks containing C, H, and N can be used as biopellets feedstock. The low sulfur content of rice husk is a positive value for this biomass since it has no negative influence on the environment or the subsequent exhaust emissions when utilized as a co-firing raw material.

3.2.3. Comparison of Proximate Analysis of Coal and Rice Husk Biomass

One of the data needed is the test results of the characteristics of coal fuel and rice husks. Both samples were tested in the laboratory.

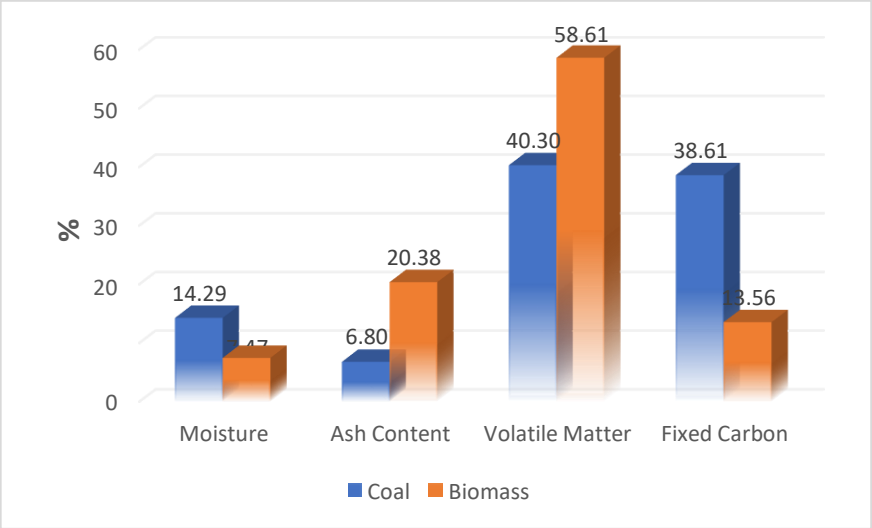
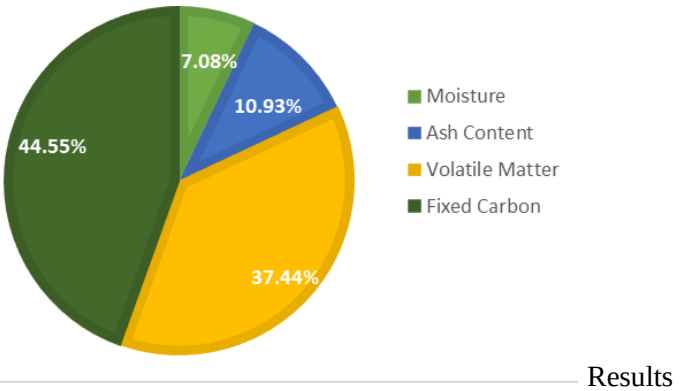


Fig. 5. Comparison of Characteristics of Coal and Rice Husks

Figure 5 shows that, characteristically, rice husks have a lower calorific and moisture content compared to coal. Meanwhile, rice husks' ash content and volatile matter are much higher than coal.

3.2.4. Proximate Analysis of Rice Husk Biopellets

Biopellets are biomass fuels in the form of pellets with uniformity in size, shape, humidity, and energy content**.** The biopellets characteristics of rice husks with variations in powder size composition and the addition of adhesives affect the quality of the biopellets produced. Figure 6 depicts that the rice husk biopellets utilized in this study had a moisture content that was 7.08 percent lower than the rice husk previous to its transformation into the biopellets. This is because rice husks are turned into biopellets by extensive drying. The amount of ash contained in rice husk biopellets was 10.93%. The characteristics of biopellets produced from rice husks, such as powder size composition and the inclusion of adhesives, influence the quality of the biopellets produced.



Results

3.2.5. Comparison of Characteristics of Coal and Rice Husk Biopellets

The homogeneous mixing of fuels has a crucial influence on combustion quality. In addition, because there are distinct variances between coal and rice husk biopellets, it is vital to pay close attention to the co-firing percentage ratio to ensure the plant's safety.

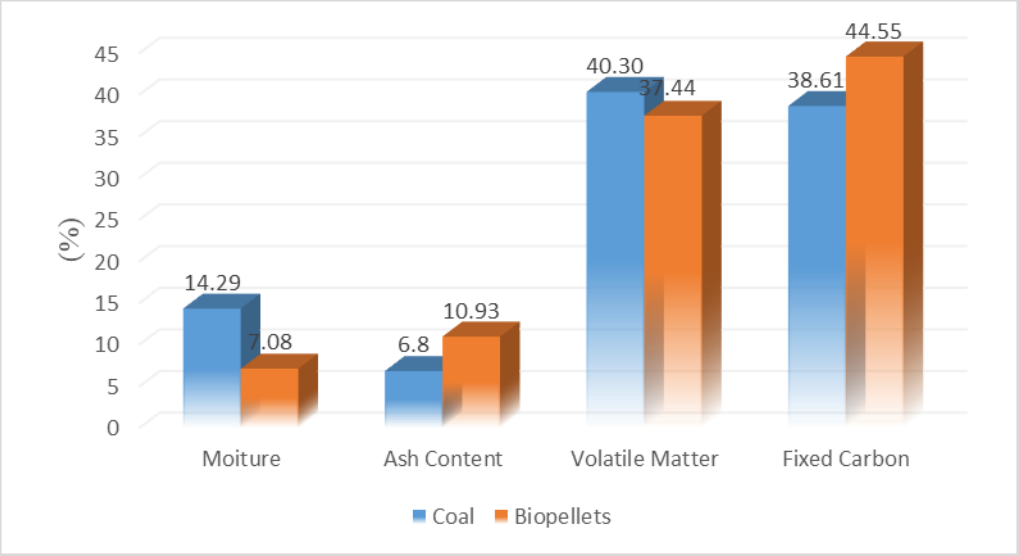


Fig. 7. Comparison of Characteristics of Sub-Bituminous Coal and Rice Husk Biopellets

Figure 7 compares the characteristics of sub-bituminous coal and rice husk biopellets. The moisture content value of rice husks after becoming biopellets is lower than the moisture content value of coal. In contrast, rice husk biopellets is higher than the ash content of sub-bituminous coal. This will enhance the flow rate of particles in the exhaust stream, increasing the work of the Electrostatic Precipitator (ESP) system. ESP is a technique that captures ash from the co-firing process by applying an electric charge to the ESP chamber. The ESP's principle is to apply a negative charge to the ashes enclosed in the ESP chamber through numerous electrodes. The ash is then transported through a column constructed of positively charged plates. The plates will draw the ash, then the ash will fall and escape the ESP system.

4. Conclusion

Based on the study's findings, it can be concluded that rice husks can be used as biopellets in coal-fired power plants as raw materials. Rice husk biomass has significant potential as a raw material for producing biopellets for co-firing, as it has a lower approximate analytical content value than the initial raw material for rice husk biomass. In addition to the ultimate analysis, all test parameters yielded improved findings. Biopellet moisture (moisture content) significantly impacts the calorific value. The greater the water content of biopellets, the lower their calorific value. Rice husk biomass has a high potential for availability in its early stages of development. In addition to the features of rice husk before it is converted into biopellet, it has a greater ash content and volatile matter. In terms of emissions, the beneficial environmental impact of cofiring coal and rice husk biopellets has reduced.

References

[1] Badan Pusat Statistik, “Statistik Kelapa Sawit Indonesia 2019,” Badan Pus. Stat., p. 137, 2019.

[2] R. Rusdianasari, L. Kalsum, N. Masnila, L. Utarina, and D. Wulandari, "Characteristics of Palm Oil Solid Waste and Its Potency for Bio-Oil Raw Material," Proc. 5th FIRST T1 T2 2021 Int. Conf. (FIRST-T1-T2 2021), vol. 9, pp. 415–420, 2022, doi: 10.2991/ahe.k.220205.073.

[3] Bow Y, Dewi T, Taqwa A and Rusdianasari 2018 Power Transistor 2N3055 as a Solar Cell Device 2018 *International Conference on Electrical Engineering and Computer Science (ICECOS) IEEE* 327-332.

[4] M. Yerizam, M. Zaman, T. Jauhari, Yuli, N., Setiawan, R., and Affrilla. Production of Bio-Pellet BriquettesfFrom Coconut Shell Waste as Alternative Energy for Household Scale. In *4th Forum in Research, Science, and Technology (FIRST-T1-T2-2020)* (pp. 57-61). Atlantis Press, 2020

[5] L. Utarina, Rusdianasari, and L. Kalsum, "Characerization of Palm Shell-Derived Bio-oil through Pyrolysis", Journal of Applied Agricultural Science and Technology 6(2), pp.139-148, 2022, https://doi.org/10.55043/jaast.v6i2.69

[6] Rusdianasari, Y Bow, RAN Moulita. Temperature effect on the biodiesel quality from waste cooking oil by induction heating. Journal of Physics: Conference Series 1450, 012003, 2020

[7] A.A. Rentizelas, A.J. Tolis, and I.P. Tatsiopoulos, "Logistics issues of biomass: the storage problem and the multi-biomass supply chain," Renew. Sustain. Energy Rev., 13 (4) 887–894 (2009).

[8] D. Wulandari, Rusdianasari, and M. Yerizam, "Characterization Biofuel from Empty Fruit Bunch through Thermal Cracking", International Journal of Research in Vocational Studies (IJRVOCAS) 2 (2), pp.15-22, 2022

[9] Novarini, Rusdianasari, S Kurniawan, Y Bow. Waste-to-Energy (WTE) Method to Mitigate Harmful Environmental and Health Consequences Due to LDPE Plastic Waste. IOP Conference Series: Earth and Environmental Science 810 (1), 012014, 2021

[10] A. Meidinariasty, Rusdianasari, Y. Bow, I. Rusnadi, and A.L. Fuady, "Treatment of Leachate from Garbage using Electrocoagulation Type MP-P (MonoPolar-Paralel) Methode. Journal of Physic: Conference Series 1167(012054), 2019, doi:10.1088/1742-6596/1167/1/012054

[11] Rusdianasari, A Taqwa, J Jaksen, A Syakdani. Treatment Optimization of Electrocoagulation (EC) in Purifying Palm Oil Mill Effluents (POMEs). Journal of Engineering and Technological Sciences 49 (5), 604-616, 2017

[12] U. Arena, "Process and technological aspects of municipal solid waste gasification. a review," Waste Manag., 32 (4) 625–639 (2012).

[13] Ilham, M. F., & Suedy, S. W. A. (2022). Effect of Cofiring Using Sawdust on Steam Coal Power Plant Heat Rate Value. *Jurnal Energi Baru dan Terbarukan*, *3*(2), 121-127.

[14] Y Bow, A Syakdani, M Taufik, Rusdianasari. Effect of Drying Airflow Rate on H2O Mass Evaporated on Banana Chips Drying using Photovoltaic Solar panel. Journal of Physic: Conference Series 1500, 012015, 2020

[15] N. Angie, E.M. Tokit, N.A. Rahman, F. Al Zahrah Mohamad Saat, F.S. Anuar, and N.M.M. Mitan, "A preliminary conceptual design approach of food waste composter design," Evergreen, 8 (2) 397–407 (2021). doi:10.5109/4480721.

[16] Siregar, S. R., Nursani, D., Wiyono, A., Pratiwi, T. P. S. I., Dafiqurrohman, H., & Surjosatyo, A. (2021). Effect of Ratio Composition and Particle Size to Pelletizing Combination Performance of MSW and Biomass Feedstocks.

[17] Rusdianasari, L. Utarina, L. Kalsum, D. Wulandari, and Y. Bow, "Environmental Potential Impact on Biofuel Production from Thermal Cracking of Palm Shell using Life Cycle Assessment", Journal of Ecological Engineering, 23(12), pp.61–67, 2022, https://doi.org/10.12911/22998993/154847

[18] S. Yunsari, Rusdianasari, and A. Husaini, "CPO Based Biodiesel Production Using Microwaves Assisted Method," J. Phys. Conf. Ser., Vol. 1167, No. 1, 2019, Doi: 10.1088/1742-6596/1167/1/012036.

[19] D. Wulandari, R. Rusdianasari, and M. Yerizam, “Life Cycle Assessment of Production Bio-Oil from Thermal Cracking Empty Fruit,” Asian J. Appl. Res. Community Dev. Empower., Vol. 6, No. 3, 2022, Doi: Https://Doi.Org/10.29165/Ajarcde.V6i3.118.

[20] Rusdianasari, A. Taqwa, A. Syakdani, and Jaksen. Treatment of landfill leachate by electrocoagulation using aluminum electrode. Matec Web of Conference 101 (EDP Science), 02010, 2017

[21] ASTM. (2012). Annual Book of ASTM Standar D-1298 Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Product by Hidrometer. Philadelphia: American Society for Testing nd Material

[22] I. Amri, and A.A. Cahyono. Upgrading Characteristics of Empty Fruit Bunch Biopellet with Addition of Bintaro Fruit as Co-firing. In Journal of Physics: Conference Series (Vol. 1655, No. 1, p. 012127), 2022.

[23] Rusdianasari, A. Syarif, M. Yerizam, M.S. Yusi, L. Kalsum, and Y. Bow. Effect of Catalysts on the Quality of Biodiesel from Waste Cooking Oil by Induction Heating. Journal of Physics: Conference Series 1500, 012052, 2020.

[24] Y. Bow, S. Effendi, A. Taqwa, G. Rinditya, M.Y. Pratama, and Rusdianasari. Analysis of Air Fuel Ratio on Combustion Flames of Mixture Waste Cooking Oil and Diesel using Preheating Method. IOP Conference Series: Earth and Environmental Science 709 (1), 012004, 2021

[25] D. Irtas, Y. Bow, Rusdianasari. The Effect of Electric Current on the Production of Brown’s Gas using Hydrogen Fuel Generator with Seawater Electrolytes. IOP Conference Series: Earth and Environmental Science 709 (1), 012001, 2021

[26] Rusdianasari, I. Arissetyadhi, L. Kalsum, Y. Bow, A. Syarif, and F. Arifin. Characterization of Empty Fruit Bunch of Palm Oil as Co-firing Biomass Feedstock. Asian J. Appl. Res. Community Dev. Empower., Vol. 7(1), 2023. DOI: https://doi.org/10.29165/ajarcde.v7i1.237