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Advanced Materials Research Vols. 1044-1045 (2014) pp 251-254 Submitted: 10.08.2014 Online available since 2014/Oct/01 at www.scientific.net Accepted: 11.08.2014 © (2014) Trans Tech Publications, Switzerland doi:10.4028/www.scientific.net/AMR.1044-1045.251 Behavior of Flame Propagation in Biogas Spark Ignited Premix Combustion with Carbon Dioxide Inhibitor Willyanto Anggono1,a, Fandi Dwiputra Suprianto2,b, Tubagus P. Wijaya3,c, Michael S.C. Tanoto4,d 1,2,3,4Mechanical Engineering Department, Petra Christian University, Indonesia awilly@petra.ac.id, bfandi@petra.ac.id, cskyforged@gmail.com, dmichael_tanoto@yahoo.com Keywords: Biogas, Carbon dioxide, Flame propagation, Premix combustion, Sustainable energy. Abstract. Biogas is a mixture of gases which commonly consists of methane (up to 50%) and other inhibitor gases which are dominated by carbon dioxide (up to 50%). Biogas is produced naturally by the decomposition of organic materials such as vegetation or animal manure in the absence of oxygen and it also contributes less greenhouse gases which may lead to global warming or climate change. The presence of carbon dioxide (CO2) in biogas is presumed to have some effects on biogas flame propagation characteristics. This study focuses on the effect of carbon dioxide (CO2) as the biggest inhibitor composition in biogas on flame propagation speed as the important flame propagation characteristic in spark ignited premix combustion. Propagating flames are employed to measure the flame propagation speed as a function of the mixture composition. This parameter was measured using a transparent tube fuel chamber with dimensions of 60 mm inner diameter and 300 mm height based on DIN 51649 standards and recorded by high speed digital photographic technique. The characteristic of biogas-oxygen flames were studied at stoichiometric, room temperature and atmospheric condition from 0% to 50% CO2 biogas inhibitor composition increased by 10% for each experiment. The results showed that the carbon dioxide decreases flame propagation speed of biogas. These indicated that carbon dioxide reduced reaction rate of biogas premixed combustion. Introduction Biogas is a mixture of gases which commonly consists of methane (up to 50%) and other inhibitor gases which are dominated by carbon dioxide (up to 50%). Methane is a flammable gas, whereas, carbon dioxide is inhibitor. Biogas is produced naturally by the decomposition of organic materials such as vegetation or animal manure in the absence of oxygen and it also contributes less greenhouse gases which may lead to global warming or climate change. Biogas, an alternative fuel that is sustainable and renewable which derived from fermentation of organic material in digester [1-4]. Biogas is suitable as an environmentally friendly, alternative fuel to substitute fuels like kerosene, LPG, coal and other materials derived from fossil. Biogas contains many impurities that affect the characteristics of the biogas. While some research has been conducted to study the use of biogas for cooking (stove) and machinery such as gas turbines, more research is required before it becomes a substitute for fossil fuels [1-10]. Inhibitors content of the biogas cause a reduction in the velocity of a laminar burning velocity due to the reduced concentration of methane and reduced flame temperature caused by absorbed heat by carbon dioxide and nitrogen [1-4]. A further research is required to determine the influence of carbon dioxide levels in biogas combustion characteristics. Combustion itself is a chemical reaction between a fuel and oxidizer (oxygen or air) that produce heat and light. The heat or energy that is used to activate fuel molecules is called activation energy. Visual observation towards the produced flame shows that in the absence of carbon dioxide, a perfect combustion produces a blue flame. Additionally, 25% and 50% of carbon dioxide content causes a yellowish flame. The color of 252 Frontiers of Energy, Materials and Information Engineering the flame indicates the type of ion produced during combustion process. Flame color is the wavelength of dominant vibrations of ions in flames. CO_2 lowers the flame burning velocity due to CO_2 molecules inhibits the reaction of collisions between molecules of the hydrocarbon content of propane with molecular oxygen [11]. Experimental Methods Details of experimental apparatus are shown in Fig. 1. This study was carried out by using experimental standard a transparent tube fuel chamber with dimensions of 60 mm inner diameter and 300 mm height based on DIN 51649 standard and recorded by high speed digital photographic technique. Fig. 1. The Experimental Schematic Diagram The characteristics of biogas-oxygen flames were studied at stoichiometric, room temperature and atmospheric condition. Initially, all the experiments in this study were implemented at atmospheric pressure (1 atm) and with inhibitorless biogas at ambient temperatures. The findings were compared with those from biogas (containing CO_2) at atmospheric pressure with 0% to 50% CO_2 biogas inhibitor composition increased by 10% for each experiment. Results and Discussion The characteristics of biogas-oxygen flames were studied at stoichiometric, room temperature and atmospheric condition from 0% to 50% CO_2 biogas inhibitor composition increased by 10% for each experiment. The images obtained from the flame propagation within the cylindrical combustion chamber are shown in Fig. 2. Advanced Materials Research Vols. 1044-1045 253 Fig. 2. Flame Propagation Experimental Results Increasing carbon dioxide concentration in biogas reduces flame propagation speed and the reaction rate was occurred slower. This can be seen with the same time (4.17 milliseconds), the distance in which the flame propagates decrease with the increase of carbon dioxide concentrations in the fuel as shown in Fig. 3. Fig. 3. Effect Carbon Dioxide on Flame Propagation Speed The decrease of flame propagation speed is seen by the distance traveled by the flame within 4.17 milliseconds. On fuel with 0% content of carbon dioxide, flame reached the 298.2 mm in 4.17 ms. On 10% carbon dioxide inhibotor, the flame reached 243.4 mm in 4.17 ms, this distance indicates that there is a decrease of flame propagation speed. The same tendency applies to 20%, 30%, 40% and 50% carbon dioxide inhibotors. 50% content of carbon dioxide have the slowest flame propagation speed. This is due to the ability CO_2 in biogas fuel as an inhibitor that reduces oxidation chemical reactions in combustion. The presence of carbon dioxide reduces the amount of methane in the fuel component so that the total amount of reactive material is lower than that in a pure methane fuel (inhibitorless biogas). Moreover, carbon dioxide will absorb the heat of combustion and hence reduces the combustion temperature. Conclusion The presence of carbon dioxide in biogas reduces flame propagation speed at biogas spark ignited premix combustion. This is due to the ability CO_2 in biogas fuel as an inhibitor that reduces oxidation chemical reactions in combustion. The presence of carbon dioxide reduces the amount of 254 Frontiers of Energy, Materials and Information Engineering methane in the fuel component so that the total amount of reactive material is lower than that in a pure methane fuel (inhibitorless biogas). Moreover, carbon dioxide absorbs the heat of combustion and hence reduces the combustion temperature. Acknowledgments Many thanks to Direktorat Jendral Pendidikan Tinggi Kementrian Pendidikan Nasional Republik Indonesia (Hibah Penelitian Fundamental 2014) and Petra Christian University, Indonesia. References [1] Anggono W, Wardana ING, Lawes M, Hughes KJ, Wahyudi S, Hamidi N. Laminar Burning Characteristics of Biogas-Air Mixtures in Spark Ignited Premix Combustion. Journal of Applied Sciences Research 2012;8:4126-32. [2] Anggono. W., Wardana. I.N.G., Lawes. M., Hughes. K.J., Wahyudi. S., Hamidi. N., and Hayakawa. A.. Laminar Burning Velocity and Flammability

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