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Judul artikel	**:**	**Thermodynamic Simulation of Producer Gas Combustion from Biomass Gasification**
Jurnal	**:**	**EAI Endorsed Transactions on Energy Web**
Penulis	**:**	**Fajri Vidian, Arif Rahman Hakim**

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Thermodynamic Simulation of Producer Gas from Biomass Gasification

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Abstract

The use of new and renewable energy for application on gas burners is very beneficial, especially for the environment. The result of biomass gasification in the form of producer gas can be used as a fuel gas burner. In this study, a thermodynamic simulation of the combustion of producer gas from biomass gasification is carried out to obtain the effect of excess of air on combustion flame temperature and heat release during the combustion process. Simulations are carried out by applying mass and energy balance. The simulation results show that an increase in excess of air will decrease the non-adiabatic and adiabatic flame temperature. The increase in excess of air will reduce the amount of heat release to the environment for the same flame temperature. The maximum adiabatic flame temperature is at 1725.43^{0}C. The non-adiabatic flame temperature in the range of 600 to 800 ^{0}C at heat release in the range of 20.1 kW to 28.8 kW and excess of air in the range of 0 to 40%.

Keywords: Simulation, Thermodynamic, Temperature, Heat release, Combustion, Producer Gas

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1. Introduction

Producer gas from gasification is an alternative fuel for substituting fossil fuels, especially from biomass gasification [1]. Producer gas can be burned as gas fuel and has environmental advantages if it is used in the burner [2]. The results of the combustion of producer gas in the gas burner can be used for various applications, such as drying, gas turbines, and boilers. This application is needed in a high temperature. Many factors affect the flame temperature of combustion such as the amount of air combustion and heat release from the burner [3]. Simulation is a very good method in specifying the flame temperature of combustion which can be obtained through the various parameters. It could reduce the design time and the cost of experimental [4]. The amount of heat release during the combustion process and the amount of nitrogen in the air are factors to specify the value of flame temperature. It can be modelled thermodynamically to see the effect of heat release and the amount of nitrogen in the air on the combustion flame temperature.

Several thermodynamic simulations of the combustion process have been carried out by researchers. Vitázek [5] performed a thermodynamic simulation of biogas combustion using the principle of mass and energy balance. Caligiuri [6] did a thermodynamic simulation of dual fuel diesel and producer gas combustion in an internal combustion engine, the simulation was carried out by applying the first law of thermodynamics to a closed system. Larionov [7] conducted a thermodynamic simulation of the combustion of a mixture of methane and hydrogen fuel, the simulation was carried out by applying the first law of thermodynamics. Rahim [8] simulated a burning speed of methane air diluent mixture, the mass fraction and temperature in combustion chamber was determinate by applying the equation conservation mass and energy. Saghaei [9] conducted a thermodynamic simulation of porous-medium combustion chamber to explain diesel engine combustion, the simulation applied energy and single step combustion equation. Hariram [10] conducted a zero-dimensional thermodynamic simulation of thermodynamic property of compressed ignition engine, the simulation was done by using the first law of thermodynamics. Feng [11] simulated a zero dimensional of marine two stroke engine, the simulation was done by applying mass conservation equation, energy conservation equation and ideal gas equation. Papagiannakis [12] conducted thermodynamic simulation in a wood gas spark ignition engine, the simulation was done by applying mass conservation equation, energy equation and ideal gas equation.

In this research, a thermodynamic simulation of the combustion of single producer gas from biomass gasification is carried out by applying mass balance, energy balance in an open system. This study aims in general to get the effect of excess of air on flame temperature (adiabatic and non-adiabatic) and the heat release during the combustion process. The specific objective is to obtain the amount of heat release at temperatures between 600 and 800 ^{0}C.

2. Thermodynamic Model

Each The analysis of the combustion process is carried out by applying the first law of thermodynamics. The first law of thermodynamics is shown below

$$E_{in} - E_{out} = \Delta E_{system} \quad (1)$$

Furthermore, this combustion process takes place in open system combustion by applying the control volume. For steady flow ($\Delta E_{system} = 0$), The first law of thermodynamics become as follow:

$$\mathbf{E_{in} = E_{out}} \quad (2)$$

the components of energy in and out are heat, work, and mass flow. Then the equation becomes:

$$Q_{in} + W_{in} + \sum\left(h + \frac{v^2}{2g} + gz\right)_{in} = Q_{out} + W_{out} + \sum\left(h + \frac{v^2}{2g} + gz\right)_{out} \quad (3)$$

By ignoring in kinetic energy, potential energy, work and heat entering system, the equation above becomes as follow

$$\mathbf{Q_{out}} = (h_{in} - h_{out}) \quad (4)$$

In the combustion process, there is a change in internal energy, namely chemical energy and sensible energy. Based on this, the enthalpy for the combustion process consists of formation and sensible enthalpy as shown in the following equation:

$$h = \bar{h}_f^0 + (\bar{h} - \bar{h}^\circ) \quad (5)$$

$$Q_{out} = \sum N_{in}\left(\bar{h}_f^0 + \bar{h} - \bar{h}^\circ\right)_{in} - \sum N_{out}\left(\bar{h}_f^0 + \bar{h} - \bar{h}^\circ\right)_{out} \quad (6)$$

When the combustion process takes place adiabatically, the value of $Q_{out} = 0$. The equation is as follow.

$$\sum N_{in}\left(\bar{h}_f^0 + \bar{h} - \bar{h}^\circ\right)_{in} = \sum N_{out}\left(\bar{h}_f^0 + \bar{h} - \bar{h}^\circ\right)_{out} \quad (7)$$

2.1. Fuel Composition

The fuel used in this simulation is producer gas from palm oil shell gasification with a producer gas composition as in table 1 with a gas heating value at 6.1 MJ / Nm^3.

Table 1. Fuel Composition

No	Species	% Vol
1	CO	22.55
2	H_2	8.35
3	CH_4	8.21
4	CO_2	14.1
5	O_2	1.32
6	N_2	45.47

2.2. Stoichiometric of combustion reaction

The stoichiometric equation is obtained by applying mass conservation equation, as follows:

$$(0{,}2255\ CO + 0{,}0835\ H_2 + 0{,}0821\ CH_4 + 0{,}141\ CO_2 + 0{,}4547\ N_2 + 0{,}0132\ O_2) + 0{,}3055\ (O_2 + 3{,}76N_2) \longrightarrow 0{,}4486\ CO_2 + 0{,}2477\ H_2O + 1{,}6033\ N_2 \quad (8)$$

2.3. Parameter of Simulation

Simulations are carried out with variations in excess of air each of 0%, 10%, 20%, 30%, 40%, and 50% with the mass flow rates of air and fuel as in table 2. In the non-adiabatic simulation, the heat release of the burner gas is assumed to be 70000 kJ/h

(19.4 kW). This is in the range of the result of experiments conducted by [13-14]. Non-adiabatic simulations are carried out using two methods. The first is to get the effect of excess of air on the temperature of flame by varying the excess of air and heat release keep constant of 70000 kJ/h. The second is to get the effect of excess of air and temperature of flame on the heat release rate, the simulation is carried out to vary the excess of air and set the temperature of flame constant.

Table 2. Parameter of simulation

Excess of Air (%)	Air mass flow rate (kg/h)	Fuel mass flow rate (kg/h)
0	41.8169	27.1659
10	45.9984	27.1659
20	50.1799	27.1659
30	54.3615	27.1659
40	58.5430	27.1659

3. Results and Discussion

3.1. The Effect of Excess of Air on Flame Temperature

Figure 1 and Figure 2 show the effect of excess air on the temperature of the flame under non-adiabatic and adiabatic conditions. The increase in excess of air will reduce the flame temperature in both non-adiabatic and adiabatic conditions, it have the same trend to the reports by [15-18]. Because the increasing of excess of air will increase the nitrogen content in the combustion product which then absorbs the heat from the combustion so that the flame temperature will decrease. In non-adiabatic conditions with a heat release at 70000 kJ/h, the maximum flame temperature is at 986.68 ^{0}C with excess air at 0%. Each increase in excess air at 10 ^{0}C will decrease the temperature in the range of 40 - 43°C. In adiabatic conditions, the maximum flame temperature is at 1753 ^{0}C of excess of air at 0%. Each increase in excess air at 10 ^{0}C will decrease the temperature in the range of 60 - 78 °C.

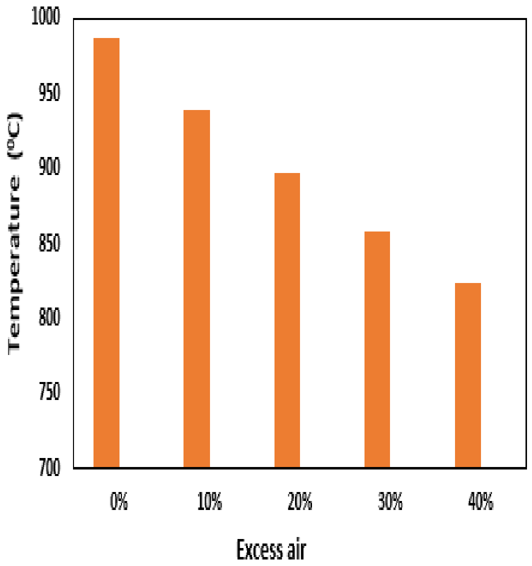

Figure 1. The influence of excess of air to non-adiabatic flame temperature

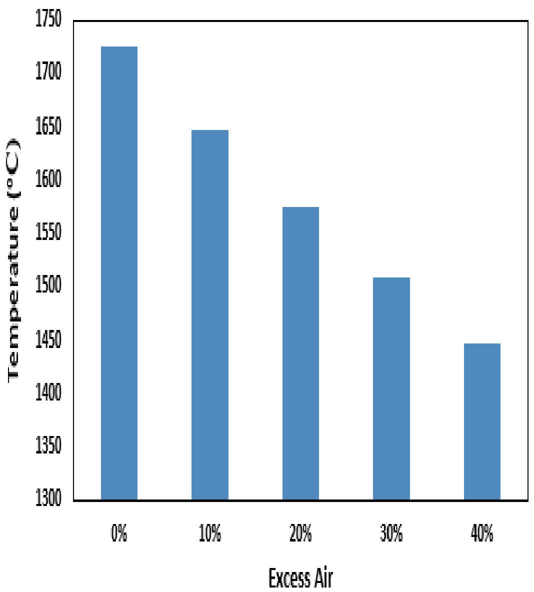

Figure 2. The influence of excess of air to adiabatic flame temperature

3.2. The Effect of Flame Temperature on The Heat Release in Various of Excess of Air

Figure 3 shows the effect of the temperature of the flame on the amount of heat release from the combustion chamber at the variation of excess of air. An increase in the flame temperature will reduce the amount of heat release for various excess of air. It can be seen that for each the same flame temperature, the greatest of heat release occurs at the lowest of excess of air. Due to the energy from combustion is the lowest absorbed by excess of air. The temperature flame is produced in the ranges of

600 to 800 ^{0}C with heat release during the process in the range of 72490 kJ/h to 103800 kJ/h (20.1 kW to 28.8 kW). This range of the temperature always get from reporting on combustion of producer gas by researcher [19-20]. In excess of air at 40% with a flame temperature at 1400 ^{0}C, it is seen that the heat release is close to zero (close to adiabatic conditions), where the adiabatic flame temperature for the excess of air of 40% is at 1447.78 ^{0}C.

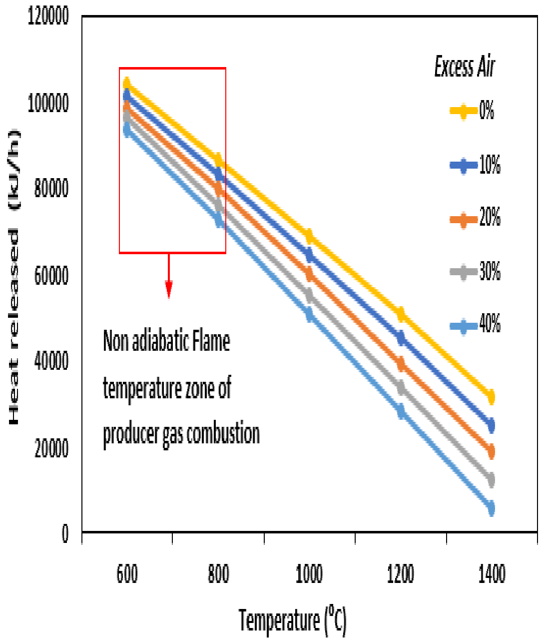

Figure 3. The influence of flame temperature to heat release on variation of excess of air

3.3. The Effect of Flame Temperature on The Heat Release in Various of Excess of Air

The comparison of experimental and simulation is carried out in adiabatic conditions. Punnarapong [21] reported that a result of the experiment of adiabatic flame temperature obtained was at 1260 ^{0}C and the simulated adiabatic temperature was at 1750 ^{0}C. This is due to the difference in the composition of the producer gas which uses the heating value of gas wherein the experiment the average heating value is at 5.2 MJ/Nm^{3} while in the simulation it is at 6.1 MJ/Nm^{3}.

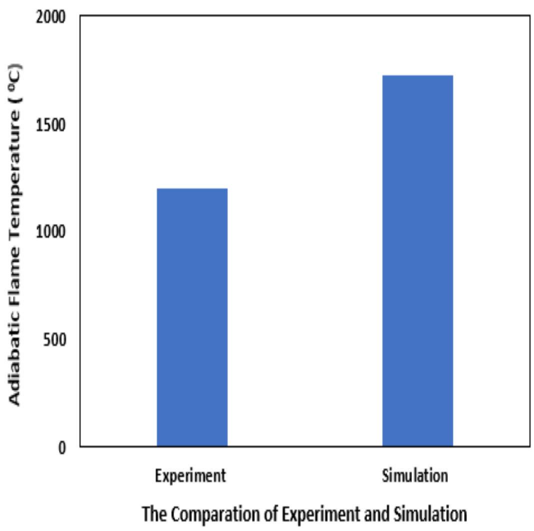

Figure 4. The Comparison of simulation and experimental

4. Conclusion

An increase in excess of air will decrease the adiabatic and non-adiabatic flame temperatures of biomass producer gas temperature. The maximum adiabatic flame temperature is at 1725.43 ^{0}C at 0% excess of air and the minimum of adiabatic flame temperature is at 1447.78 ^{0}C at 40% excess of air. The greater the resulting non-adiabatic temperature, the less heat is released during the combustion process for the excess of air constant. The non-adiabatic flame temperature in the range of 600 to 800 ^{0}C at heat release in the range of 20.1 kW to 28.8 kW and the excess of air in the range of 0 to 40%.

Nomenclature

E_{in}	-	Total Energy Entering the System
E_{out}	-	Total Energy Leaving the System
ΔE_{system}	-	Change in the total energy of the system
Q_{in}	-	Energy Entering the System by Heat
Q_{out}	-	Energy Leaving the System by Heat
$\dot{W}_{in}$	-	Energy Entering the System by Work
$\dot{W}_{out}$	-	Energy Leaving the System by Work

m_{in} - Mass entering the system

m_{out} - Mass entering the system

h - Enthalpy

h_{in} - Enthalpy entering the system

h_{out} - Enthalpy leaving the system

$\bar{h}_f^0$ - Enthalpy formation at standart reference temperature

$\bar{h}$ - Enthalpy at spesific state temperature

$\bar{h}^{\circ}$ - Enthalpy at standart reference temperature

N_{out} - mole entering the system

N_{in} - mole entering the system

References

[1]. Gomez H.O, Calleja M.C, Fernandez L.A, Kiedrzynska A, Lewtak R, Application of the CFD simulation to the evaluation of natural gas replacement by syngas in burners of the ceramic sector, Energy, 2019;185; 15-27.

[2]. Sami. S, Gasification, Producer Gas and Syngas, *Agriculture and Natural Resources*.

[3]. Masum B.M, Kalam M.A, Masjuki H.H, Palash S.M, Study on the effect of adiabatic flame temperature on NOx formation using ethanol gasoline blend in SI Engine, *Advanced Materials Research*, 2013; 781-784; 2471-2475.

[4]. Gaultier E.V, Shengals A.A, Tikhonov A.S, Klyavin O.I, Procedure for simulation of combustion in the burner device of the low emission combustion chamber, WSEAS Transaction on System and Control, 2020,15, 468-476.

[5]. Vitázek I, Klúčik J, Uhrinová D, Mikulová Z, Mojžiš M, Thermodynamics of combustion gases from biogas, Res. Agr. Eng, 2016; 62; Special Issue: S8–S13.

[6]. Caligiuri C, Renzi M. Baratieri M, Development of a 0D Thermodynamics Combustion Simulation Tool for a Dual Fuel Diesel – Producer Gas Engine, Proceedings of the European Combustion Meeting 2017; 8th European Combustion Meeting. 2017.

[7]. Larionov V.M, Saifullin E. R, Konstantinov N. V, Nazarychev S. A, Malakhov A. O, Yunusova E. A, The influence of hydrogen concentration on the flame temperature of a mixture of methane-hydrogen fuel with air, Journal of Physics: Conf. Series, 1328 012048, 2019.

[8]. Rahim F, Far K. E, Parsinejad F, Andrews R. J, Metghalchi H, A Thermodynamic Model to Calculate Burning Speed of Methane-Air-Diluent Mixtures, Int. J. of Thermodynamics, 2008; 11(4); 151-160.

[9]. Saghaei M, Mohammadi A, Thermodynamic simulation of porous-medium combustion chamber under diesel engine-like conditions, Applied Thermal Engineering, 2019; 153; 306–315.

[10]. Hariram V, Bharathwaaj R, Application of zero-dimensional thermodynamic model for predicting combustion parameters of CI engine fuelled with biodiesel-diesel blends, Alexandria Engineering Journal, 2016; 55, 3345-3354.

[11]. Feng Y, Wang H, Gao R, Zhu Y, A Zero-Dimensional Mixing Controlled Combustion Model for Real Time Performance Simulation of Marine Two-Stroke Diesel Engines, Energies, 2019; 12; 1-19.

[12]. Papagiannakis R.G, Zannis T.C, Thermodynamic analysis of combustion and pollutants formation in a wood-gas spark-ignited heavy-duty engine, International Journal of Hydrogen Energy, 2013; 38 (28); 12446-12464.

[13]. Surjosatyo A, Priambodho Y. D, Investigation of Gas Swirl Burner Characteristic on Biomass Gasification System Using Combustion Unit Equipment (CUE), Jurnal Mekanikal, 2011; 33; 15-31.

[14]. Lee Y.P, Delichatsios M. A, Silcock G.W.H, Heat Flux Distribution and Flame Shapes on the Inert Façade, Fire Safety Science Proceedings of

Ninth International Symposium, 2008, pp. 193-204.

[15]. Cala O. M, Meriño L, Kafarov V, Saavedra J, Evaluation of combustion models for determination of refinery furnaces efficiency, *Ingeniare. Revista chilena de ingeniería*, 2015; 23 (3); 429-438.

[16]. Lou H. H, Chen D, Martin C. B, Li X, Li K, Vaid H, Singh K. D, Gangadharan P, Optimal Reduction of the C1−C3 Combustion Mechanism for the Simulation of Flaring, Ind. Eng. Chem. Res. 2012; 51 (39); 12697–12705.

[17]. Glaude P.A, Sirjean B, Fournet R, Bounaceur R, Vierling M, Montagne P, Molière M, Combustion and oxidation kinetics of alternative gas turbines fuels, Turbine Technical Conference and Exposition 2014 (pp 1-9).

[18]. Law C.K, Makino A, Lu T.F, On the off-stoichiometric peaking of adiabatic flame temperature, Combustion and Flame, 2006; 145; 808–819.

[19]. Surjosatyo A, Vidian F, Tar Content Evaluation of Produced Gas in Downdraft Biomass Gasifier, Iranica Journal of Energy & Environment, 2012; 3(3); 210-212.

[20]. Panwar N.L, Salvi B.L, Reddy V.S, Performance evaluation of producer gas burner for industrial application, Biomass and Bioenergy, 2011; 35(3); 1373-1377.

[21]. Punnarapong P, Sucharitakul T, Tippayawong N, Performance evaluation of premixed burner fueled with biomass derived producer gas, Case Studies in Thermal Engineering, 2017; 9; 40–46.

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thermodynamic simulation of the combustion of producer gas from biomass gasification is carried out to obtain the effect of excess of air on combustion flame temperature and heat release during the combustion process. Simulations are carried out by applying mass and energy balance. The simulation results show that an increase in excess of air will decrease the non-adiabatic and adiabatic flame temperature. The increase in excess of air will reduce the amount of heat release to the environment for the same flame temperature. The maximum adiabatic flame temperature is at 1725.430C. The non-adiabatic flame temperature in the range of 600 to 800 0C at heat release in the range of 20.1 kW to 28.8 kW and excess of air in the range of 0 to 40%.

2 . Innovation impact of the proposed concept
thermodynamic simulation of the combustion of producer gas from biomass gasification is carried out to obtain the effect of excess of air on combustion flame temperature and heat release during the combustion process. Simulations are carried out by applying mass and energy balance. The simulation results show that an increase in excess of air will decrease the non-adiabatic and adiabatic flame temperature. The increase in excess of air will reduce the amount of heat release to the environment for the same flame temperature. The maximum adiabatic flame temperature is at 1725.430C. The non-adiabatic flame temperature in the range of 600 to 800 0C at heat release in the range of 20.1 kW to 28.8 kW and excess of air in the range of 0 to 40%.

3 . Technical content and correctness of the contribution
biomass gasification in the form of producer gas can be used as a fuel gas burner

4 . Importance of the manuscript for the thematic area
yes

5 . Implementation potential of the proposed concept
The use of new and renewable energy for application on gas burners is very beneficial, especially for the environment.

6 . Completeness of the references
complete

7 . Quality of the writing
good

** General comments by referee 1 to Author**

Note for this paper the preparation of the paper is still reversed for a better Nomenclature after reference and this paper has not explained the evaluation of the Thermodynamic Simulation of Producer Gas from Biomass Gasification, please make it, thank you

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...

2 . Innovation impact of the proposed concept
...

3 . Technical content and correctness of the contribution
...

4 . Importance of the manuscript for the thematic area
...

5 . Implementation potential of the proposed concept
...

6 . Completeness of the references
...

7 . Quality of the writing
...

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The proposed methodology is very weak.
The author should compare the propsed system with atleast five state art of the method.
In the conclusion section, the authors claim that their system is better when comparing with the existing system; however, there are no metrics and graphs provided to support their claim.

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2.	this paper has not explained the evaluation of the Thermodynamic Simulation of Producer Gas from Biomass Gasification, please make it,	the true of the manuscript title is "Thermodynamic Simulation of Producer Gas **Combustion** from Biomass Gasification", so it has been explained in the manuscript revision.
Reviewer 2		
No	Comments	Responses
1.	The organization of the paper is not in proper order	The organizations paper has been improved and corrected, please see in manuscripts revision
2.	The need for the proposed system is not justified. Please clearly mention the problems in the existing system	The problem of existing system is very hard to get the value of heat release, by using simulation thermodynamic from this model, It is easy to get
3.	The proposed methodology is very weak	The proposed methodology has been improved, Please see in manuscript revision

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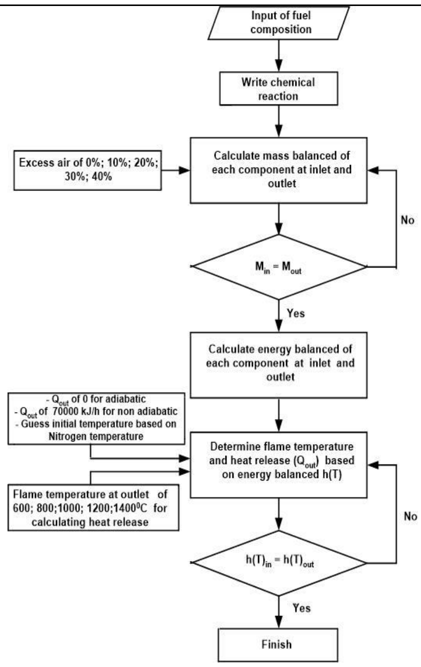
<tr><td></td><td></td><td>
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In Page of 357
2. Xiaoli Hao, Guoqiang Zhang, Youming Chen, Jin Zhou, Thermodynamic Model and Numerical Simulation of Single-Shaft Microturbine Performance, HVAC Technologies for Energy Efficiency, Vol. IV-10-1, pp 1-7,2006
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3. A. Durante , G. Pena-Vergara , P.L. Curto-Risso ,</td></tr>
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		A. Medina , A. Calvo Hernández , hermodynamic simulation of a multi-step externally fired gas turbine powered by biomass, Energy Conversion and Management 140 (2017) 182–191 4. In Richard V. James, Howells I. Hart, Barinyima Nko, Thermodynamic and Environmental Assessment of Gas Flaring in the Niger Delta Region of Nigeria. Journal of Power and Energy Engineering, 6, 39-56.2018 In Page of 43. Page of 185 5. Larionov V.M, Saifullin E. R, Konstantinov N. V, Nazarychev S. A, Malakhov A. O, Yunusova E. A, The influence of hydrogen concentration on the flame temperature of a mixture of methane-hydrogen fuel with air, Journal of Physics: Conf. Series, 1328 012048, 2019 In Page of 1-2 it is put on manuscript revision at '3.3 The Comparation of Thermodynamic Simulation and Experimental' with paragraph of "The simulation method adopted was also referenced [7, 22-25]".
5	In the conclusion section, the authors claim that their system is better when comparing with the existing system; however, there are no metrics and graphs provided to support their claim.	The author does not conclude that this simulation result is better, but only describes the simulation results obtained by the author for the gas composition conditions used. Then the results of this simulation can be compared with the experimental results described in section "3.3 . The

		Comparation of Thermodynamic Simulation and Experimental” although the results are still different because the operating parameters used are different. The comparison graph between the simulation and experimental results is shown in Figure 5.
6.	There no future direction added	it is put on manuscript revision ‘3.3 The Comparation of Thermodynamic Simulation and Experimental’ with paragraph of “To remedy this situation, the future study must equalize the operating parameters and improve both the simulation and experimental aspects”.
7.	Improve your English. The majority of the sentences lack clarity	The English has been improved by using proof reading, please see on the manuscript revision

Artikel Revisi yang di Submit

Thermodynamic Simulation of Producer Gas Combustion from Biomass Gasification

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Abstract

The use of new and renewable energy for the application on gas burners is beneficial for the environment. This study aims to determine the effect of excess air during the combustion of producer gas from biomass gasification to release heat used as a fuel gas burner. Simulations are carried out by applying mass and energy balance, showing that an increase in excess air will decrease the non-adiabatic and adiabatic flame temperature. The result showed that an increase in excess of air reduces the amount of heat released to the environment for the same flame temperature. The maximum adiabatic flame temperature is at 1725.43^{0}C, while the non-adiabatic ranges from 600 to 800^{0}C. Furthermore, heat is released in the range of 20.1 kW to 28.8 kW, and excess air from 0 to 40%.

Keywords: Simulation, Thermodynamic, Temperature, Heat release, Combustion, Producer Gas

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1. Introduction

Producer gas is an alternative used for substituting fossil fuels, specifically biomass gasification [1]. It has certain environmental advantages when used on the burner [2]. The combustion process results can be used for various applications, such as drying, gas turbines, and boilers. Several factors affect the flame, such as the amount of combusted air and heat released from the burner [3]. Simulation is a good method to detect the combustion process's specific temperature. This can also be obtained through various parameters. It reduces the design time and the experimental cost [4]. The amount of heat released during the combustion process and the quantity of nitrogen in the air are factors that specifically affect the flame temperature. It can be thermodynamically modelled to ascertain the effect of heat release and the quantity of nitrogen.

Several preliminary studies have been carried out on thermodynamic simulations. Vitázek [5] performed a similar analysis on biogas combustion using the mass and energy balance principle. Caligiuri [6] carried out a thermodynamic simulation of dual fuel diesel and producer gas in an internal combustion engine. This was performed by applying the first law of thermodynamics to a closed system. Larionov [7] carried out a similar analysis on the combustion of a mixture of methane and hydrogen fuel. This was also performed based on the first law of thermodynamics. Rahim [8] simulated the burning speed of the methane-air diluent mixture, while its mass fraction and temperature in the combustion chamber were determined by applying the conservation mass and energy equation. Saghaei [9] also investigated a porous-medium chamber using thermodynamic simulation, including energy and single-step equations, to explain the combustion process in a diesel engine. Hariram [10] carried out a zero-dimensional thermodynamic simulation of a compressed ignition engine. This was performed by using the first law of thermodynamics. Feng [11] simulated a zero-dimensional marine two-stroke engine by applying mass and energy conservation as well as ideal gas equations. Papagiannakis [12] performed a thermodynamic simulation on a wood gas spark ignition engine using similar processes.

This study performed a thermodynamic simulation of single producer gas from biomass gasification by applying mass, and energy balance in an open system. It aims to determine the general effect of excessive air on flame temperature. The specific objective is to obtain the heat released during the combustion process at temperatures between 600 and 800^{0}C.

2. Methodology

The combustion process was analyzed by applying the mass balance and the first law of thermodynamics (energy balance). The mass balance for the steady state condition is shown in Equation 2

$$M_{in} - M_{out} = \Delta M_{system} \tag{1}$$

for steady state condition ΔM_{system} = 0, then

$$M_{in} = M_{out} \tag{2}$$

The first law of thermodynamics is shown as follows:

$$E_{in} - E_{out} = \Delta E_{system} \tag{3}$$

Furthermore, this combustion process occurs in an open system by applying the control volume. For steady flow (ΔE_{system} = 0), the first law of thermodynamics is stated as follows:

$$E_{in} = E_{out} \tag{4}$$

The components of inlet and outlet energies are heat, work, and mass flow. The equation then becomes:

$$Q_{in}+W_{in}+\Sigma\left(h+\frac{v^2}{2g}+gz\right)_{in} = Q_{out} + W_{out} + \Sigma\left(h+\frac{v^2}{2g}+gz\right)_{out} \tag{5}$$

By ignoring kinetic and potential energies, including work done and heat entering the system, the earlier stated equation becomes:

$$Q_{out} = (h_{in} - h_{out}) \tag{6}$$

During the combustion process, a change was detected in the internal energy. This includes chemical and sensible energies. Based on this, the combustion process consists of formation and sensible enthalpies, as shown in the following equation:

$$h = \bar{h}_f^0 + (\bar{h} - \bar{h}^\circ) \tag{7}$$

When the combustion process occurs adiabatically, the value of Q_{out} = 0. The equation is further stated as follows:

$$\sum N_{in}\left(\bar{h}_f^0 + \bar{h} - \bar{h}^\circ\right)_{in} = \sum N_{out}\left(\bar{h}_f^0 + \bar{h} - \bar{h}^\circ\right)_{out} \tag{8}$$

The flame's temperature and quantity of heat released is started to calculate based on the fuel composition that written on chemical reaction equation. The fuel used in this simulation is producer gas from palm oil shell gasification. Its constituents are shown in Table 1 with a gas heating value of 6.1 MJ/Nm^3.

Table 1. Fuel Composition

No	Species	% Vol
1	CO	22.55
2	H_2	8.35
3	CH_4	8.21
4	CO_2	14.1
5	O_2	1.32
6	N_2	45.47

The stoichiometric equation is obtained by applying mass conservation, which is stated as follows:

$$(0{,}2255\ CO + 0{,}0835\ H_2 + 0{,}0821\ CH_4 + 0{,}141\ CO_2 + 0{,}4547\ N_2 + 0{,}0132\ O_2 + 0{,}3055\ (O_2 + 3{,}76N_2) \longrightarrow 0{,}4486\ CO_2 + 0{,}2477\ H_2O + 1{,}6033\ N_2 \tag{9}$$

The mass and energy equation is applied using the earlier stated chemical reaction. The initial flame's temperature is used base on temperature of Nitrogen composition.

Simulations are carried out in accordance with varying excess air, namely 0%, 10%, 20%, 30%, 40%, and 50%. The mass flow of air and fuel is shown in Table 2. In the non-adiabatic simulation, the heat released from the burner gas is assumed to be relatively 70000 kJ/h (19.4 kW). This is within the range of the results obtained from the experiments carried out by [13-14]. Non-adiabatic simulations are performed using two methods. The first is to determine the effect of excess air on the fame's temperature at a constant heat value of 70000 kJ/h. The second is to determine the effect of an excess of air and the flame's temperature on the heat release rate. The simulation process is carried out based on a constant flame's temperature. A flow chart of the calculating procedure is shown in Figure 1.

Table 2. Parameter of Simulation

Excess of Air (%)	Air mass flow rate (kg/h)	Fuel mass flow rate (kg/h)
0	41.8169	27.1659
10	45.9984	27.1659
20	50.1799	27.1659
30	54.3615	27.1659
40	58.5430	27.1659

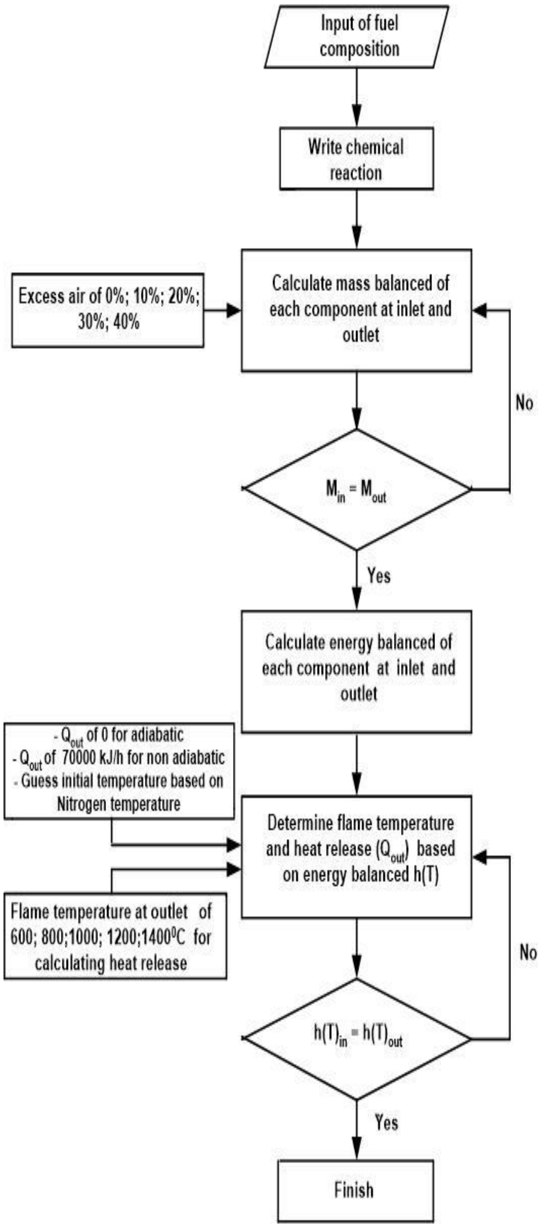

Figure 1. Flow Chart of Thermodynamic Model

3. Results and Discussion

3.1. The Thermodynamic Evaluation of Excess of Air on Flame Temperature of Producer Gas Combustion

Figures 2 and 3 show the effect of excess air on the flame's temperature under non-adiabatic and adiabatic conditions. Furthermore, excess air increases and reduces the flame temperature under both conditions. This is similar to the reports made by [15-18]. It is because an increase in excess air triggers the nitrogen content of the combustion product. This further absorbs the heat from the combustion process, reducing the flame temperature. In non-adiabatic conditions, with the heat released at 70000 kJ/h, the maximum flame temperature is 986.68^{0}C with excess air at 0%. Each increase in excess air at 10^{0}C reduces the temperature by 40 to 43^{o}C. Meanwhile, in adiabatic conditions, the maximum flame temperature is 1725^{0}C at excess air of 0%. Each increase in excess air at 10^{0}C reduces the temperature by 60 to 78^{o}C.

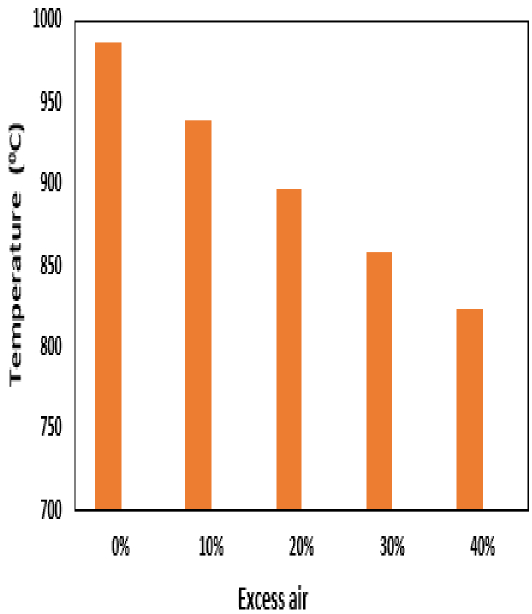

Figure 2. The Influence of Excess of Air to Non-adiabatic Flame Temperature

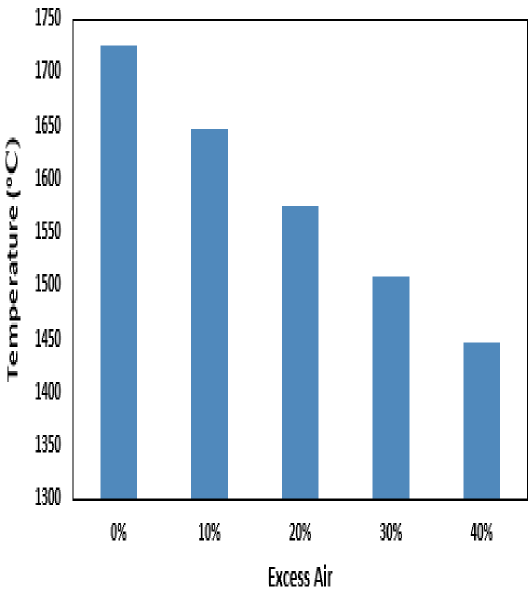

Figure 3. The Influence of Excess of Air to Adiabatic Flame Temperature

3.2. The Thermodynamic Evaluation of Flame Temperature on The Heat Release in Various of Excess Air

Figure 4 shows the effect of the flame temperature on the quantity of heat released from the combustion chamber at varying excess air. An increase in the flame temperature reduces the amount of heat released for various excess air. It is evident that for each flame temperature, the maximum quantity of heat released occurs at the lowest excess of air. This is because the energy from the combustion process is the least absorbed by excess air. The flame's temperature is within the range of 600 to 800^{0}C. The heat released during the process is 72490 kJ/h to 103800 kJ/h (20.1 kW to 28.8 kW). Similar studies reported a similar temperature range for the combustion of producer gas [19-20]. Excess air at 40% with a flame temperature of 1400^{0}C proved that the heat released is close to zero. However, in this circumstance, the adiabatic flame temperature for the excess air of 40% is 1447.78^{0}C.

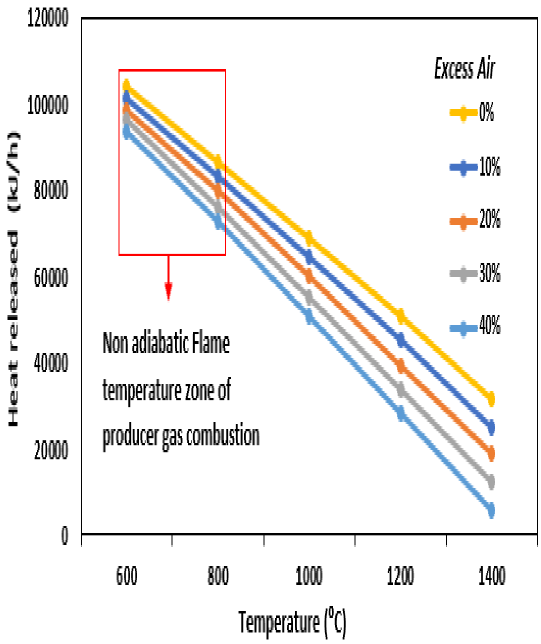

Figure 4. The Influence of Flame Temperature to Heat Release on Variation of Excess of Air

3.3. The Comparation of Thermodynamic Simulation and Experimental

Figure 5 compares the experimental by [21] and simulation processes carried out in adiabatic conditions. Punnarapong [21] reported that the experimental adiabatic flame temperatures obtained were 1260^{0}C. Meanwhile, This simulation resulted were 1725^{0}C,The differences is due to the difference in the producer gas composition, which uses an average heating value of 5.2 MJ/Nm^3 and 6.1 MJ/Nm^3 during the experimental and simulation processes, respectively. The simulation method adopted was also referenced [7, 22-25]. To remedy this situation, the future study must equalize the operating parameters and improve both the simulation and experimental aspects.

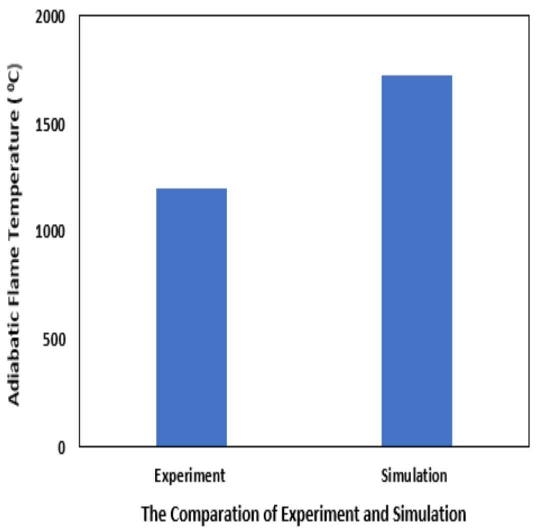

Figure 5. The Comparison of simulation and Experimental [21]

4. Conclusion

An increase in excess air causes a reduction in both adiabatic and non-adiabatic temperatures of biomass producer gas. The maximum and minimum adiabatic flame temperature are 1725.43^{0}C and 1447.78^{0}C at 0% and 40% excess air, respectively. The greater the resulting non-adiabatic temperature, the lesser the heat released during the combustion process for the excess air constant. The non-adiabatic flame temperature is usually 600 to 800^{0}C, while the quantity of heat released is within 20.1 kW to 28.8 kW, and the excess air is approximately 0 to 40%.

References

[1]. Gomez H.O, Calleja M.C, Fernandez L.A, Kiedrzynska A, Lewtak R, Application of the CFD simulation to the evaluation of natural gas replacement by syngas in burners of the ceramic sector, Energy, 2019;185; 15-27.

[2]. Sami. S, Gasification, Producer Gas and Syngas, *Agriculture and Natural Resources*.

[3]. Masum B.M, Kalam M.A, Masjuki H.H, Palash S.M, Study on the effect of adiabatic flame temperature on NOx formation using ethanol gasoline blend in SI Engine, *Advanced Materials Research*, 2013; 781-784; 2471-2475.

[4]. Gaultier E.V, Shengals A.A, Tikhonov A.S, Klyavin O.I, Procedure for simulation of combustion in the burner device of the low emission combustion chamber, WSEAS Transaction on System and Control, 2020,15, 468-476.

[5]. Vitázek I, Klúčik J, Uhrinová D, Mikulová Z, Mojžiš M, Thermodynamics of combustion gases from biogas, Res. Agr. Eng, 2016; 62; Special Issue: S8–S13.

[6]. Caligiuri C, Renzi M. Baratieri M, Development of a 0D Thermodynamics Combustion Simulation Tool for a Dual Fuel Diesel – Producer Gas Engine, Proceedings of the European Combustion Meeting 2017; 8th European Combustion Meeting. 2017.

[7]. Larionov V.M, Saifullin E. R, Konstantinov N. V, Nazarychev S. A, Malakhov A. O, Yunusova E. A, The influence of hydrogen concentration on the flame temperature of a mixture of methane-hydrogen fuel with air, Journal of Physics: Conf. Series, 1328 012048, 2019.

[8]. Rahim F, Far K. E, Parsinejad F, Andrews R. J, Metghalchi H, A Thermodynamic Model to Calculate Burning Speed of Methane-Air-Diluent Mixtures, Int. J. of Thermodynamics, 2008; 11(4); 151-160.

[9]. Saghaei M, Mohammadi A, Thermodynamic simulation of porous-medium combustion chamber under diesel engine-like conditions, Applied Thermal Engineering, 2019; 153; 306–315.

[10]. Hariram V, Bharathwaaj R, Application of zero-dimensional thermodynamic model for predicting combustion parameters of CI engine fuelled with biodiesel-diesel blends, Alexandria Engineering Journal, 2016; 55, 3345-3354.

[11]. Feng Y, Wang H, Gao R, Zhu Y, A Zero-Dimensional Mixing Controlled Combustion Model for Real Time Performance Simulation of Marine Two-Stroke Diesel Engines, Energies, 2019; 12; 1-19.

[12]. Papagiannakis R.G, Zannis T.C, Thermodynamic analysis of combustion and pollutants formation in a wood-gas spark-ignited

heavy-duty engine, International Journal of Hydrogen Energy, 2013; 38 (28); 12446-12464.

[13]. Surjosatyo A, Priambodho Y. D, Investigation of Gas Swirl Burner Characteristic on Biomass Gasification System Using Combustion Unit Equipment (CUE), Jurnal Mekanikal, 2011; 33; 15-31.

[14]. Lee Y.P, Delichatsios M. A, Silcock G.W.H, Heat Flux Distribution and Flame Shapes on the Inert Façade, Fire Safety Science Proceedings of Ninth International Symposium, 2008, pp. 193-204.

[15]. Cala O. M, Meriño L, Kafarov V, Saavedra J, Evaluation of combustion models for determination of refinery furnaces efficiency, *Ingeniare. Revista chilena de ingeniería*, 2015; 23 (3); 429-438.

[16]. Lou H. H, Chen D, Martin C. B, Li X, Li K, Vaid H, Singh K. D, Gangadharan P, Optimal Reduction of the C1−C3 Combustion Mechanism for the Simulation of Flaring, Ind. Eng. Chem. Res. 2012; 51 (39); 12697–12705.

[17]. Glaude P.A, Sirjean B, Fournet R, Bounaceur R, Vierling M, Montagne P, Molière M, Combustion and oxidation kinetics of alternative gas turbines fuels, Turbine Technical Conference and Exposition 2014 (pp 1-9).

[18]. Law C.K, Makino A, Lu T.F, On the off-stoichiometric peaking of adiabatic flame temperature, Combustion and Flame, 2006; 145; 808–819.

[19]. Surjosatyo A, Vidian F, Tar Content Evaluation of Produced Gas in Downdraft Biomass Gasifier, Iranica Journal of Energy & Environment, 2012; 3(3); 210-212.

[20]. Panwar N.L, Salvi B.L, Reddy V.S, Performance evaluation of producer gas burner for industrial application, Biomass and Bioenergy, 2011; 35(3); 1373-1377.

[21]. Punnarapong P, Sucharitakul T, Tippayawong N, Performance evaluation of premixed burner fueled with biomass derived producer gas, Case Studies in Thermal Engineering, 2017; 9; 40–46.

[22]. Mondal P, Ghosh S, Thermodynamic Performance Assessment of a Biogasification Based Small-scale Combined Cogeneration Plant Employing Indirectly Heated Gas Turbine, International Journal of Renewable Energy Research, 2015; 5(2); 354-366.

[23]. Hao X, Zhang G, Chen Y, Zhou J, Thermodynamic Model and Numerical Simulation of Single-Shaft Microturbine Performance, HVAC Technologies for Energy Efficiency, 2006; IV-10-; 1-76

[24]. Durante A, Pena-Vergara G, Curto-Risso P.L, Medina A , Calvo Hernández A.C, Thermodynamic simulation of a multi-step externally fired gas turbine powered by biomass, Energy Conversion and Management, 2017; 140; 182–191.

[25]. James R.V, Hart H.I, Nko B, Thermodynamic and Environmental Assessment of Gas Flaring in the Niger Delta Region of Nigeria. Journal of Power and Energy Engineering, 2018, 6, 39-56.

Nomenclature

E_{in}	-	Total Energy Entering the System
E_{out}	-	Total Energy Leaving the System
ΔE_{system}	-	Change in the Total Energy of the System
Q_{in}	-	Energy Entering the System by Heat
Q_{out}	-	Energy Leaving the System by Heat
$\dot{W}_{in}$	-	Energy Entering the System by Work
$\dot{W}_{out}$	-	Energy Leaving the System by Work
m_{in}	-	Mass Entering the System
m_{out}	-	Mass Entering the System
h	-	Enthalpy
h_{in}	-	Enthalpy Entering the System

h_{out} - Enthalpy Leaving The System

$\bar{h}_f^0$ - Enthalpy Formation at the Standard Reference Temperature

$\bar{h}$ - Enthalpy at Specific State Temperature

$\bar{h}^\circ$ - Enthalpy at the Standard Reference Temperature

N_{out} - Mole Entering the System

N_{in} - Mole Entering the System

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