Solar driven biomass gasification: Sri Lankan context

P. R. K. Aluthge[1], D. V. Sanjeewa[1], B. N. L. Senarathna[1], Dr.D. Gunarathna[1]
[1)], Department of Chemical and Process Engineering, University of Moratuwa, Moratuwa, Sri Lanka

ABSTRACT - Solar driven biomass gasification is an energy conservation process which produce combustible gas called syngas which consists of Hydrogen, Carbon dioxide, Carbon Monoxide and Methane. Product gas has higher energy density and handling is easy for combustion purposes in industrial applications. By replacing biomass with syngas, combustion process is to be more economical with high efficiency. In this process, concentrated solar energy is used to heat up biomass in the reactor call gasifier. Because of that, process saves much biomass and it is sophisticated solution for deficiency of biomass fuel. As main objective, feasibility of the solar driven biomass gasification process for Sri Lanka was analyzed.

KEY WORDS: Biomass, gasification, solar

INTRODUCTION

Biomass has become one of the major renewable energy source in the world and the contribution of biomass to the world energy consumption is rapidly growing. Biomass gasification is a process that converts carbonaceous materials at high temperature into syngas (Ciferno & Marano, 2002, June). Composition and the quality of the syngas produced by biomass gasification depend on several factors such as operating temperature and pressure of the gasifier, biomass type and steam/biomass ratio (Drift, 2015).

Generally, biomass gasification reactions are endothermic. Therefore, part of the biomass is combusted to supply the required energy. We are interested in saving the amount of biomass that is combusted to supply heat by taking heat from solar radiation. In this research, we have analyzed the feasibility of biomass gasification in Sri Lankan context. Objective of the research were follows,

- Simulate the biomass gasification process
- Determine the optimum temperature,
  pressure and steam biomass ratio
- Simulate the solar irradiation in Sri Lanka
- Determine the feasibility of process foe Sri Lankan context

METHODOLOGY

Aspen plus simulation model was developed for biomass gasification process and results taken for optimum temperature, optimum pressure and optimum steam biomass ratio. Here we used Rubber, Albesia and Pinus woods as biomass. Because, they are mostly available wood types in Sri Lanka. Thus, MATLAB Simulink model developed to determine the solar irradiation in Sri Lanka and amount monthly average solar irradiation are included.

2.1 Aspen plus simulation model for biomass gasification

In Aspen Plus, there is no particular gasifier model designed for biomass gasification, therefore to model a fluidized-bed gasifier, whole process is separated into different blocks that can be simulated with the existing models provided by Aspen Plus.

Decomposition reactor is used to decompose the biomass into its conventional components such as such as C, H_2, O_2, Cl_2, N_2, S. Separator spilt a portion of char into the combustor and rest is send to the gasifier reactor. Combustion reactor is used to combustion the chat to provide merge heat for the gasification reaction. Gasifier is used for modeling the gasification reaction. It produces syngas. (Eikeland)

2.2 Determination of solar irradiation of Sri Lanka

The consumption of the heat for the biomass decomposition is nearly 1/4 of the total heat produced after the gasification process. Here we consider about use the solar energy for satisfy that energy consumption. However, amount of solar energy is limited (Davies & Dey, 2013). Because, it requires large amount of solar energy collectors and large capital cost. Therefore, part of energy requirement is supplied by solar energy and rest is supplied by char combustion.

Using MATLAB Simulink model, daily average solar irradiation can be calculated. Using that data, monthly average solar irradiation can be determined. We consider about 100 m^2 solar concentrated system. Gained solar energy of the collector is changed daily. Therefore, we consider about monthly average solar irradiation.

RESULTS AND DISCUSSION

Analytical data of Albesia, Rubber and Pinus woods are used for the aspen model. Energy requirement for gasification, solar energy availability for each month and percentage energy savings are calculated. Here we used optimum operating conditions that calculated above.

When Pinus is used as fuel, solar energy replaces about 20 to 23 % of energy requirement. When Albesia is used as a fuel, about 25% of energy can be saved using solar energy. Solar energy replaces about 20% to 23 % of energy requirement for Rubber wood.

4. CONCLUSION

To determine the syngas properties and gasification condition, proximate and ultimate analysis of Rubber, Albisia and Pinus were taken according to the literature review data. By simulation for all above biomass of 10kg feeding, Optimum temperature is 800^0C, Optimum pressure is 1 bar and Optimum steam biomass ratio is 0.45.

Syngas produced from the Albesia has lowest external energy requirement 60446.5 W and syngas composition is 60% CO, 5.9% H_2, 0.4 CH_4 for these optimum values.

According to the solar simulation model, solar irradiation was not constant over the year; minimum irradiation was 755.44 Wm^{-2}/day in December month and maximum was 891.28 Wm^{-2}/day in April month.

The gasification system and solar irradiation system were combined by solar concentrators, which are Fresnel lenses with 15% efficiency. For these type concentrators with 100 m^2, external energy requirement for 10 kg of biomass, additional to the solar energy was calculated for all months.

REFERENCES

Davies a, P., & Dey b, P. (2013). *Design of a novel solar thermal collector using a multi-criteria.* UK: elsevier.

Ciferno, J., & Marano, J. (2002, June). *Benchmarking Biomass Gasification Technologies for* U.S: U.S. Department of Energy.

Drift, B. (2015). C*hallenges in biomass gasification.*

M.S. Eikeland, R. T. (n.d.). *Aspen Plus Simulation of Biomass Gasification with known.* Norway: Department of Process, Energy and Environmental Technology, Telemark University College, Norway.