HMI SIMULATION OF BIOGAS HANDLING OF GAS ENGINE SYSTEM

Effect of Temperature on Biohydrogen Production from Palm Oil Mill Effluent (POME) Fermentation

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Abstrak

Limbah minyak sawit seperti Palm Oil Mill Effluent (POME) dapat membahayakan lingkungan, karena POME masih mengandung senyawa organik dengan indikator COD dan BOD yang tinggi. Untuk menurunkan COD dan BOD, POME perlu diproses menjadi produk yang ramah lingkungan dan bermanfaat. Salah satu produknya adalah biogas, yang dapat digunakan sebagai bahan bakar untuk mesin gas untuk menghasilkan listrik. Biogas bisa menjadi alternatif pengganti bahan bakar diesel. Hasil penelitian menunjukkan bahwa terdapat beberapa kriteria kandungan gas pada biogas dari proses limbah POME yang dapat digunakan untuk memasok mesin gas. Untuk itu diperlukan desain Human Machine Interface (HMI) dari sistem pembersihan biogas seperti bioscrubber, dehumidifier, dan unit blower, yang menggunakan perangkat lunak instrumentasi dan kontrol yang disebut Laboratorium Instrumen Rekayasa Virtual Workbench (LabVIEW). LabVIEW adalah platform desain sistem dan lingkungan pengembangan untuk bahasa pemrograman visual dari National Instruments (NI), AS. Sistem instrumentasi dan kontrol dirancang untuk otomatisasi dengan bahasa pemrograman grafis. Interface pada LabVIEW membantu menyederhanakan fungsi kompleks seperti memvisualisasikan sistem kontrol dalam database besar dan mengoptimalkan pemrosesan sistem yang telah dirancang.

Kata kunci : biogas, gas engine, gas handling, labVIEW, POME (Palm Oil Mill Effluent)

Abstrak

Palm oil waste such as Palm Mill Effluent (POME) can endanger the environment, since POME still contains organic compounds with high COD and BOD. To reduce COD and BOD level, POME needs to be processed into environmentally friendly and useful products. One of the products is biogas, which can be used as fuel for gas engines to produce electricity. Biogas can be an alternative to diesel fuel. The results of the study indicated that the amount of biogas content from the new POME waste process can be used to supply gas engines. It is necessary to optimize the design of the Human Machine Interface (HMI) of the biogas cleaning system such as bioscrubber, dehumidifier, and blower units, using instrumentation and control software called Virtual Instrument Engineering Workbench Laboratory (LabVIEW). LabVIEW is a system design platform and development environment for visual programming languages from National Instruments (NI), USA. Instrumentation and control systems are designed for automation with graphic programming languages. The built-in interface helps simplify complex functions such as visualizing the control system in a large database and system-processing optimization that has been designed.

Kata kunci: biogas, gas engine, gas handling, labVIEW, POME (Palm Oil Mill Effluent)

1. INTRODUCTION

Palm Oil Mill Effluent (POME) can endanger the environment, since POME is categorized as a very high contaminating wastewater that contains a biochemical oxygen demand (BOD) of 25,000 mg and chemical oxygen demand (COD) of 69,500 mg (Najafpour, 2006). Since raw POME normally is discharged at 80–90 °C, therefore several researchers reported that treatment of POME can be done whether in mesophilic or thermophilic

conditions (Zhang, 2008 ; Mustapha, 2003).

Production of biogas from POME is widely known by using either anaerobic or aerobic digestion (Akobi, C. et al., 2016). The typical production process is as illustrated in Figure 1. Anaerobic digestion is a process where organic materials are decomposed in a condition where there is no oxygen present and useful biogas is produced, simultaneously. There are three stages of

reactions involved in anaerobic digestion and then, its potential of treating wastes while producing renewable energy become biogas. The first stage is hydrolysis, followed by acidogenesis and lastly methanogenesis (O-Thong, et al., 2016 ; Yuzir A. et al., 2012).

Gas engine is a spark ignition combustion that uses gas fuel, in which the mixture of air and gas is compressed and ignited with spark plug. Biogas could be an alternative fuel to replace biomass fuel and diesel. Biogas is typically composed of 50–75% methane (CH_4), 25–45%, carbon dioxide (CO_2), and trace amounts of other gases (Rahayu, dkk., 2015 ; Youngsukkasem, et al., 2013 ; Yunus, dkk., 2015). Gas engine usually used fossil fuel and now gas engine can use biogas from result POME processing.

Beforehand, POME is treated with some processes, one of which is separation process from unnecessary substances in the scrubber system, water content separation with biogas in the dehumidifier system, and distribution of gas by blower to gas engine by blower system and finally the gas engine will convert the mechanical energy to electrical energy. All of those processes starting from bioscrubber system until supplying biogas to a gas engine is called gas handling. Different blends of biogas with methane or propane and hydrogen additions are used according to the gas engine requirement which is presented in Table 1 (Gómez Montoya JP., et al., 2016).

Table 1. Typical composition of biogas

Compound	Formula	%
Methane	CH_4	50-75
Carbon Dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen Sulphide	H_2S	0-3
Oxygen	O_2	0-0

Figure 1. Typical Biogas Production Process

2. MATERIALS AND METHODS

The flow chart in Figure 2 explains biogas processing steps, especially on gas engines. A gas engine is a combustion process that converts biogas into electrical energy. The gas engine process starts when the gas and liquid separation results in the scrubber (SB-301), if it has not produced gas and there is still a lot of content in liquid form, it will be back to the CSTR tank and reprocessed continuously. But if the gas has been

produced, then it will be distributed to the dehumidifier and analysed by analytical transmitter whether the gas content is in accordance with specification of gas engine specifically designed for biogas. If the gas produced is not in accordance with the specification, the gas will be discarded and burned in flares, but if the gas produced is in accordance with the gas engine specification, then the blower will automatically turn on and open the gas channel so that it can be directly injected into the gas engine as fuel.

3. RESULTS AND DISCUSSION

3.1. HMI, Process System and Logic Diagram

In the bio-scrubber system as shown in Figure 3, gas from the SC2 valve enters the SC2 pipe and goes into the scrubbersystem. In scrubbersystem, the temperature and pH of the gas will be purified to reduce H_2S levels by flushing water which will convert H_2S to SO_4 , the temperature inside the scrubber must be in the range of $40\text{--}50^\circ\text{C}$ and pH between 6.5 - 7.5 after the methane gas is lowered the gas will enter the GH 21 and GH 22 pipes and then enter the gas holder.

In the dehumidifier system as shown in Figure 4, water content of biogas will be reduced through cooling process. Before entering gas dehumidifier, the biogas must meet requirements that H_2O must be below 80%, H_2S must be below 2000 ppm, CH_4 must be below 60% and the pH must be between 6.5 to 7.5.

Figure 3. HMI of Bio-scrubber System

Figure 4. HMI of Dehumidifier System

Gas handling system as shown in Figure 5 will direct the gas with reduced water content from dehumidifier to enter the gas holder. Gas in the gas holder will be pumped to the gas engine as fuel by the blower system. If the system detected excessive pressure in the gas holder, the valve (Valve 2) to flaring system will then open and direct

the gas to flaring system.

Figure 6 show that there are 5 while loops in the logic diagram, each while loops has different function in value change box the function for hyperlinking and launching the program simulation.

Figure 5. Gas Handling System

Figure 6. Logic diagram of Human Machine Interface Overview in LabVIEW

There are 4 led indicator in the dehumidifier logic diagram, the led indicator will show green colour if the gas from bio-scrubber is suitable with all the gas components requirement and the blower will purify the gas to remove the water content. Each gas components has specific requirement for content and level, it can be less than or higher than or in the midst of. Also, this logic diagram is using basic logic gates, especially AND. Because in the dehumidifier, if one gas component not suitable with the requirement, the blower will not activate and the gas will be directed back to the bio-rubber.

There are 2 LED indicator in the scrubber logic

diagram. The led indicator will show green and red colour, Green LEDs indicates that the biogas has entered the scrubber is in accordance with pH level requirement, if the pH level is appropriate then the LED will turn on the indicator to enter the gas engine. Red LED indicator indicates no biogas supply goes to the gas engine because the biogas will be looped once more into the scrubber for treatment repetition. If after treatment it does not show the pH level that matches gas engine specification, the biogas will be directed to flaring system and LED indicator on the flaring system will be turned on.

Figure 7. Logic Diagram of Dehumidifier

Figure 8. Logic Diagram of Bio ScrubberSystem

Many indicators are contained in the gas engine diagram block. Because in fact there are many parts of the engine that must be continuously monitored. The block diagram above is a simple example that has been made in part from the overall engine monitoring system. Part of the monitoring system is specific fuel consumption of the engine during operation. Another is input voltage from PLN which is displayed with aims to

compare the supply voltage of PLN and the voltage produced by the gas engine generator. Then there is frequency indicator, engine battery voltage, and of course the engine speed (RPM). In addition, there will be a graph of engine vibration, engine oil control, power factor (PF), gas engine display, blower display and other supporting displays that can be added as needed.

Figure 9. Logic Diagram Gas Engine

3.2. Instrument and Prototype

3.2.1. Gas Engine

Gas engine is a spark ignition combustion engine that uses gas fuel, in which the mixture of air and gas is compressed and ignited with spark plug.

Figure 10. 700 kW Gas Engine installed in PKS Tandun, PTPN 5 Riau

3.2.2. Arduino Mega

Arduino is a microcontroller which has an open source, so it's easy to access. Arduino Mega has 54 digital I/O pins and 16 analog inputs.

Figure 11. Arduino Mega

3.2.3. Pressure Transmitter (PT)

MPX 53DP is a pressure transmitter and pressure sensor. MPX 53DP has Operating Pressure of 7.25 PSI (50 Kpa) and max pressure 25.38 PSI (175 Kpa).

Figure 12. Pressure Transmitter (left) and Prototype Pressure Transmitter MPX 53DP

3.2.4. Temperature Transmitter (TT)

Thermocouple MAX6675 is one of thermometer and can use to measurement 0-800°C with Ktype temperature probe.

Figure 13. Temperature Transmitter (left) and Prototype Thermocouple MAX6675

3.2.5. Flow Transmitter (FT)

Flow sensor can use to measurement air flow or liquid flow. This sensor can measurement flow between 10 L/min.

Figure 14. Flow Transmitter (left) and prototype FT Flow sensor

3.2.6. Gas sensor

The MQ series of gas sensors use a small heater inside with an electro-chemical sensor. They are sensitive for a range of gasses and are used indoors at room temperature.

Figure 15. MQ Series Gas sensors

4. CONCLUSIONS

The experiment result showed that, process of POME can be processed to produce biogas fuel. Result of substances is 50–75% methane (CH_4), 25–45% carbon dioxide (CO_2), and trace amounts of other gases (Rahayu, dkk., 2015 ; Youngsukkasem, et al., 2013 ; Yunus, dkk., 2015). Methane (CH_4) will then become gas engine fuel.

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