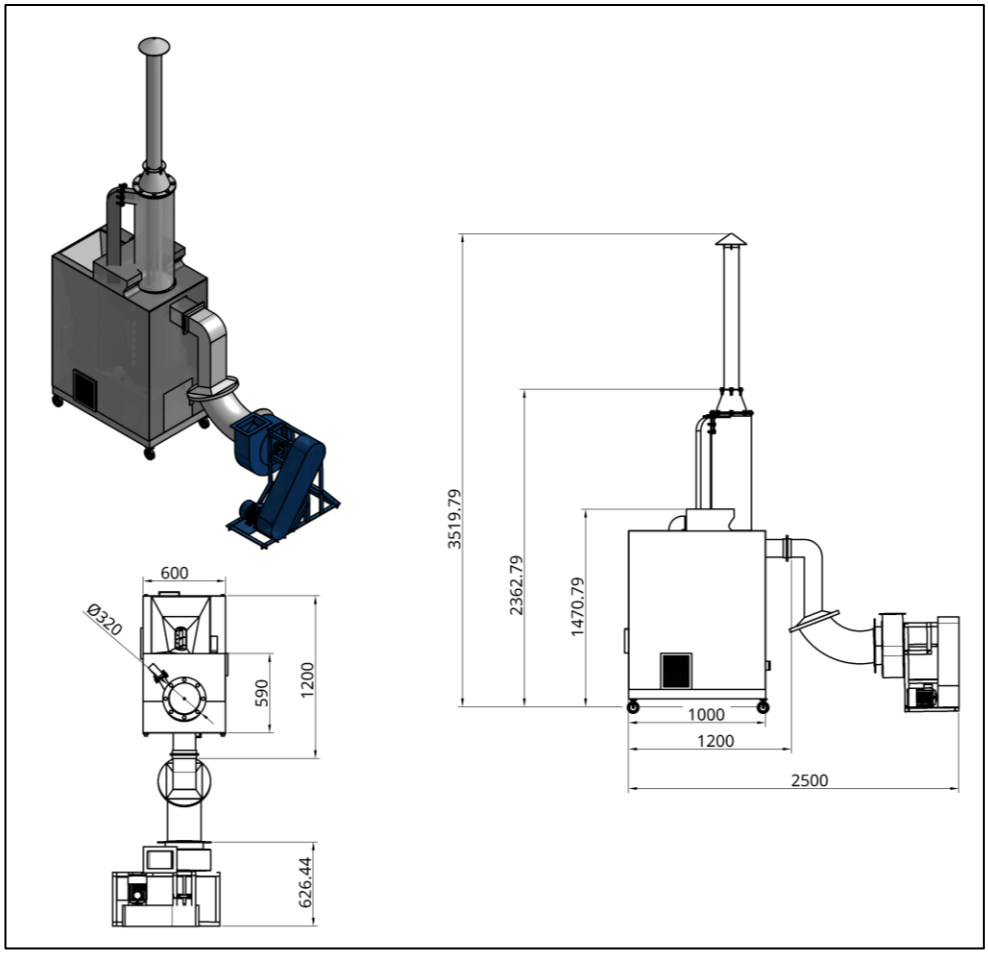
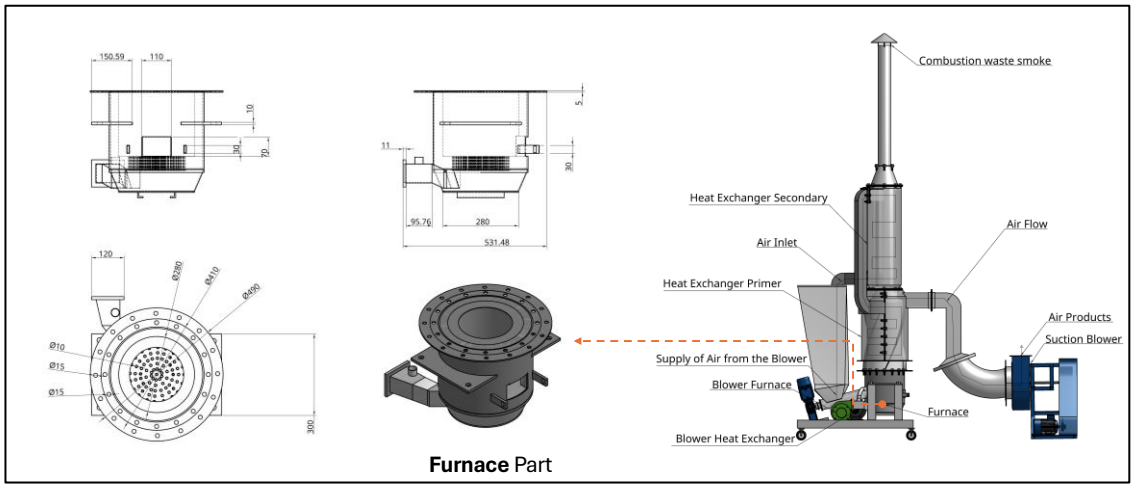
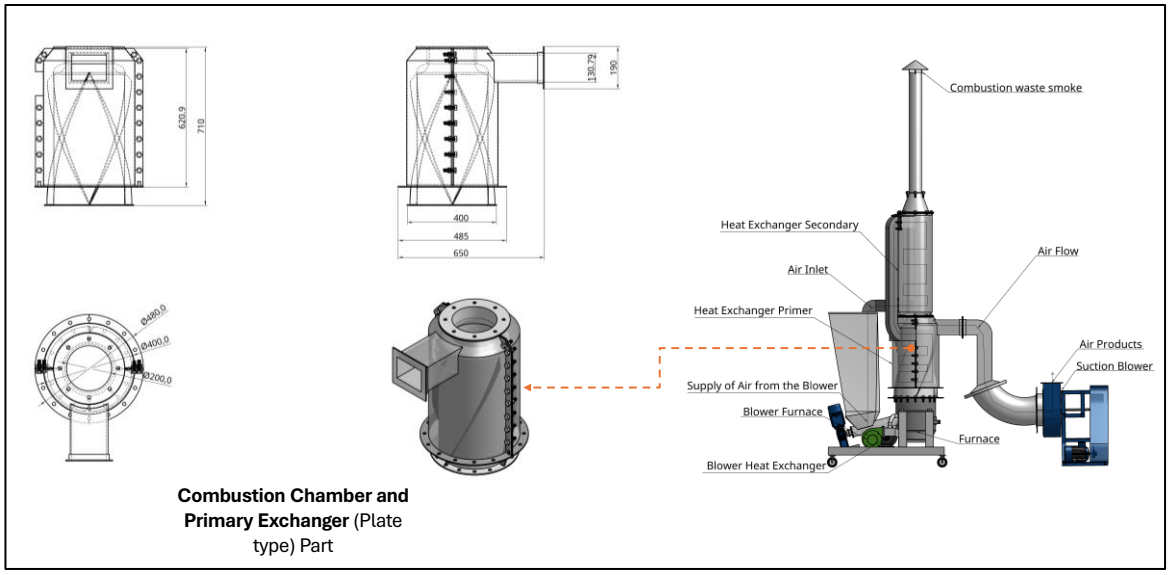

600
Ø320
590
1200
626.44
3519.79
2362.79
1470.79
1000
1200
2500

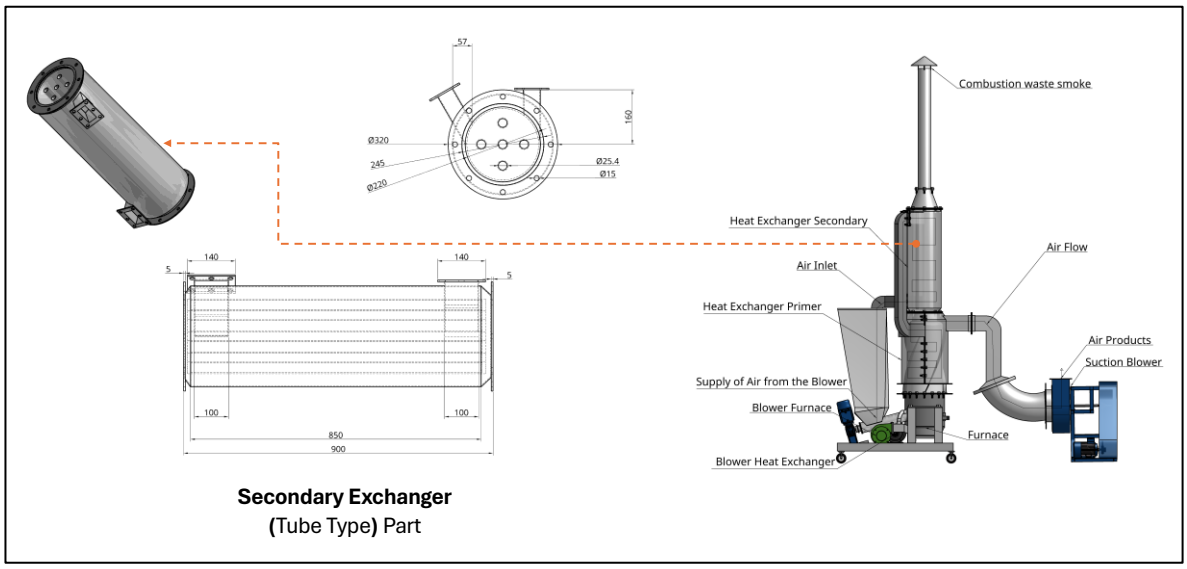
(a)


Combustion waste smoke
Heat Exchanger Secondary
Air Inlet
Heat Exchanger Primer
Air Flow
Air Products
Suction Blower
Supply of Air from the Blower
Blower Furnace
Furnace
Blower Heat Exchanger
Furnace Part

(b)



(c)



(d)

Figure 1 Detail dimension of the machine: (a) overall dimension, (b) furnace dimension, (c) primary HE dimension, and (d) secondary HE dimension

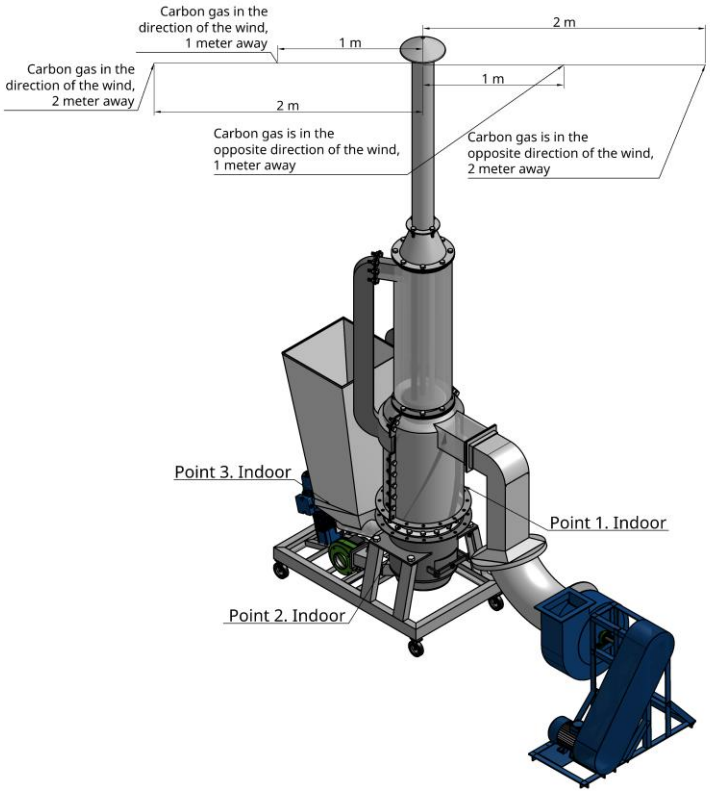


Figure 2 CO measurement position

Table 1 The design requirements of the biomass pellet burner

Name	: Prototype Mobile Vertical Burner
Function	: Heating fresh air
Working Principle	: Based on fresh air passing through the tube type and plate type heat exchangers drawn by the blower, heat comes from wood pellets that are burned in the combustion chamber and then flow through the heat exchanger and exit vertically into the chimney.
Operation	: Continuous
Capacity	: 15 kg/hr
Required hot air output	: 80-120 ^{o}C with 800-1000 CFM

Table 2 The usage of LPG for tea drying using ball tea machine July-October 2024 at PPTK Gambung

Month	Fresh Tea Leaf (kg)	Dried Tea (kg)	Yield (%)	LPG consumption (kg)	Energy Ratio (kg LPG/kg dried tea)	Cost ($/Kg dried Tea)
July	296,763	79,619	26.83	11,000	0.138	0.167
August	292,040	81,254	27.82	8,550	0.105	0.127

September	109,830	31,815	28.97	3,850	0.121	0.146
October	90,177	25,580	28.37	3,600	0.141	0.170
Average	197,203	54,567	28.00	6,750	0.126	0.153

Table 3 The proximate value of biomass pellets.

Testing	Testing Report
Water content (%)	7.36
Bulk Density (gr/cm3)	1.37
Fixed Carbon Content (%)	85.02
Volatile matter (%)	3.72
Burning Rate (gr/hour)	3.03
Calorific Value (Cal/gr)	4331.96

Table 4 Calibration of instruments used in experiment

No	Instrument Name	Serial Number	Calibration Date	Reference Standard Used	Measured Value	Standard Value	Deviation	Status (Pass/Fail)
1	Elitech Thermohygrometer	RC-4HC	6/12/2024	Calibrated Thermohygrometer	50.20%	50%	0.20%	Pass
2	Thermometer data logger and Thermometer type K	TA-612CI	6/12/2024	Mercury Thermometer	99.5 °C	100.0 °C	-0.5 °C	Pass
3	Anemometer	NTC GM816	6/12/2024	Calibrated Wind Tunnel (traceable)	5.08 m/s	5.00 m/s	+0.08 m/s	Pass
4	Digital Scale	ACIS AW-X-7.5	6/12/2024	100 g Class F1 weight	100.2 g	100 g	+0.2 g	Pass

Table 5 Calibration of fuel feeding input rate using a screw motor

Revolution Time (s)	Volume (ml)	Mass (gr)	Density (g/ml)
2	70.70	106.00	0.67
4	148.50	232.00	0.64
6	207.40	330.10	0.63
8	257.70	430.10	0.60
10	319.10	536.00	0.60

average/second	34.23	54.68	0.63

Table 6 Calibration of fuel feeding input rate using a screw motor

Number of revolutions	Revolution Time								
	2 Second			4 Second			6 Second		
	Mass (gr)	Volume (ml)	Density (gr/ml)	Mass (gr)	Volume (ml)	Bulk Density (gr/ml)	Mass (gr)	Volume (ml)	Bulk Density (gr/ml)
2 revolutions	159.0	253.0	0.63	301.5	466.67	0.65	395.5	658.3	0.60
4 revolutions	312.0	520.00	0.60	638.8	996.67	0.64	830.6	1366.7	0.61
6 evolutions	450.3	780.0	0.58	919.0	1503.33	0.61	1251.5	2070.0	0.60
avg/sec/rev	38.76	64.46	0.60	38.64	61.09	0.63	34.11	56.44	0.60

Table 7 Suction air setup calibration

Electromotor Frequency (Hz)	Suction Air Velocity (m/s)				Average (m/s)	CFM
	Point 1	Point 2	Point 3	Point 4		
50	17.86	14.46	13.96	18.72	16.25	895.23
55	20.35	17.15	16.45	20.73	18.67	1028.55
60	21.26	18.38	17.58	22.90	20.03	1103.47

Table 8 Experimental factors and its levels

Fuel Input Rate (kg/hour)	Output Airflow (CFM)
5	895.23
7	1028.55
9	1103.47

Table 9 Distribution of 4 air heating stages

Machine Operational Phase	Time Range (minutes)
Stage no 1	Interval 1-30
Stage no 2	Interval 31-60
Stage no 3	Interval 61-90
Stage no 4	Interval 91-120

Table 10 One-way ANOVA analysis of the correlation between time stages of temperature attainment using the Pairwise Comparisons method
Measure: Temperature changes

(I) ΔT HE Primer	Mean Difference (I-J)	Std. Error	Sig.b	95% Confidence Interval for Difference

					Lower Bound	Upper Bound
ΔT HE at stage 1	ΔT HE at stage 2	-15.367*	1.270	0.000	-19.787	-10.947
	ΔT HE at stage 3	-19.264*	1.270	0.000	-23.684	-14.844
	ΔT HE at stage 4	-20.253*	1.270	0.000	-24.673	-15.833
ΔT HE at stage 2	ΔT HE at stage 1	15.367*	1.270	0.000	10.947	19.787
	ΔT HE at stage 3	-3.897	1.270	0.092	-8.317	0.523
	ΔT HE at stage 4	-4.886*	1.270	0.029	-9.306	-0.466
ΔT HE at stage 3	ΔT HE at stage 1	19.264*	1.270	0.000	14.844	23.684
	ΔT HE at stage 2	3.897	1.270	0.092	-0.523	8.317
	ΔT HE at stage 4	-0.989	1.270	1.000	-5.409	3.431
ΔT HE at stage 4	ΔT HE at stage 1	20.253*	1.270	0.000	15.833	24.673
	ΔT HE at stage 2	4.886*	1.270	0.029	0.466	9.306
	ΔT HE at stage 3	0.989	1.270	1.000	-3.431	5.409

Based on estimated marginal means

*. The mean difference is significant at the 0,05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 11 One-way ANOVA analysis of the correlation between combustion time stages

Pairwise Comparisons

Measure: Efficiency

(I) Range_Efisiensi		Mean Difference (I-J)	Std. Error	Sig.b	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Efficiency at stage 1	Efficiency at stage 2	-18.425*	0.481	0.000	-19.850	-16.999
	Efficiency at stage 3	-23.106*	0.603	0.000	-24.891	-21.320
	Efficiency at stage 4	-24.783*	0.463	0.000	-26.156	-23.410

Efficiency at stage 2	Efficiency at stage 1		18.425*	0.481	0.000	16.999	19.850
	Efficiency at stage 3		-4.681*	0.292	0.000	-5.547	-3.815
	Efficiency at stage 4		-6.358*	0.508	0.000	-7.863	-4.853
Efficiency at stage 3	Efficiency at stage 1		23.106*	0.603	0.000	21.320	24.891
	Efficiency at stage 2		4.681*	0.292	0.000	3.815	5.547
	Efficiency at stage 4		-1.677*	0.489	0.018	-3.125	-0.229
Efficiency at stage 4	Efficiency at stage 1		24.783*	0.463	0.000	23.410	26.156
	Efficiency at stage 2		6.358*	0.508	0.000	4.853	7.863
	Efficiency at stage 3		1.677*	0.489	0.018	0.229	3.125

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 12 Emission (CO) measured on using the proposed Mobile Vertical Burner Biomass Pellet

Chimney			
Direction Of Wind		Opposite Direction of Wind	
1m	**2m**	**1m**	**2m**
CO ppm	**CO ppm**	**CO ppm**	**CO ppm**
132.4	58.2	0.4	0.3

Table 13 Stage II green tea drying process (Ball Tea Dryer Machine)

Process	**Value**	**Unit**	**Reference**
Inlet temperature	135	°C	(Bardant et al., 2019)
Machine Capacity	250	Kg	PPTK Gambung
Air supply			
Fill	710.49	CFM	Test Report
Blank	833.35	CFM	Test Report
Processing Time	13	Hours	(Lestari et al., 2022)
Initial water content	51.09	%	(Lestari et al., 2022)
Final water content	5.25	%	(Lestari et al., 2022)

LPG requirements	0.1	kg/dried tea	PPTK Gambung
Drive Motor			
Ball tea cylinder	1.491	kW	PPTK Gambung
Blower Fan	1.491	kW	PPTK Gambung