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PRODUCTION OF BIOGAS BASED ON HUMAN FESSES AS AN ALTERNATIVE ENERGY FOR REMOTE AREAS APPLICATION

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ABSTRACT: The utilise of biogas for remote areas is a problem because it is challenging to supply hydrogen. Hence a study of the utilisation of human fesses as biogas raw material for biogas production is proposed. Due to high investment costs to build miniature power plants, modified gasoline engines are used as mini power plants even though it is a laboratory scale. Based on results, human fesses can be used as raw material for biogas production. Performance engine using biogas derived from human fesses is 9% different from LPG. The maximum efficiency of the biogas system is 32%, and that of the LPG is 41%.

KEY WORDS: Biogas, human fesses, gasoline engine, power plant

1. INTRODUCTION

The increase in population is proportional to the energy consumed. In Indonesia, in 2025, it is predicted that the energy consumed will be 2.2 barrels of oil per day (BOPD) [1]. The Government of Indonesia, through Presidential Regulation (Peraturan Presiden) number 5 of 2006 concerning the National Energy Policy (Kebijakan Energi Nasional), seeks to meet energy needs is the composition sourced from new and renewable energy by more than 5% by 2025 [2]. Subsequently refined through the National Energy General Plan (Rencana Umum Energi Nasional) in 2017, the national energy composition by new and renewable energy of 23%, petroleum of 25%, natural gas of 22%, and coal of 30% [1]. Furthermore, the preventive steps taken by the Government of Indonesia are the conversion of kerosene to liquefied petroleum gas (LPG) and liquefied natural gas (LNG).

The use of LPG and LNG as substitute energy sources needs to be reviewed. Since LPG and LNG have limited reserves and are non-renewable, this motivates many studied to find new alternative energy sources that are easy, inexpensive, and environmentally friendly. The alternative energy source of concern is biogas because the potential is large, methane content (CH4) is high, and calorific value ranges from 4800 to 6.700 kcal/m^3 [3]. Biogas is considered safer than LPG because it has a methane gas density of 55 lower than LPG [4]. Another advantage of biogas is that it has a research octane number (RON) of 130 higher than gasoline of 94, benzol of 98, LPG of 112, and compressed natural gas (CNG) of 120 [5]. The high RON of biogas produces lower gas emissions than gasoline, benzol, LPG, and CNG [6].

The Indonesian government target that in 2025 that biogas exploitation will reach 5.5 GW (16.9%) from a potential of 32.7 GW [1], designated as a power plant. In refining the target, the Indonesian government will build a biogas installation with a household scale. Therefore, the use of biogas made from fesses as an alternative fuel becomes interesting to study.

In Indonesia, there have been many studies that examine the use of biogas as alternative energy. Kholiq and Muharom (2012) [3] have examined the utilisation of human fesses as a biogas reactor with a capacity of 16 m^3. It was concluded that to get methane gas (CH_4) with a content of 77%, lighting lamps for biogas were needed at 0.23 hours/m^3 with a pressure of 45 mmH_2O [3]. Haryati (2006) [7] utilised the livestock waste for producing biogas, where the optimum conditions for producing biogas are at temperatures of 32 to 35^0C and pH between 6.8 to 8 [7]. Purnomo (2009) [8] conducts biogas purification using H_2S, where the purified biogas is tested on a gasoline engine. Purnomo concluded the H_2O absorption method using H_2S was successful, with 1.76 g H_2O /hours [8]. Elizabeth and Rusdiana (2011) [6] utilise biogas as a power plant fuel for remote areas. Biogas produces by plant waste, and livestock fesses and human fesses [6]. Feasibility study of biogas produced by plant waste, livestock fesses and human fesses as a power plant fuel is recommended to be applied in remote areas in Indonesia [6].

Biogas has become a special concern for both the Indonesian government and researchers. Studies of the characterisation of chemical kinetics and thermodynamics of biogas have been carried out [9,10]. Based on reports, the challenge in utilising large-scale biogas is the instability between production (supply) and consumption [11]. The solution is to add H_2 to save fuel to anticipate instability [11]. The utilise of biogas for remote areas is a problem because it is difficult in supplying H_2. Therefore, a study of the utilisation of human fesses as biogas raw material for biogas production is proposed. Due to high investment costs to build miniature power plants, even though it is a laboratory scale [12–14], modified gasoline engines are used as mini power plants.

2. METHOD

Biogas was produced from the process of decomposing organic matter by microorganisms in anaerobic (vacuum) conditions. The anaerobic processes break down organics matters by activating bacteria; these bacteria naturally contain organics material: fesses by animal or human and household organics waste [8].

Biogas production uses an anaerobic process consists of three stages: hydrolysis is the decomposition of complex organic matter into simple, structure changes in the polymers form to monomers; acidification, acidification of monomers component (simple sugars) created in the hydrolysis stage is food for bacteria; methanogenic, the process of developing methane gas, bacteria reduce sulphate and other sulphur components into hydrogen sulphide. The process production biogas (fermentation) can be seen in Fig. 1.

Fig. 1 describes the process of changing cellulose to gas. The bacteria in the anaerobic process are hydrolytic, fermentative bacteria, acidogenic bacteria, and methanogenic bacteria [8]. The hydrolytic bacteria function to break down organics matter into sugars and amino acids [6]. The fermentative bacteria convert sugars and amino acids into organics acid [8]. The acidogenic bacteria change organics acid to hydrogen, carbon dioxide and acetic acid [3]. The methanogenic bacteria transform hydrogen, carbon dioxide and acetic acid into methane [7].

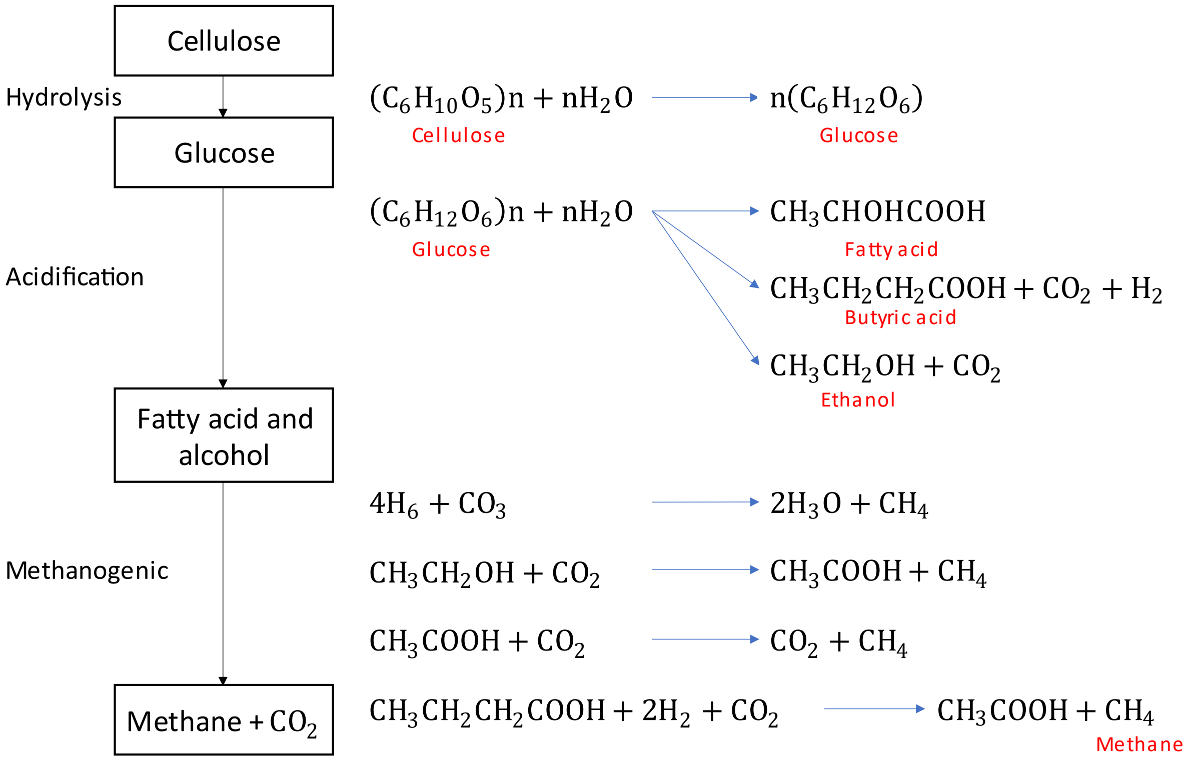

Fig. 1. Fermentation process [7]

The fesses are processed in a digester in the condition of anaerobic with temperature maintained at 35 °C. The first production is CO_2 gas on days 1 to 8. The methane gas and CO_2 gas are produced on the 10 to 14. For more than 14 days, methane gas without CO_2 gas is produced. The methane gas produced over 14 days was used. However, gas production depends on the composition of the raw material used. For this case, the results obtained are like this.

The digester is connected to the gasoline engine using a pipe, gas carburettor, gas regulator, and valve (Fig. 2). This case compares biogas with LPG. The valve opening for the biogas system is 180°. Gas pressure conditions of 180° for biogas are equivalent to 40° for LPG systems.

Fig. 2. Biogas system installation

3. RESULTS AND DISCUSSION

Based on Fig. 3, as the engine speed increases, the water flow increases. The highest water discharge produced by a water pump using biogas fuel is 0.118 m^3/s at 6600 rpm, while LPG produced was 0.150 m^3/s. From the results, the discharge of LPG fuel water is higher than biogas because LPG gas pressure into the combustion chamber is more constant than biogas. Based on Fig. 4, the increased discharge produced by the water pump, the greater the waterpower (P_w) produced. The maximum waterpower produced by the water pump using LPG fuel is 1.6 kW at 6600 rpm, and biogas is 1.26 kW.

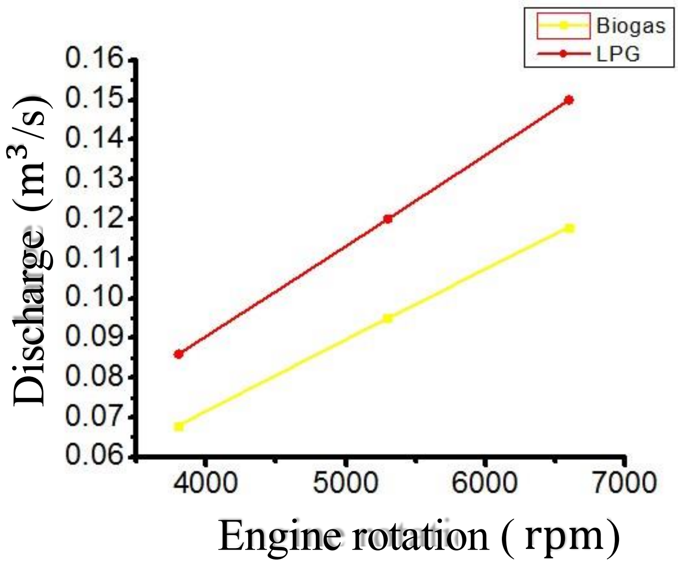

Fig. 3. Relation of discharge into engine rotation

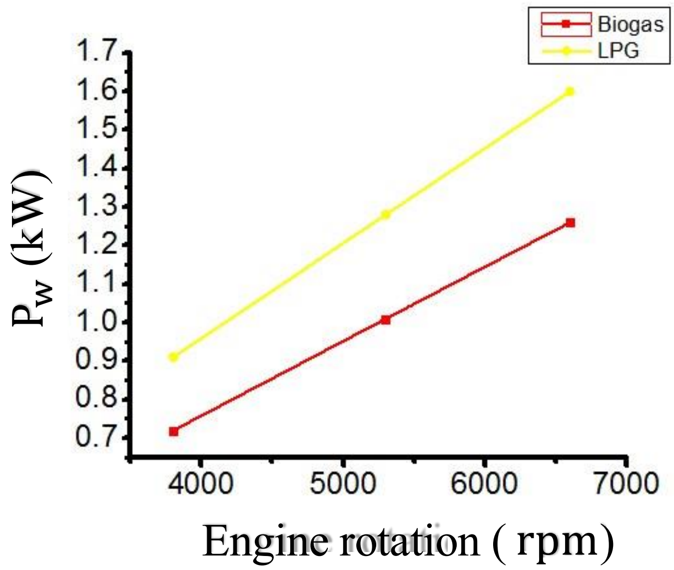

Fig. 4. Relation of P_w into engine rotation

From Fig. 5, the maximum efficiency of the biogas system is 32%, and that of the LPG is 41%. From the results, biogas is an appropriate alternative as a fuel source and being environmentally friendly because the combustion is close to perfect and does not smoke. Biogas combustion also does not produce odor (even if it comes from faeces), consequences, and is safe to use for the household.

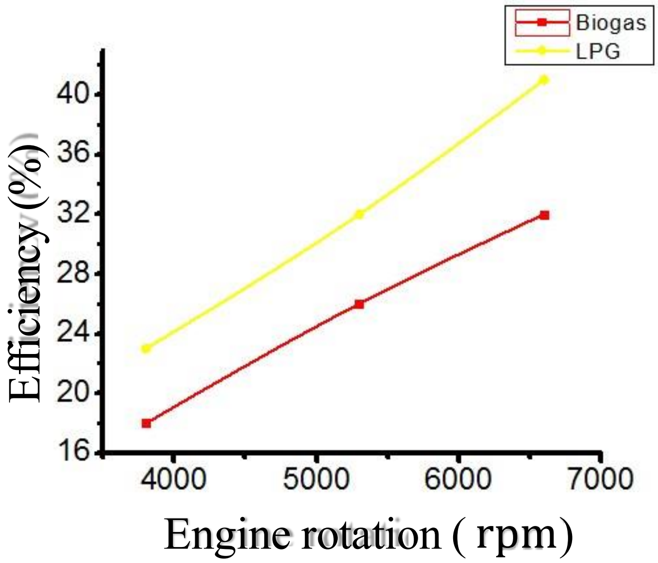

Fig. 5. Relation of efficiency into engine rotation

4. CONCLUSION

Based on results, human fesses can be used as raw material for biogas production. Performance engine using biogas derived from human fesses is 9% different from LPG. The maximum efficiency of the biogas system is 32%, and that of the LPG is 41%.

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