Purification Of Synthetic Gas From Undeground Coal Gasification By Absorption

Hardyanty Dwi Pratiwi, Muhammad Faizal, David Bahrin

Abstract: An Underground Coal Gasification (UCG) Experiment has been modified in a laboratory scale conducted to produce of synthesis gas and to purify of synthetic gas. Synthetic Gas produced from modified UCG reactor composed of hydrogen gas (H_2), carbonmonoxide (CO), methane (CH_4), are the main gas, mixed with carbondioxide gas (CO_2), Nitrogen gas (N_2), hydrogen sulfide (H_2S) and other gases. All three of hydrogen gas (H_2), carbon monoxide (CO), methane (CH_4) are combustible gas as a fuel. While non fuel gas containing CO_2 is that high enough as one of the undesirable gas. CO_2 gas content can reduce heating value from syngas, so do gas absorption CO_2 process in syngas using K_2CO_3 solution with 4 N with concentration 0.5 Litres volume by using column bubble (bubble coulum). Variables used are syngas flow rate by total of air plus oxygen from 5 litre per minute to 15 litre per minute and absorption time 10 to 30 minutes with range 10 minutes. The occur mechanisms is process CO_2 absorption by K_2CO_3 solution and with reaction between the two compounds. The results experiment showed optimal conditions is syngas flowrate 15 litres per minute with total air input 5 litres/minute plus oxygen input 10 litres/minute in 20 minutes time absorption can absorb CO_2 gas 25% with escalation gas CH_4 content 40.6%mole, syngas caloric value 441.1 Btu/Scf with ratio fuel gas/non fuel gas 1.02.

Index Terms: UCG Gasification, Syngas, Absorbtion, K_2CO_3, Purification

1 INTRODUCTION

One source of energy that has not been exploited to the maximum by the Government is coal. During this time the coal production of Indonesia about 70% more exported abroad. Meanwhile, the availability of coal in Indonesia is very rich with total resources of coal 105,184.44 million tons and 21,131.84 million tons of coal reserves that are the largest coal producer in the world-se **[1].** Revealing Coal in Indonesia are generally of the type of the content of sub-bituminous coal and subbituminus carbons range 50-80%**[2].** One of the coal utilization without mining the Coal Gasification process is underground (Underground Coal Gasification, UCGB) **[3]**. Underground Coal Gasification (UCG) is the conversion of coal into gaseous products directly in the ground, using a mixture of reagents in the form of air, air/water vapor or oxygen/water vapor. The resulting gas from gasification process called synthetic gas (syngas), Synthetic Gas produced from UCG reactor consists of hydrogen gas (H_2), carbon monoxide (CO), methane (CH_4), which is the desired gas, mixed with carbon gas dioxide (CO_2), water vapour (H_2O), hydrogen sulfide gas (H_2S) and gases or other substances that are very small content. Third of hydrogen gas (H_2), carbon monoxide (CO), methane (CH_4) is a gas that can be burned producing heat or as a gasfuel. While CO_2 gas can be removing through absorption **[4]**. Synthetic gas producedfrom gasification still contains gas pollutant that can affect the characteristics of synthetic gas. Purification syngas can be done by several methods, including the method of adsorption, absorption and cryogenic, either in physics or chemistry.

- *Hardyanty Dwi Pratiwi is Graduate Program Student Of Chemical Engineering Magister Program, Faculty Of Engineering, Sriwijaya University, Palembang 30139, Indonesia Email: Hardyantydwipratiwi@gmail.com*
- *Muhammad Faizal is Lecturer of Chemical Engineering Magister Program, Faculty of Engineering, Sriwijaya University, Palembang 30139, Indonesia*
- *David Bahrini is Lecturer of Chemical Engineering Magister Program, Faculty of Engineering, Sriwijaya University, Palembang 30139, Indonesia*

Chemical CO_2 gas absorption process of syngas in a bubble column, heavily influenced by some factors such as the type and concentration of absorbenabsorben as well as the operating conditions and the rate of contacting absorbent. Various variables above can determine the magnitude of the absorption or gas absorption of CO_2 from the gas resulting from the process of land **[5].**

2 EXPERIMENTAL SECTION

2.1 Materials

The material used is coal higher, K_2CO_3 (4 N), oxygen and steam. UCG reactor modified, bubble colum, portable pump and portable comprerssor

2.2 Methods

The method used is the laboratory scale research. Performed in the laboratory of chemistry of the University of Sriwijaya. On this research will be carried out testing against the composition of the CO_2 content of synthesis gas is absorbed in the result of underground Coal Gasification. Research used for installation shown in Figure1.

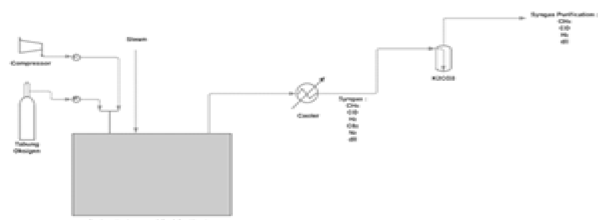

Figure 1. *Underground Coal Gasification Modified Reactor*

Installation of research consists of a square container with size 50 cm x 40 cm x30 cm, which features 2 inlet pipe in the upper and and one pipe product also colum for solution of K_2CO_3. Step tests conducted burning coal, after that initial UCG gasifier closed parts of it.Then do oxygen mixer (variation of 5.10 and 15 m/s) and Air 9 (variation of 10, 20 and 30 minutes) in the pipe inlet first, steam outlet pipe on the second. Gasification syngas is passed then the column bubble solution K_2CO_3

3 RESULT AND DISCUSSION

3.1 The Influence of Time Absorption and Flow rate percent Gas or Syngas taking action against carbon dioxide (CO_2) being Absorbed

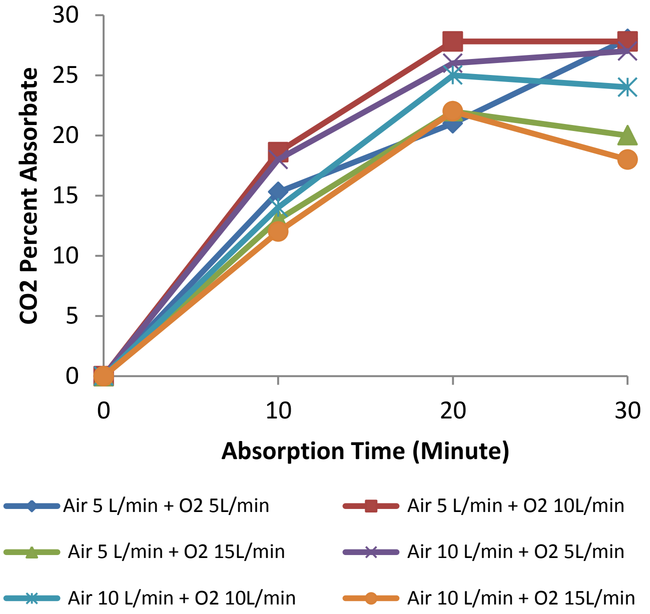

Figure 2. *Influence of Long Time Absorption and flow rate percent Gas or Syngas taking action against carbon dioxide (CO_2) being Absorbed*

The influence of the concentration of gas absorption rate absorben against carbondioxide (CO_2) on the condition that this research high at the time of 20 minutes to the absorption, which each give the maximum absorption of 27.0 percent% and 27.8%. While the influence of the flow rate of gas absorption rate of syngas against carbondioxide (CO_2) obtained the maximum absorption at percent the flow rate or syngas with oxidizing air 5 litres/min + oxygen 5 litres/min and oxidizing air 5 litres/min + oxygen 10 litres/ minutes i.e. respectively 28% and 27.8%.Percent absorption of carbondioxide gas (CO_2) are very small at the time to 10 minutes of contact, at the range 12 to 15.3%, this can be seen from the position of the flow chart shown in Figure 2. where the flow charts that ter so for gas absorption percent carbon dioxide (CO_2) of 12% and 15.3% is far below the flow graph of carbondioxide gas absorption% (CO_2) 27.0% and 27.8%. The second flow chart for carbondioxide gas absorption% (CO_2) 27 and 27.8% are on point along the range of the increase in the concentration of absorben, this give the illustration that can be clearly determined the optimal absorption of the contact time is to 20 percent carbondioxide gas absorption with (CO_2) reached 27.8%. As for the mechanism of the reaction that occurs is as follows:

$$K_2CO_{3(aq)} + CO_{2\,(l)} + H_2O_{\,(l)} \rightarrow 2\ KHCO_{3\,(aq)} \qquad (1)$$

(CaliumCarbonate)(carbondioxide)(steam)(caliumbicarbonate)

3.2 The Influence of Time Absorption and flow rate of Gas or Syngas taking action against Rising percent of methane (CH4) in the Syngas

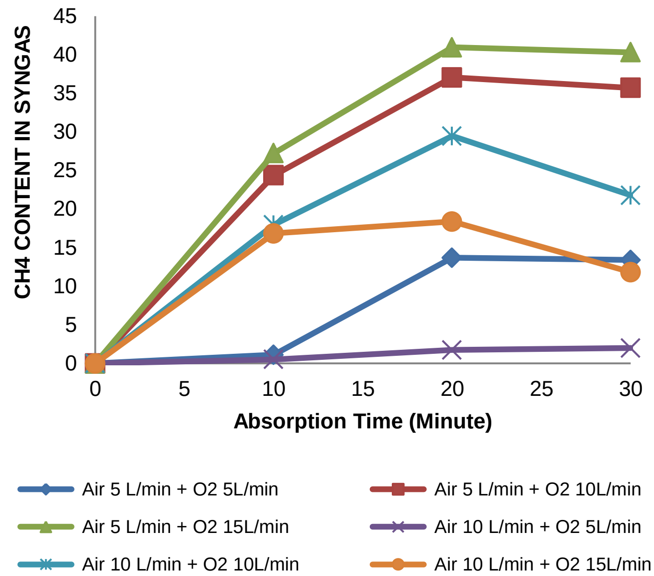

Figure 3. *Influence of Time Absorption and flow rate of Gas or Syngas taking action against Rising percent of methane (CH_4) in the Syngas*

The flow Chart in Figure 3. provides an excellent overview on syngas flow rate with oxidizing air 5 litres/min + oxygen 10 litre/min and oxidizing air 5 litres/min + Oksigen 15 litres/min. The two flow rate of each gas molecule percent for methane (CH_4) in the syngas maximum 40.6% and 47.6%.

3.3 Influence of Time Absorption and flow rate of Gas Fuel Ratio taking action against Syngas/Non Fuel Gas in the Syngas

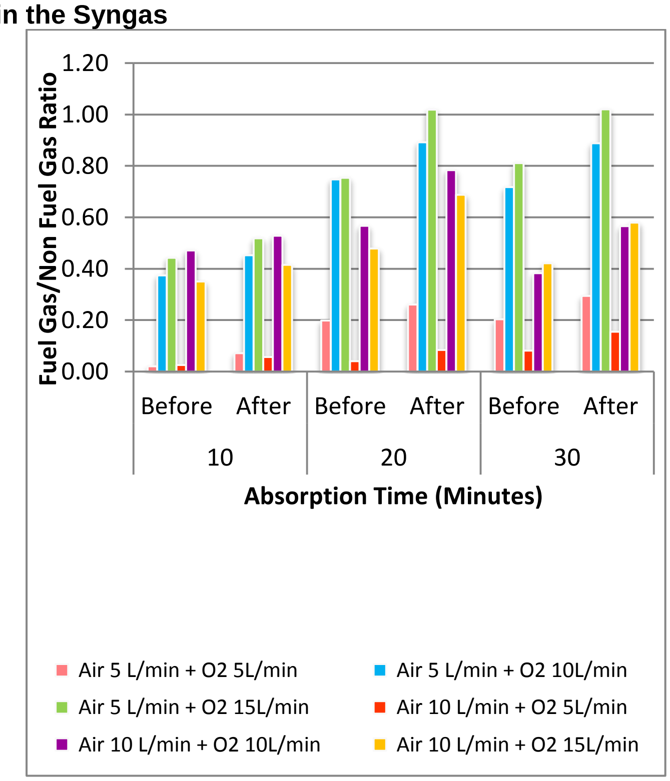

Figure 4. *Influence of Time Absorption and flow rate of Gas Fuel Ratio taking action against Syngas/Non Fuel Gas in the Syngas*

On the process of gasification sufficient air supply is required depends on the mass of its fuel, because if the air is too large debit can allow the amount of gas produced will contain a lot of oxygen (O_2) and nitrogen (N_2), which is derived from the input Air **[6]**. Can be seen in Figure 4.2.3 profile ratio fuel gas/non fuel gas or syngas with variations in flow rate air 5 litres/min + 15 Litres/minute Oxygen higher than the flow rate of the air 5liter/min + oxygen 15 Litres/minute.Thus the ratio of fuel gas/non fuel gas obtained at best conditions on research this is a flow rate of air 5 litres/min + oxygen 15 litres/minute and flowrate air 5 litres/min + oxygen 15 litres/min with a value of ratio of 1.02

4 CONCLUSION

The optimal condition for absorption time gas carbon dioxide (CO_2) in this research took place at the 20th minutes and optimal flow rate at 15 litres/min with an oxidizing air 5 litres/min + oxygen 10 litres/min obtained percent absorption of gases carbondioxide (CO_2) by 25% and increased gas content of mol% methane (CH_4) in the syngas 40.6% mole and heat value of 441.1 Btu/scf ratio fuel gas/non fuel gas amounting to 1.02. The use of potassium carbonate absorben (K_2CO_3) in a kind of bubble absorption column is good enough to Absorption the gas carbondioxide (CO_2) in the fuel or syngas, it is apparent from the content of carbon dioxide gas (CO_2) remaining on the conditions optimal in biogas amounted to 13.5% Mole.

REFERENCES

[1] Kementrian ESDM. (2014).Statistikbatubara. http://prokum.esdm.go.id/Publikasi/Statistik/Statistik%20Batubara.pdf. diakses : 20 juli 2018

[2] Kusumopradono, M. (1994). Potensi Batubara Indonesia. PidatoPengukuhan Ahli Madya. UniversitasDiponegoro : Semarang.

[3] Faizal, M, 2010, Pencampuran Batubara, Laporan Penelitian RUSNAS EnergiTahun 2010.

[4] Yu, C.H., Huang, C. H., dan Tan, C. S., 2012. " A Review of CO2 Capture by Absorption and Adsorption, Aerosol and Air Quality Research, 12: 745–769, ISSN: 1680-8584 print / 2071-1409 online, doi: 10.4209/aaqr.2012.05.0132

[5] Perry,Robert H,& Green DW.2008. Perry's Chemical Engineers Handbook. Eight Edition. Mc Graw-Hill. New York.

[6] Vidian, F. 2008. "Gasifikasi Tempurung Kelapa Menggunakan Updraft Gasifier Pada Beberapa Variasi Laju Alir UdaraPembakaran". Jurnal Teknik Mesin. 10(2) Oktober 2008:88-93

[7] Bhutto, A.W., Bazmi, A.A., dan Zahedim, G., 2013, Underground coal gasification: From fundamentals to applications, Progress in Energy and Combustion Science 39 (2013) 189-214

[8] Budiraharjo, Imam. (2009). AnalisisMikrobatubara,terjemahanbebasdari Coal Science Handbook", Bab "Sekitan no tetteikenkyuu", sub bab "Sekitan wo mikuronibunsekisuru" dan "Sekitan wo mikurokaramakuro made kagakusuru". Japan Coal Energy Center. available from URL :http://imambudiraharjo.wordpress.com/2009/03/11/analisis-mikro-batubara/, diakses : 5 Juli 2018.

[9] Faizal, M, 2008, Pencairan Batubara, LaporanPenelitian RUSNAS EnergiTahun 2008

[10] Faizal, M, 2016, Utilization Biomass and Coal Mixture to Produce Alternative Solid Fuel for Reducing the Green House Gas Emission, SICEST 2016.

[11] Faizal, M., Said, M.dan, Setiabudidaya, D., 2017, "Pengaruh Debit Udara Dan WaktuTerhadapProduksi Synthetic Gas Pada Proses Underground Coal Gasification " LaporanAkhirPenelitianKompetitif, LPPM Unsri

[12] Harish, K.R.N., Udayakumar, D.L., Stojcevski, A., Oo, A.M.T., 2014, Underground Coal Gasification: an alternate, Economical, and Viable Solution for future Sustainability, International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org , Volume 3, Issue 1, PP.57-68

[13] Higman, C., dan VDM. (2003). Gasification, Oxford : Gulf Professional Publishing.

[14] Kumar, K. Vasanth., Subanandam,K., Ramamurthi,V.danb Sivanesan, S. (2004). Solid Liquid Adsorption for Wastewater Treatment : Principle Design and Operation.India : Departement of Chemical Engineering – A.C. College of Technology, Anna University.

[15] Lili, M., Meijun, W., Huimin, Y., Hongyan, Y., dan Lipping, C. (2011). Catalytic effect of alkali carbonates on CO_2 gasification of Pingshuo Coal. Minning Science and technology, 21. Pp, 587-590.

[16] Nahas, N.C. (1983). Exxon Catalytic coal gasification procces: Fundamental to flowsheets. Fuel, 62. Pp, 39-41.

[17] Porada, S. Czerski, G., Dziok, T., Grzywacz, P. dan, Makowska, D., 2015, Kinetics of steam gasification of bituminous coals in terms of their use for underground coal gasification, Fuel Processing Technology 130 (2015) 282–291

[18] Prabu, V., Jayanti, S, 2012, Laboratory scale studies on simulated underground coal gasification of high ash coals for carbon-neutral power generation, Energy, Vol. 46, Issue 1, October 2012, pp. 351–358, http://doi.org/10.1016/j.energy.2012.08.016

[19] Rochyani, et all 2014, Study on Environment Characteristics for Mining Management at East Pit 3 West Banko Coal Mine, IJASEIT, Vol.4 (2014) No. 3, ISSN: 2088-5334, pp.45-48

[20] Smolinski, A. (2011). Coal char as a fuel selection criterion for coal-based hydrogen-rich gas production in the procces of steam gasification. Energy Conversion and Management, 52. Pp, 37-45.

[21] Sun, Zhiqiang; Wu, Jinhu; Wang, Yang dan Zhang, Dong-ke. (2005a). Methane Cracking over a Chinese Coal Char in a Fixed-Bed Reactor. 5th Asia-Pacific Conference on Combustion. The University of Adelaide. Australia.

[22] Sun, Zhiqiang; Wu, Jinhu; Wang, Yang dan Zhang, Dong-ke. (2005b). Methane and Carbon Dioxide Reactions over a Chinese Coal Char in a Fixed-Bed Reactor. 5th Asia-Pacific Conference on Combustion. The University of Adelaide, Australia.

[23] Tristantini, D., et al (2005). A study of hydrocarbon production via Fischer-Tropsch (FT) synthesis from different model bio-syngas over un-promoted and rhenium-promoted alumina supported cobalt catalysts, Proceeding of The Synbios Conference, Stockholm, Sweden, May 18-20, 2005.

[24] Tristantini, D., et al (2007a). The effect of synthesis gas composition on the Fischer-Tropsch synthesis over Co/γAl2O3 and Co-Re/γ-Al2O3 catalysts, Fuel Processing Technology, 88. Pp. 643-649.

[25] Tristantini, et al (2007b) Effect of Water Addition On Direct Use Of H2Poor Bio-Syngas Model In Fischer-Tropsch Synthesis Over Co/Al2O3 Catalyst, Proceeding of 14^{th} Regional Symposium on Chemical Engineering 2007 ISBN 978-979-16978-0-4, Dec. 4-5, 2007.

[26] Vorres, K.S. (1986). Mineral Matter and Ash in Coal. American Chemical Society, Symposium Series 302. Washington.

[27] Wang, J., Jiang, M., Yao, Y., Zhang, Y., dan Cao, J. (2009a). Steam gasification of coal char catalyzed by K_2CO_3 for enhanced production of hydrogen without formation of methane. Fuel, 88. Pp, 1572-1579.

[28] Wang, J., Jiang, M., Yao, Y., dan Cao, J. (2009b). Enhanced catalysis of K_2CO_3 for steam gasification of coal char by using $Ca(OH)_2$ in char preparation. Fuel, 89. Pp, 310-317.

[29] Yu, J., Tian, F.J., Chow, M.C., McKenzie, L.J., Li,dan C.Z. (2006). Effect on iron on the gasification of Victorian brown coal with steam: enhnancement of hydrogen production. Fuel, 85. Pp, 127-133.

[30] Zhang, L.X., Huang, J.J., Fang, Y.T., Wang, dan Y. (2005). Effect of mineral matter on gasification and activation of typical Chinese anthracite chars. J Taiyuan UnivTechnol, 34(5). Pp, 85-90