with 75% corncob and 25% husk gave the calorific value of 5,331.95 kcal/kg [6]

2) Inherent Moisture : The Fig. 7 shows the influence of the composition of carbonized corn cobs, carbonized banana peels and carbonized fine coal waste on the inherent moisture content of biobriquette. If the percentage of carbonized banana peels and carbonized corn cobs ratio was increased, the inherent moisture of biobriquette was increased from 5.14 % to 8.82 %. The increasing of inherent moisture of this biobriquette was caused by the inherent moisture of banana peels higher than inherent moisture of corn cobs. This inherent moisture of all biobriquette composition were matched with standard ≤ 8 %, except for carbonized banana peels and carbonized corn cobs ratio more than 50:30.

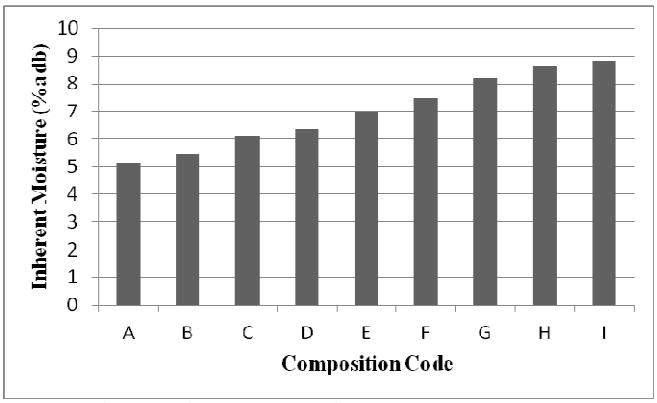

Fig. 7 Influence of composition of carbonized corn cobs, carbonized banana peels and carbonized fine coal waste on inherent moisture content of biobriquette

3) Ash Content : The Fig. 8 shows the influence of the composition of carbonized corn cobs, carbonized banana peels and carbonized fine coal waste on ash content of biobriquette. This Fig. 8 represents the percentage of carbonized banana peels and carbonized corn cobs ratio was increased, the ash content of biobriquette was increased from 6.06 % to 16.82 %. The increasing of the ash content of this biobriquette was caused by ash content of banana peels higher than ash content of corn cobs. These ash content of all biobriquette composition were matched with standard ≤ 8 %, except for carbonized banana peels and carbonized corn cobs ratio more than 10:70.

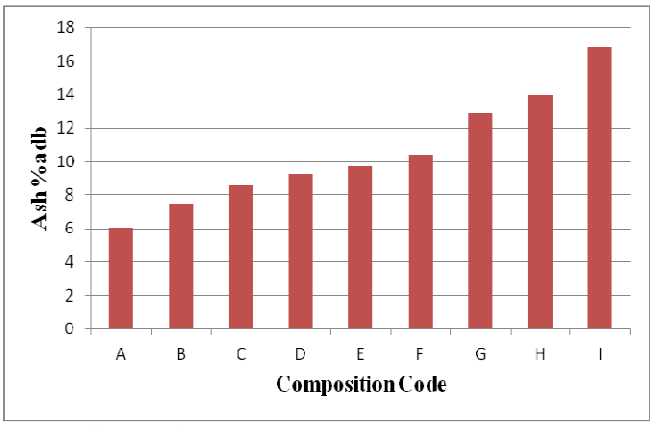

Fig. 8 Influence of carbonized corn cobs, carbonized banana peels and carbonized fine coal waste composition on ash content of biobriquette

4) Volatile Matter : The Fig. 9 indicates the influence of the composition of carbonized corn cobs, carbonized banana peels and carbonized fine coal waste on volatile matter content of biobriquette. Increasing of carbonized banana peels and carbonized corn cobs ratio, the volatile matter content of biobriquette increased from 26.18 to 42.2 % adb. The increasing of volatile matter of biobriquette was influenced by volatile matter content of banana peels higher than volatile matter content of corn cobs.

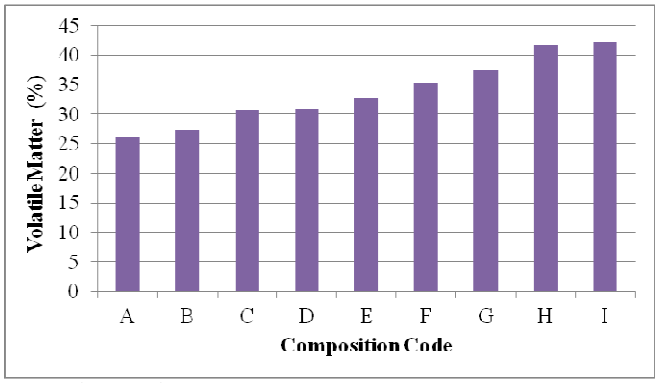

Fig. 9 Influence of carbonized corn cobs, carbonized banana peels and carbonized fine coal waste composition (%w/w) on volatile matter content of biobriquette

5) Fixed Carbon : Influence of carbonized corn cobs, carbonized banana peels ratio in biobriquette on fixed carbon content is presented in Fig. 10 as following. Fig. 10 represents an increase of carbonized banana peels and carbonized corn cobs ratio, while the fixed carbon content of biobriquette was decreased from 62.62 to 32.16 % adb. The decreasing of fixed carbon content of biobriquette was caused by fixed carbon content of banana peels less than fixed carbon content of corn cobs. These fixed carbon contents of all biobriquette composition did not match to the standard (≥ 77 %).

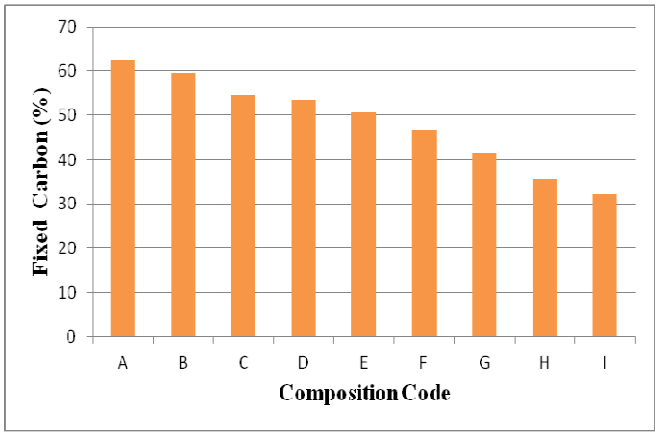

Fig. 10 Influence of carbonized corn cobs, carbonized banana peels and carbonized fine coal waste composition on fixed carbon content of biobriquette

IV. Conclusion

After the carbonization, the calorific value of coal, corn cobs and banana peels were increased, but for the banana peel, the calorific value was decreased with the increasing of carbonization temperature range from 300°C - 500°C.

The highest calorific value of 6,386 kcal/kg of carbonized corn cobs was measured at a temperature of 500^{o}C. The highest calorific value of 6,042 kcal/kg of carbonized banana peels was obtained at a temperature of 300^{o}C, and for carbonized fine coal waste at 500^{o}C, the calorific value was of 6,330 kcal/g.

The percentage of carbonized banana peels and carbonized corn cobs ratio was increased, the calorific value of biobriquette was decreased. The highest calorific value of biobriquette of 6,297 kcal/kg was obtained for the composition of carbonized coal, carbonized corn cobs and carbonized banana peels ratio was of 20:80:00. In general calorific value of all biobriquette composition were higher than standard calorific ≥ 5,000 kcal/kg. It is recommended that in the future research, characterization of flue gas of biobriquette combustion should be measured.

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REFERENCES

[1] N. Shekhar, "Popularization of Biomass Briquettes- A means for Sustainable rural Development," *Asian Journal of Management Research*, Vol. 2 Issue 1, ISSN 2229 – 3795, pp. 457-473, 2011.

[2] S. Suvunnapob, S., B.I. Ayudhya,, and B. Kusuktham, "A Study of Cotton Dust Mixed with Wood Dust for Bio-Briquette Fuel," *Engineering Journal*, Vol. 19 Issue 4, DOI:10.4186/ej.2015.19.4.57, 2015.

[3] D. Shyamalee, A.D.U.S. Amarasinghe, N.S. Senanayaka, "Evaluation of different binding materials in forming biomass briquettes with saw dust,"*International Journal of Scientific and Research Publications*, Vol. 5, Issue 3, pp.1-8., 2015.

[4] P.V. Jadhav, S. Dashore, and K. Chaudhary, "Biomass Briquette System: Pollution Free Thermal Energy Resources," *International Journal of Innovative Research in Science, Engineering and Technology*, pp. 1165-1171, Jan. 2016.

[5] M.K. Sharma, G. Priyank, and N. Sharma, "Biomass Briquette Production: A Propagation of Non-Convention Technology and Future of Pollution Free Thermal Energy Sources," *American Journal of Engineering Research (AJER)*, Vol. 04, Issue-02, pp. 44-50, 2015.

[6] C. Mulyana, A.P. Wulandari, D. Hidayat, B.M. Wibawa, and A. Permana, "Development of Indonesia Corncob and Rice Husk Biobriquette as Alternative Energy Source," in *AIP Conference Proceedings* , p. 1712, 2016.

[7] G. Borowski and J.J. Hycnar, "Utilization of Fine Coal Waste as a Fuel Briquettes," *International Journal of Coal Preparation and Utilization*, 33: pp.194–204, 2013.

[8] F.Zannikos, S. Kalligeros, G. Anastopoulos, and E.Lois, "Converting Biomass and Waste Plastict Solid Fuel Briquettes," Journal *of Renewable Energy*, Hindawi Publishing Corporation, pp.1-9, Volume 2013.

[9] S. Yaman, M. Sahan, H. Haykiri Acma, K. Sesen, S. Kucukbayra, "Fuel briquettes from biomass–lignite blends," *Fuel Processing Technology*, pp. 1–8, 72, 2001.

[10] U. Habib, M. Habib, and A. U. Khan, " Factors Influencing the Performance of Coal Briquettes," *Walailak Journal Science & Technology*, Vol. 11(1): pp. 1-5, 2014.

[11] A.B. Nasrin, Y.M. Choo, W>S. Lim, L. Joseph, and S. Michael, " Briquetting of Empty Fruit Fibre and Palm Shell as a Renewable Energy Fuel," *Journal of Engineering and Applied Science* Vol. 6(6), pp. 446-451, 2011.

[12] A. M. Omer, "Biomass energy resources utilisation and waste management," *Journal of Agricultural Biotechnology and Sustainable Development*, Vol. 3(8), pp. 149 -170, October 2011.

[13] P. Siritheerasas, C. Chunniyom, and P. Sethabunjong, "Combustion of Moist Coal Briquettes," *Chiang Mai Journal. Science*." Vol. 35(1), pp. 35-42 , 2008.

[14] Maninder, R. S. Kathuria, S. Grover, "Using Agricultural Residues as a Biomass Briquetting: An Alternative Source of Energy," *IOSR Journal of Electrical and Electronics Engineering (IOSRJEEE)*, Vol. 1, Issue 5, pp. 11-15, July-Aug. 2012.

[15] I.E. Markson, W. A. Akpan, E. Ufot, "Determination of Combustion Characteristics of Compressed Pulverized Coal-Rice Husk Briquettes," *International Journal of Applied Science and Technology*, Vol. 3 No. 2; February 2013.

[16] M. Yerizam, M. Faizal, Marsi and Novia, "Characteristics of Composite Rice Straw and Coconut Shell as Biomass Energy Resources (Briquette)(Case study : Muara Telang Village, Banyuasin of South Sumatera)," *International Journal on Advaced Science Engineering Information Technology*, Vol. 3 No. 3, pp.42-48, May 2013.

[17] R. M. Singh, " Biobriquetting in Nepal – Scope and Potentials : A Riview," Kathmandu University Journal of Science Engineering and Technology, Vol.9, No. II, pp.104-120, Dec 2013.

[18] J.T. Oladeji, "Fuel Characterization of Briquettes Produced from Corncob and Rice Husk Resides," *The Pacific Journal of Science and Technology*, Vol. 11. No. 1, pp.101– 106, May 2010.

[19] *G Borowski*, **"** Pilot tests for utilization of fine coal to fuel briquettes production," Archives of Waste Management and Environmental Protection, Vol. 15 , Issue 2, pp. 9-18, 2013.

[20] *Badan Standarisasi Nasional (BSN)*, SNI No. 1/6235, 2000.