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Abstract. This study conducted the gasification simulation of palm starch with focuses on Synthetic gas (Syngas) performance by using the Minimum Energy Gibbs method. The palm starch waste was changed as the fifth RDF (Refuse Derived Fuel) by palletisation process. The investigation of palm starch waste RDF in tekMIRA laboratory show that the palm starch waste has Carbon (C) 38.74%, Sulphur (S) 0.07%, Hydrogen (H2) 6.41%, Nitrogen (N2) 0.26%, and Oxygen (O2) 51.25%. This the data was used as the input parameters for the gasification simulation mixed with oxygen and moisture in air dried. The simulation results shown that palm starch waste could produce syngas 119.241 kg/hr (CO, CO\textsubscript{2}, H\textsubscript{2}, CH\textsubscript{4}) with good efficiency is 94%. Therefore, the palm starch has good potential waste of energy as fuel gas (syngas) through the palletization process and gasification.

1. Introduction
Waste has become a global problem, almost all countries in the world suffered serious impacts caused by garbage. The data from the Ministry of Environment and forestry show that every year Indonesia produces the 65.000.000 ton of waste. This data is waste data of municipal waste. On the other hand, in Indonesia has the home industry waste that became the new problem. This due to the home industry waste has become a source of water and soil pollution in central of home industry in Indonesia. The environmental problem because of home industry waste was found in central of Sohun noodles industry, Bendo Village, Klaten city. This industry used the palm starch as raw material. The solid wastes of palm starch became the source of soil and water pollution in Klaten. The latest data shows that there is currently about 137 home industry of palm starch with the estimation of solid waste 50 ton/day [1]. Therefore, Bendo village produced solid waste more than 18,250 tons/year [2]. Based on the quantity and potential solid waste of palm starch, gasification process could be developed. Hosseini and Wahid [3] divide the waste treatment method in the thermochemical process into 5 type i.e. direct combustion, pyrolysis, gasification, liquefaction, and co-firing. Gasification is a process of converting solid fuel thermochemical into gas. In the gasification process, the required amount of air is lower than that used in the endothermic combustion process. The solid waste of palm starch can be processed into solid fuel...
in gasification process [4]. Nanda and team [5] investigate this study conducted the gasification simulation of palm starch waste with focuses on Synthetic gas (Syngas) performance by using the Energy Gibbs Minimum method. Hosseini and Wahid [3] also analyses the syngas production by vapour concentration. The optimize biomass was conducted by palletisation process named pellet RDF (Refuse Derived Fuel).

RDF with low quality occur at steam temperature 400°C, pressure of 250 lb / in2,and a high steam production of 4.2 tons/ton refuse, compared MSW steam temperature 620°C, pressure of 400 lb/ in2, and a high steam production of 3.6 tons / ton refuse [6]. RDF provides high performance in converting biomass into syngas energy. According to Liu [7]. RDF is flammable garbage and separated from the hard burned through the enumeration process, sieving and air classification. RDF pellets have been studied fundamentally by Nezhaad [4] as a low-emission alternative fuels and energy optimization approach the non-biomass fuels other.

Estimate the potential energy of fuel prefer using simulation by modelling process. Ghofar [8] from Central Institute of Technology and Energy Resources and Chemical industry Serpong regency, perform simulation analysis and estimation of gasifier with raw material coal in South Sumatra and South Kalimantan. Research use Aspen plus Software V.8.4 with thermodynamic equilibrium by Kishore and Ramanjaneyulu [9] conduct the same study, biomass gasification simulation using Aspen Plus can predict production Synthetic Gas (Syngas) optimally. Increased temperature improve the quality of Syngas production. Specific research help knowing the best choice according to industry needed.

Analysis of energy using innovative technologies provide relevant support data to energy generator. Software Innovative capable to predict energy performance as well as other indicators are needed to improve performance of systems or just comparing the right technology [10]. Doherty [11] has analyse of syngas production in a steam blown dual fluidised bed. Amount of steam give great influence in the process of converting biomass into syngas. Steam is able to accelerate the decomposition of biomass into syngas and accelerate reaching approach temperature (optimal temperature of syngas).

Currently, coal is still being excellent fuel for the company energy support. However, research shows biomass processed, can approach the energy produced by coal. Biomass has been through the process terification equaled coal energy with efficiency reached 88% [12]. In addition, the exhaust emissions (CO2) can be controlled and kept to a minimum. Software innovative capable to predict syngas production in order to reduce exhaust emissions [13]. Even the size of particles in the reactor can be investigated using Software innovative [7]. Innovative software also gives large influence to obtain optimization energy.

Software innovative able to calculate and analyse the potential for energy use energy formulas and parameters-parameter necessary. Each software also featured with variety of advanced features and levels accuracy. Simulation result can be used to predict the real technology approach. This study aims to determine the potential of palm waste energy in the form of RDF 5 in gasification process using innovative Software Aspen Plus V.8.8.

2. Methods

2.1. Input component
This modelling simulation use raw material (palm waste) in dry mass basis (adb = air dried basis) depend on ultimate analysis and proximate analysis results. Gasification input components are divided into three types, namely: Solid, Conventional and Nonconventional.
Table 1. Input parameter.

| ID | Type       | Name             | Formula |
|----|------------|------------------|---------|
| O₂ | Conventional | Oxygen           | O₂      |
| CO | Conventional | Carbon Monoxide  | CO      |
| H₂ | Conventional | Hydrogen         | H₂      |
| CO₂| Conventional | Carbon Dioxide   | CO₂     |
| H₂O| Conventional | Water            | H₂O     |
| CH₄| Conventional | Methane          | CH₄     |
| N₂ | Conventional | Nitrogen         | N₂      |
| H₂S| Conventional | Hydrogen Sulfide | H₂S     |
| C₆H₆| Conventional | Benzene          | C₆H₆    |
| C  | Solid      | Carbon Graphite  | C       |
| S  | Solid      | Sulfur           | S       |
| RDF| Non Conventional | …               | …       |
| Dry-RDF| Non Conventional | …               | …       |
| Char| Non Conventional | …               | …       |
| Ash NC| Non Conventional | …               | …       |

2.2. Energy Gibbs minimum

The analyse production of syngas through a scheme of energy Gibbs minimum calculations. Energy Gibbs assumed in minimum of oxidation and reduction reactions (Gasification). In this scheme, a stoichiometric reaction is not specified. Mathematic calculation needed to predict the amount of waste conversion into syngas. Aspen Plus is a software easy to calculate the energy Gibbs minimum. The tool of Aspen Plus calculate energy minimum in many kind of reactor.

![Energy Gibbs minimum](image)

Figure 1. Energy Gibbs minimum.

2.3. Properties

This research using IDEAL method, refer to the analysis proximate and ultimate analysis data. Calculation by using air dry basis result from tekMIRA laboratory, Bandung. See following result data.

Table 2. Ultimate and proximate analysis result.
### Analysis proximate

| Component         | Dry Basis | Unit   |
|-------------------|-----------|--------|
| Moisture          | 13.37     | %      |
| Ash               | 3.27      | %      |
| Volatile Matter   | 72.27     | %      |
| Carbon fixed      | 11.09     | %      |
| Caloric           | 3843      | Cal/gram |

### Analysis ultimate

| Element  | %       |        |
|----------|---------|--------|
| Carbon   | 38.74   | %      |
| Oxygen   | 51.25   | %      |
| Hydrogen | 6.41    | %      |
| Nitrogen | 0.26    | %      |
| Sulphur  | 0.07    | %      |

2.4. **Reactions**

Gasification is endodermal reaction process [4]. There are three main processes: RDF Drying, Pyrolysis and Char decomposition. RDF Drying is the process of drying the fuel (RDF) to reduce the water content of non-conventional material. The drying process also referred to separation process of solid fuel with water by oxidation. Pyrolysis is the process of structure decomposition of fuel with less oxygen while heating become gasses. This process happens start from 700°C temperature, and it would leave residual material called char, that consist of volatile, ash, and carbon.

3. **Data analysis**

Ultimate Data consist of 5 chemical elements, Carbon (C), Hydrogen (H2), Nitrogen (N2), Sulphur (S), and Oxygen (O2). Each biomass has different characteristics and amount percentage. Following diagram showed the percentage of view organic waste chemical contents. Carbon become one of potential contents in order to produce gas (syngas). Amount of chemical content influence the characteristic of syngas result, depend on quality. Type of gasifier influence the quality of syngas, fixed bed reactor advantage with less of chars.

![Simulation process](image)

**Figure 2. Simulation process.**

Experiment showed that carbon composition of palm waste 38.74% with H2 and O2 the most dominant element. Palm waste has the highest oxygen which indicate that it’s has good burning capability. Carbon and oxygen influence the amount of caloric value. Amount of N and S in the range of 0.00 to 2.40%, this shows good characteristic. Good biomass should content N and S no more than 13 %. Less of N and S increase the quality of syngas.

RDF feed entrance into reactor about 125 kg/hr assumed by the maximum capacity of real reactor. Decomposition RDF assumed completely burned in reactor, and all the chemical element was
decomposed. Running parameter refer to Novendra [14] by analyse using energy Gibbs minimum. The graph showed that ash decomposition start at 400°C indicate incompletely combustion process. The highest ash content about 0.896% occur at 1000°C. Less of carbon element become the reason of less ash decomposition element. This analyst giving evidence that palm starch waste has potential syngas energy to develop.

![Figure 3. Sensitivity result.](image)

Gasification take temperature between 400°C - 2000°C, and always showing good significant result. Output element of gasification process divided into three form: Ash, syngas, and others hydrocarbon. Pure palm starch waste able to produce 12,462 kg/hr syngas from 125 kg/hr mass flow feed, 98 % efficiency. The ash occur on temperature 1000°C. The graph shows insignificant gasses decomposition above to 1000°C temperature, on that amount the highest ash decomposition appear. Other hydrocarbon that occur to the modelling process is benzene (C6H6), but the amount too small to count. In the other side, moisture content has fluctuation amount refer to conversion phase chance occur

Volatile Decomposition Reaction [15]
Volatil + 0.437 O2 → 0.95 CO + 0.95 H2O + 0.014 N2

Carbon Reaction
C + 0.5O2 → CO
C + CO2 → 2CO
C + H2O → CO + H2
C + 2H2 → CH4
C + O2 → CO2

Oxidation
CO + H2O ↔ CO2 + H2

The most dominant composition in the RDF simulation is CO (Carbon Monoxide). CO increase significantly, as the increase of temperature. This increase followed by H2 (Hydrogen) although just a bit chance. On the other side the amount of CO2 and CH4 decreased significantly as the increase of temperature. It shows good performance depend on carbon emissions for environment. The cross-peak point of decomposition temperature in 625°C, this show the optimum temperature a fuel material decomposed. This point help operator to know the limit of Oxygen, Water content, and steam entrance to gasifier. We could control feeding process depend to get optimum energy. Following picture showing the graph result of syngas (CO, CO2, H, and CH4) decomposition. Graph showing a same trend line of Rio Nandra Novendra [14] and Bagus Rahman Fadhillah [16]
4. Conclusion
Based on the analysis, pure waste produce syngas about 124,426 kg/hr with calorific value of 3.843 kCal/gram. Syngas quantity production is 18171 tons per year, it’s comparable to the amount of electricity generated energy potential about 81 GW/year. The conclusion show that palm starch waste by RDF 5 has potential biomass energy to be develop.

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