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Analysis of the Effect of Preheating System to Improve Efficiency in LPG-fuelled Small Industrial Burner

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Abstract

Nowadays, industries have been using combustion system as one of energy supply in their utility system. However, incomplete combustion process often takes place in the process, which resulted in several disadvantages for the industry such as less energy efficiency, higher CO emission and higher production cost. The aimed of this study was to understand characteristics and increasing combustion efficiency in fuel preheating system technology and to find out the effect of various initial temperature of LPG to combustion efficiency and CO emission. Results showed that increasing initial temperature of LPG from 28 °C to 50 °C would raise efficiency of the burner up to 6.75 % while CO emissions decreased 49.06 %. Furthermore, if the temperature increased up to 100 °C the burner efficiency would raise significantly and CO emissions considerably decreased.

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Keywords: Combustion; preheat; burner; efficiency; LPG

Nomenclature

CO	carbon monoxide	**LPG**	Liquefied Petroleum Gas
% v/v	percentage by volume according to International System of Units	**SNI**	Indonesian National Standard

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1. Introduction

Combustion is a chemical reaction that involves two components, i.e. fuel and the oxidant (normally air), which each component plays important role in the reaction. Combustion occurs when two gaseous, premixed components, are introduced to a container maintained at a uniformly controlled temperature [1].

Currently, almost all industries involving combustion process as one of energy supply in their utility system. However, incomplete combustion process often takes place in the reaction which cause increasing toxic emission (such as carbon monoxide), higher fuel consumption and higher production cost [2]. Since the cost increase, improvement of energy efficiency in the industry is a must. Therefore, it is important to design combustion process within the burner to increase combustion efficiency in the industry [3]. In Indonesia, increasing efficiency in energy usage is a must to prevent industries from spending higher expenses of production cost.

This study, elucidated about the result of increasing energy efficiency in LPG-fuelled small industrial burner. The aimed of this study was to understand characteristics and increasing combustion efficiency in fuel preheating system technology and to find out the effect of various initial temperature of LPG to combustion efficiency and CO emission. Results from this study have high potential in facilitating the development of high efficiency of small industry burner.

2. Material and methods

2.1. Preparation of LPG

LPG was stored in 12 kg gas cylinder (was obtained from PT. Pertamina) to analyze its physical and chemical characteristic. Analysis of LPG was referred to LPG specification issued by Directorate General of Oil and Gas Government of Indonesia No. 26525.K/10/DJM.T/2009. The parameters observed are referred to LPG specification such as specific gravity, copper strip corrosion, vapor pressure, weathering test, total sulphur, water content and composition. Result of physical and chemical characteristics of LPG is shown in Table 1. Based on the test results, all parameters of physical and chemical characteristics fulfill the specification of LPG issued by the government.

Table 1. Physical and chemical characteristic of LPG.

Parameter	Unit	Limit		LPG	Methods	
		Min	Max		ASTM	Other
Specific gravity	-		To be reported	0.5374	D-1657	
Vapor pressure	kPa	-	827.37	689.47	D-1267	
Weathering test	%	95	-	99.8	D-1837	
Copper corrosion	-	-		1b	D-1838	
Water content	-		No Free Water	-	-	Visual
Composition :					D-2163	
DME	% v/v			0		
C_2	% v/v	-	0.8	0.16		
C_3 and C_4	% v/v	97.5	-	99.4		
C_{5+} (C_5 and heavier)	% v/v	-	2.0	0.4		

2.2. LPG performance test on the burner and emission test

Performance test of LPG was conducted according to the test method of Indonesian National Standard (SNI 7368:2007) [4] encompasses heat input, fuel consumption, time for boiling water and combustion efficiency. Water boiling test is also known as international standard for stove efficiency [5]. Efficiency test was conducted by heating 6.1 kg of water in a vessel (diameter 260 mm) from 20 °C to 90 °C. Schematic diagram for LPG performance test with and without preheating system is shown in Fig. 1.

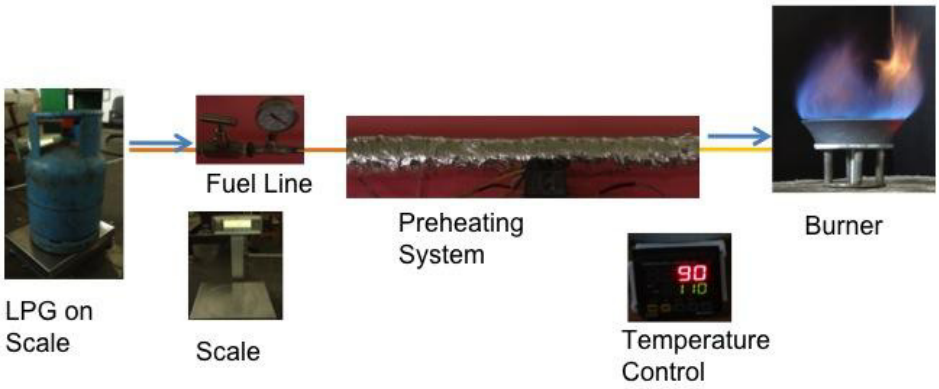

Fig. 1 Schematic diagram for LPG performance test with and without preheating system

Emission test from LPG combustion was conducted according to the schematic diagram as shown in Fig. 2.

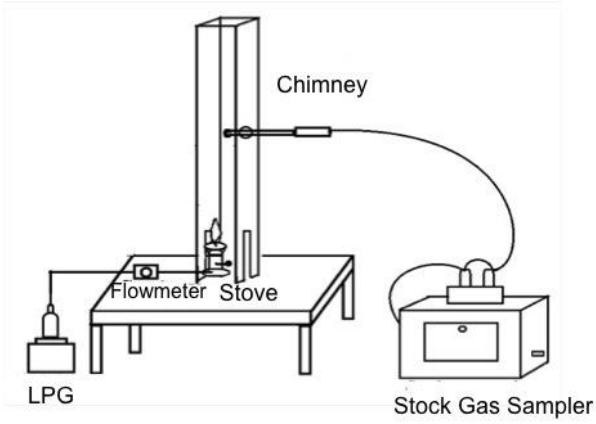

Fig. 2. Schematic diagram for emission test from LPG combustion.

3. Results and discussion

3.1. LPG performance in the burner

LPG performance test in the burner with and without preheating system was conducted by increasing temperature gradually in LPG fuel line before the tip of the burner and the heater. Initial LPG temperature was set at

28 °C and increased gradually to 30 °C, 35 °C, 40 °C, 45 °C, 50 °C, 55 °C, 60 °C, 65 °C, 70 °C, 75 °C, 80 °C, 85 °C, 90 °C, 95 °C, and 100 °C. Fuel consumption and combustion efficiency data was obtained from the performance test. Fuel consumption of one burner gas stove (Mc) is the amount of gas that is utilized to heat water in a vessel from 20 °C to 90 °C (SNI 7368:2007). In two burners gas stove, fuel consumption is calculated in a condition when burner lit one by one. Combustion efficiency was calculated with formula based on SNI 7368:2007.

$$\eta = \frac{4.186x\,10^{-3}xMex(t-t_1)x100}{(McxHs)} \quad (1)$$

Where:
Me = total water and aluminium vessel mass (kg)
t = final temperature of water, °C
t_1 = initial temperature of water, °C
Mc = mass of burned gas to heat water, kg
Hs = gas calorific value, MJ kg^{-1}

Based on formula (1), the result of combustion efficiency during the performance test of LPG in the burner is shown in Table 2.

Table 2. Performance test of LPG in the burner

LPG Temperature (°C)	Consumption (kg)	Vessel Diameter (mm)	Water mass (kg)	Calorific value of LPG	Efficiency (%)	Change in efficiency (%)
28	0.232 6	350	14.500	46.056	43.10	0
30	0.239 4	350	14.500	46.056	43.12	0.02
35	0.231	350	14.500	46.056	45.64	2.54
40	0.234	350	14.500	46.056	44.10	1.00
45	0.238 2	350	14.500	46.056	44.26	1.16
50	0.207	350	14.500	46.056	49.85	6.75
55	0.209 5	350	14.500	46.056	50.32	7.22
60	0.204	350	14.500	46.056	50.58	7.48
65	0.188	350	14.500	46.056	56.08	12.98
70	0.180 3	350	14.500	46.056	57.23	14.13
75	0.168 5	350	14.500	46.056	62.57	19.47
80	0.164 9	350	14.500	46.056	62.58	19.48
85	0.167 5	350	14.500	46.056	62.94	19.84
90	0.160 5	350	14.500	46.056	64.29	21.19
95	0.160 5	350	14.500	46.056	65.69	22.59
100	0.156	350	14.500	46.056	66.15	23.05

Based on calculation from LPG performance test in a small burner as shown in Table 2, it was found that with increasing temperature at fuel line before the tip of the burner, fuel consumption decreased although same size of the vessel and same water volume was used. Results showed that combustion efficiency and performance of the burner increased significantly when preheat system were introduced in the LPG (before the tip of the burner). From

calculation of fuel consumption and combustion efficiency with preheating system in a small scale burner, from initial temperature of LPG:

- 28 °C to 30 °C, results in 0.02 % better efficiency,
- 28 °C to 50 °C, results in 6.75 % better efficiency,
- 28 °C to 60 °C, results in 7.48 % better efficiency,
- 28 °C to 70 °C, results in 14.13 % better efficiency,
- 28 °C to 80 °C, results in 19.48 % better efficiency,
- 28 °C to 90 °C, results in 21.19 % better efficiency,
- 28 °C to 100 °C, results in 23.05 % better efficiency.

The result of change in efficiency is shown in Fig. 3.

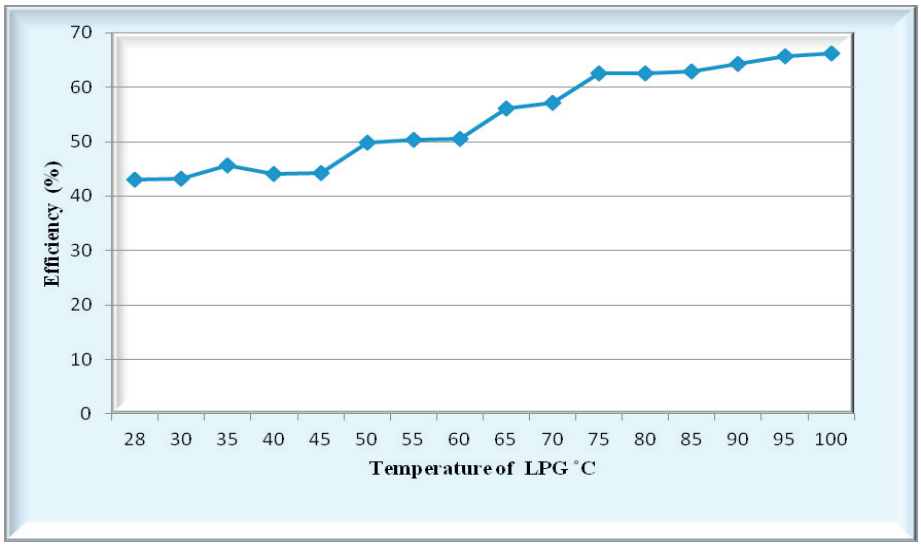

Fig. 3. The effect of preheating system to combustion efficiency.

3.2. Emission of LPG in the burner

Similar to LPG performance test in the burner, emission test was conducted with and without preheating system by increasing temperature gradually in LPG fuel line before the tip of the burner and the heater. Initial LPG temperature was set at 28 °C and increased gradually to 30 °C, 35 °C, 40 °C, 45 °C, 50 °C, 55 °C, 60 °C, 65 °C, 70 °C, 75 °C, 80 °C, 85 °C, 90 °C, 95 °C, and 100 °C. Gas analyzer (as shown in Fig. 2) was used to measure CO emission. Result showed that CO emissions considerably decreased when preheat was introduced to the burner of LPG as shown in Fig. 4.

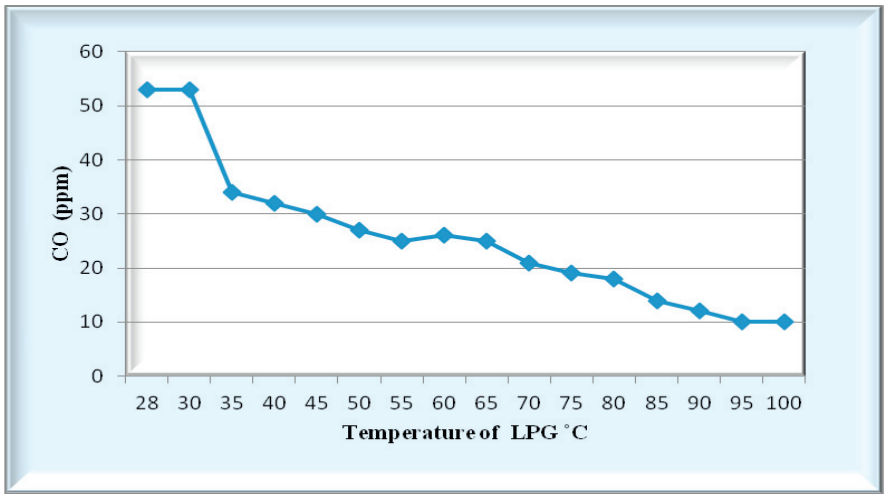

Fig. 4. The effect of preheating system to CO emission

4. Conclusion

Various initial temperature of LPG in the preheating system technology were used to observe the effect to efficiency and CO emission of the small industry burner. It was found that increasing initial temperature up to 50 °C would raise burner efficiency up to 6.75 % and decreased CO emissions to 49.06 %. Moreover, if the temperature increased up to 100 °C efficiency of the burner would raise 23.05 % while CO emissions decreased 81.13 %.

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