Advances in Engineering Research, volume 202
Proceedings of the International Conference on Sustainable Biomass (ICSB 2019)

Numerical Analysis with Simulations for Biomass Gasification

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ABSTRACT
The biomass gasification is one of the largest chemical transformation procedures of heat effectiveness. Numerical simulation is a significant instrument for studying biomass gasification. The numerical simulation of biomass gasification technologies at work and overseas is evaluated in this article. At the same moment, two commercial analysis applications (Aspen Plus and Fluent) applied in chemical processes were primarily implemented, both of which be there investigated and contrasted. In conclusion, it was suggested that is a better simulation outcome for biomass gasification could be obtained by implementing the Aspen Plus in combination with Fluent.

Keywords: *Simulation, Aspen Plus, Gasification, Biomass, Numerical, Fluent*

1. INTRODUCTION

Biomass converting technology translates energy into more convenient and in some respects or implies cleaner fuel or other oil products [1]–[3]. It primarily includes direct burning, methane fermenting, gasification, alcohol fuel, liquefied pyrolysis, ancillary liquidized and organic fuel technologies, etc. [4]–[6]. Biomass gasification process is by using oxidizing material such as oxygenated as a gasification and creates the biomass carbon into a combustible fluid. First, the biomass pyrolysis in a steam turbine, then the manufacturing gas taking part in either the oxygen-reduction reaction in the area of oxygen and reducing. The heat production from the oxidization reaction would provide the fuel for the drying, pyrolysis as well as the decreased response of biomass. Eventually, after cleaning tar and purifying? The primary structure of fuel gas is H2, CO, CH4 and then a small number of unsaturated hydrocarbons CnHm. This technology might have altered the type of biomass, enhanced energy production effectiveness, and gained highest-grade energy [2], [7], [8].

Numerical simulations included in computing systems can help to solve various technical and physical problems. Moreover, it can also be used for various natural phenomenon problems by performing numerical calculations and motions that can display images. The numerical simulations are easier and widely used in various fields compared to the use of experimental methods. Numerical simulations are widely used such as combustion temperatures, mechanical processes, hydrogeology, engine combustion, heat generation, etc. The numerical simulation process can predict the results of the experiment with the help of appropriate software. This simulation method can save time, consume labour, save money and use it very easily. Gasification of biomass is a very complex chemical and thermal process. This process must involve flow, phenomena in mass transfer, various chemical reactions and heat transfer. Therefore, the gasification process is not enough to be studied just by relying on experiments. A numerical simulation is a complementary tool that can accelerate or simplify the application and development of biomass gasification technology. Thus, complex problems such as chemical and thermal processes can be carried out in the presence of this numerical simulation software.

2. GASIFICATION MECHANISM

The pyrolysis and gasification of biomass method can be divided into the following four phases [9], [10]. The temperature in the draining area is almost 50-150oC. Free moisture becomes the gas stage of development and also the biomass is converted into dry material.

2.1 *PYROLYSIS PROCESS*

The pyrolysis of biomass was started at temperatures above 160oC. During the phase of pyrolysis, the volatile matter was released from the dry biomass. The common product of pyrolysis is C, H2, CO, CO2 and methane, coal like material as well as another hydrocarbon. The method can generally be described as follows with the chemical response equation: CHxOy = n1C + n2H2 + n3H2O + n4CO + n5CO2 + n6CH4. Throughout the equation, the formula CHxOy is the distinctive molecular model of biomass, and n1 to n6 is the standard of equilibrium determined by particular circumstances of gasification [11].

2.2 *OXIDATION REACTION*

The oxidation area temperature is between 1000ºC and 1200ºC. The response heat generated in this area may provide heat to washing biomass, pyrolysis, and decrease. The main chemical process in the oxidation area is as follows: $C + O_2 \rightarrow CO_2 + 388.53KJ$, $2C + O_2 \rightarrow 2CO + 219.31KJ$, $2CO + O_2 \rightarrow 2CO_2 + 556.91K$, $2H_2 + O_2 \rightarrow 2H_2O + 478.64KJ$ and $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 878.32KJ$.

2.3 *REDUCTION REACTION*

Even though the contraction response is hydrophilic, the temperature is smaller accordingly, roughly 600ºC to 900ºC.When the process of biomass gasification is simulated, and those other areas are strictly separated without considering the interlocking among them. This is among the factors that lead to mistakes between measured and testing outcomes. The chemical process in the area of decrease primarily involves:

$C + CO_2 \rightarrow 2CO - 168.41KJ$, $2H_2O + C \rightarrow CO_2 + 2H_2 - 89.15KJ$,

$H_2O + C \rightarrow CO + H_2 - 129.69KJ$,

$H_2O + CO \rightarrow CO_2 + H_2 - 40.11KJ$, $3H_2 + CO \rightarrow CH_2O - 249.14KJ$.

3. CURRENT STATE OF NUMERICAL SIMULATION ON GASIFICATION OF BIOMASS

The software has now been developed with various type, all of this software can be used to simulate biomass gasification especially for HSC stoichiometric calculations. Moreover, it can also be used to simulate chemical flow in general on a large scale. Such software is like Aspen Plus, Fluent for computational fluid dynamics, etc.

3.1 *DOMESTIC RESEARCHES AT PRESENT*

Many researchers have done a lot of research on biomass gasification technology. The iinvestigations of regarding biomass combustion conducted at the Chemical Engineering Laboratory of Syiah Kuala University, Banda Aceh; where the numerical simulations with gasification technology have shown very promising results. The use of simulated HSC reactors and chemical models for thermodynamic balance and the pyrolysis process of palm oil waste has been carried out[12]. CO and H_2 emissions from the results of the investigation carried out an increase with increasing pyrolysis temperature. However, if the temperature exceeds of 900ºC the results are not stable. The main components of gases such as CO_2, CO, H_2O, H_2, CH_4 and coke can be considered by HSC. While, for the small amounts of gas such as C_2H_6, C_2H_2, C_3H_8 and so on it cannot be considered. Thus, the use of PSR introduced for the dynamic mechanism of the hydrocarbon combustion reaction can simulate the pyrolysis of biomass [13], [14]. The Gasification experiments by using three types of biomass such as peanut shells, grass stalks, and chips in the normal atmosphere using air have also have been carried out[15]–[17]. Furthermore, biomass gasification is modelled and developed using Aspen Plus based on minimum energy used for simulation of the effects of gas component factors. Significantly, the temperature does not affect the speed of gas production. Increased of H_2 content when the ratio of the velocity of steam to biomass input increases when air vapour from the gasification agent functions. The H_2 content and calorific value can increase by 55% and 11MJ/m^3 respectively when steam is used as a gasification agent.

Numerical simulation methods with computer aids that are increasingly developing now have helped various problems such as converting thermochemistry to computational fluid dynamics (CFD).The 3D model built can be used for the biomass gasification kinetics process with Fluent [18].While, the development of a CFD model of steam or biomass gasification functions for the pyrolysis and hydrogen processes. The flows of regulated fluid mathematical equations, as well as the mass of chemical reactions and heat transfer, are considered with thermochemical systems. In addition, turbulence sub-models, individual processes, radiation, etc. are also included. The iinvestigation of temperature and product distribution that comes from various conditions when the operation is carried out [19]. The experiments was conducted by modelling biomass pyrolysis have also been developed by [20].The development of this biomass gasification simulation results can be used as an initial condition for the gasification input. Fluent packages can simulated the cyclone gasifier models. The combustion speed using wood powder around 19.4 kg/hour is simulated with different ratios of 0.21, 0.24, 0.27, 0.31 and 0.33. The outcomes of this simulation show that the

gas concentration and axial temperature trend of the gasifier correspond to the experimental data.

3.2 *CURRENT RESEARCH ABROAD*

Some previous researchers have applied numerical simulations for energy in various industries. The simulation gasification process of wood powder in an atmospheric area with a fluidized bed using Aspen plus has been carried out by[21], [22]. The simulation was conducted in order to analyze the sensitivity of the different parameters changes. The simulations showed that at the beginning the air heating gasification efficiency increased. While, the gasifier pressure slightly affects the gasification efficiency. The gasification model in circulating fluidized beds using Aspen Plus software has also been developed by [23], [24]. The purpose of this development is to be able to estimate the performance of the gasifier during each operation. This modelling is based on the principle of Gibbs-free minimum energy and the test data corrected based on the equilibrium limit. The gasification reaction is controlled by temperature. The Aspen Plus software works very well for predicting gas composition parameters, calorific value, and conversion efficiency. CO and H2 emissions increase when preheating of the air. The use of four reactor models at Aspen Plus and the default FORTRAN subroutine used for the gasification process in simulating reaction kinetics and hydrodynamics [25], [26]. The simulation result shows that the rate of carbon conversion and H2 emissions has increased. While, the rate of carbon conversion and CO2 emissions are directly proportional to equivalent air.

The gasification of Miscanthus wood and eucalyptus and simulated pyrolysis for raw materials in fluidized beds has been provided by [27]. The purpouse of this simulation is to find out the traces of biomass granules in the gasifier distributed for pressure and temperature in the furnace. The simulation results shows the pressure and temperature distribution. The fluidized gasifier is simulated by pyrolysis and wood gasification made by 2D mathematical modelling [28], [29].The ggasification factors such as thickness, biomass combustion speed and thermodynamic initial conditions are very influential during simulation analysis. The thermal decomposition of sawdust in the draft gasifier bed has been simulated by [30]. In the modelled simulation, the gasifier use sawdust as a sample in order to evaluate the relation between mass of the solid-gas phase and heat transfer. Simulations using large-scale computation such as D. Fletcher, CFX4, etc. for the sawdust decomposition gasification process at entrained have been carried out [31] . The method with κ - ε was chosen to consider turbulence and the rotate flow of sawdust particles showing that the gasifier appears very complex. The modelling results are made that this reference is very well used for gasifier optimization designs. While, the process of simulating biomass gasification with steam air in the circulation of fluidized bed can be carried out with the principle of two-phase flow. The modelling is only to consider equilibrium with energy quality. However, it can also be used to predict the rate of gas products using the minimum Gibbs free energy method [32].

4. ASPEN PLUS AND FLUENT COMPARATIVE ANALYSIS

There are two commonly software use in the large-scale business, i.e Aspen Plus flow sheet simulation software and fluent computational fluid dynamics software for numerical simulation technology implementation in biomass gasification. There are several variations among them to model the gasification operation, such as simulation concept, simulation framework, date entry and performance, and so on.

Aspen Plus ' primary simulation concept is to use the fundamental ownership correlation of systemic constituent (weight and power balance, velocity coefficient, response).Transfer of mass and temperature as well as all kinds of stability connection) to simulate or calculate the flow-rate, composition and property of a material, therefore optimizing the situation of reactor activity and composition etc. The ddifferent unit operating models can be used to simulate the separate procedures according to the property of the thermo chemistry transformation method happened in the gasifier. For instance, the yield block used to simulate the biomass pyrolysis method. The Gibbs block, which is located on the concept of Gibbs energy maximization, can be used to simulate the process of oxidation-reduction. Otherwise, all types of blocks will be linked together and with material-flow, heat-flow or job streams to form a block diagram shown in Figure 1.Compared for Aspen Plus, Fluent is by using Gambit to first create the gasifier's three-dimensional spatial model. Then the design is messed as well as its output and input were identified. The mesh paper is read into Fluent and afterwards appropriate models are selected such as turbulence designs, fuel-solid two-phase flow designs, P-1 burning design and many more. Suddenly, the iterative calculation is processed and also the response is received. The computation phase use Fluent is shown in Figure 2.

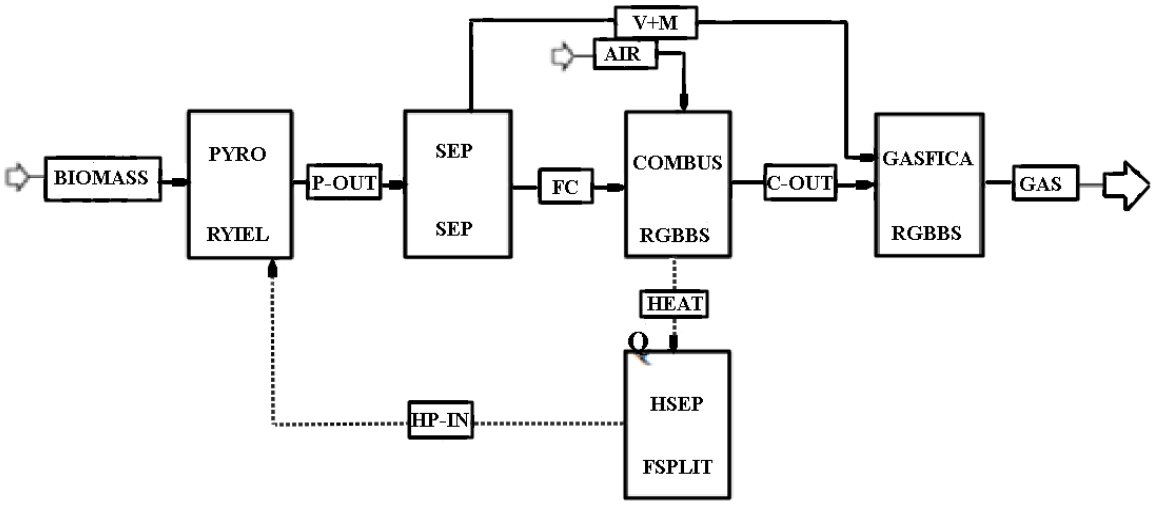

Figure 1 Flow sheet of biomass pyrolysis and gasification

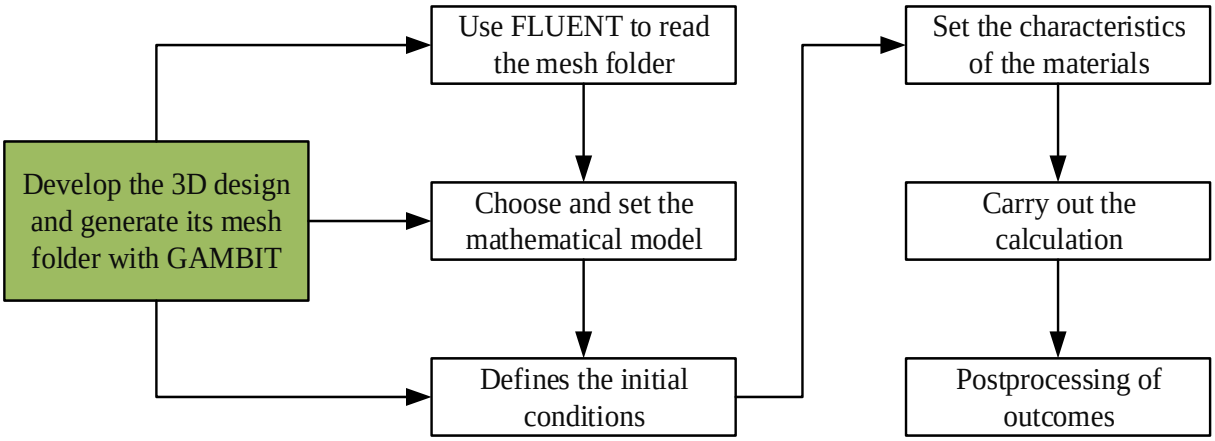

Figure 2 Simulation step using Aspen Plus and Fluent

Before simulating biomass gasification using dual software, the proximate and elemental observation of the raw material is performed since there is no raw material data in the two software database. The proximate and elementary assessment describes the raw material. On this stage, the two software are similar. However, in Aspen Plus, biomass is described as an unconventional element, so the information from the proximity and elementary evaluation could be input straight. The other gas parts generated in the reaction cycle are described as standard parts and can be discovered in the library. The non-premixed burning method is used to describe the biomass to Fluent compared to Aspen Plus. The model is more complicated. Meanwhile, because the raw materials granule is much larger than coal fines, its gasification process simulation is more complicated than coal fines.

For Aspen Plus, the result of the simulated universe is displayed as a table. The concentration of each element can be displayed in the table, including the output components for each block. However, the result for Fluent is each component's concentration cloud map. The post-processing programming Tecplot and Origin should be used to process it. In addition, the specifics of the biomass heat transfer condition, granule in the gasifier, temp distribution, and pressure and gas composition could be reflected with both the cloud graph, which is suitable to the analysis of that same gasification process.

5. CONCLUSION

The Aspen Plus and Fluent software in this study were used to simulate biomass gasification. The hypothesis of using this two software is proposed to process biomass gasification and pyrolysis. The block on the Aspen Plus software, the simulation process has become simpler. Therefore, the use of pyrolysis process is very difficult and complex to learn from the reaction equation. The completion of the simulation using the fluent software is very uncomfortable for the pyrolysis process. However, with the Ryield Aspen Plus in the biomass pyrolysis simulation process is an alternative to Fluent. The results obtained from the Ryield block can be used as initial conditions which can be incorporated into Fluent to process the remaining oxidized reduction reactions. Thus, the gas component at the end of the process can be obtained. In addition, the temperature

distribution and pressure into the gasifier can be more perfect.

AUTHORS' CONTRIBUTIONS

The first author of this article was drafter, reviewer and grand owner. While the second and third writers have passed in checking the language and as members of the first author. The fourth author is the analysis and improvement of the article. The fifth author is an analysis and data collection from various kinds of literature. Meanwhile, the sixth and seventh and ninth authors contributed assistants to the funding and laboratory financing. The eighth writer served as an assistant and assisted in collecting the data required for this work.

ACKNOWLEDGMENTS

The KEMENRISTEK DIKTI and Universitas Syiah Kuala, Research institutions and community service with the contract number of (20/UN11.2/PP/PNBP/SP3/2019), supported this research.

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