CHAPTER 5

INFLUENCE OF FUEL CHARACTERISTICS ON FLUIDIZED BED COMBUSTION OF WOODY BIOMASS

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INTRODUCTION

Biomass is one of the most promising bioenergy sources to supply future energy demand and to mitigate greenhouse gas emissions. Woody biomass is a readily available source for energy production. Bamboo is a tropical tree with advantages of short rotation and high economic value for sustainable energy production. Bamboo wood waste application in fluidized bed combustion systems may create high energy generation and can significantly contribute sustainable decarbonization. Biomass combustion may create pollutant emissions and some ash related operational problems due to high alkali content of biomass ash. Hence, the prediction of ash characteristics and emissions from biomass fuels are crucial for combustion reactor design and for success of the operation. In this study, the ash behavior of bamboo wood waste in fluidized bed combustion system was evaluated in terms of bed agglomeration, slagging, fouling and corrosion via use of empirical indices and the flue gas emissions were predicted via the developed model.

BIOMASS AS GREEN POWER

Global climate change resulting from the combustion of fossil fuels has increased the attention on renewable energy generation options. Fossil fuels account for more than 80% of the total energy consumption in the World, whereas renewables account for 18 % of the global energy consumption in 2018 (Figure 1) [1]. Among the renewables such as solar, hydro, wind, etc. biomass is the only carbon neutral

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REFERENCES

1. World Bioenergy Association, "Global Bioenergy Statistics 2020", http://www.worldbioenergy.org/uploads/201210%20WBA%20GBS%202020.pdf
2. Akyürek Z. Sustainable Valorization of Animal Manure and Recycled Polyester: Co-pyrolysis Synergy, Sustainability 2019, 11 (8): 2280, 2019. Doi: 10.3390/su11082280
3. Khan AA, Jong W, Jansens PJJ, Spliethoff, HS. Biomass combustion in fluidized bed boilers: Potential problems and remedies. Fuel Processing Technology 2009; 90(1): 21-50. https://doi.org/10.1016/j.fuproc.2008.07.012
4. Bhattacharya SC, Salam PA, Pham HL, Ravindranath NH. Sustainable biomass production for energy in selected Asian countries, Biomass and Bioenergy 2003; 25: 471-482. https://doi.org/10.1016/S0961-9534(03)00085-0
5. Wong SL, Ngadi N, Abdullah TAT, Inuwa IM. Current state and future prospects of plastic waste as source of fuel: A review. Renewable and Sustainable Energy Reviews 2015; 50: 1167-1180. https://doi.org/10.1016/j.rser.2015.04.063
6. Akyürek Z, Ullah A, Sulaiman S.A., Gungör A, The Prediction of Asf Related Issues during Agro-waste Combustion in Fluidized Beds, New Horizons in Techno-Science, Akademisyen Publishing, ISBN:978-605-258-763-8, pp. 39 -50, 2019.
7. Gogebakan Z, Co-firing Biomass and Coal in Bubbling Fluidized Bed Combustors", PhD Dessertation, 2007, Middle East Technical University.
8. Farooq S, Pans MA, Afilaka DT, Liu CSH, Experimental investigation of woody and non-woody biomass combustion in a bubbling fluidised bed combustor focusing on gaseous emissions and temperature profiles, Energy 2017, 141: 2069-2080. https://doi.org/10.1016/j.energy.2017.11.118.
9. Werther, J, Saenger, M, Hartge, EU, Ogada, T, Siagi, Z. Combustion of agricultural residues, Progress in Energy and Combustion Science 2000; 26: 1–27. PII: S0360-1285(99)00005-2
10. Tobiasen L, Skytte R, Pedersen LS, Pedersen ST, Lindberg MA. Deposit characteristic after injection of additives to a Danish straw-fired suspension boiler. Fuel Process. Technol. 2007, 88: 1108-1117. https://doi.org/10.1016/j.fuproc.2007.06.017
11. Jensen PA, Stenholm M, Hald P. Deposition investigation in straw-fired boilers", Energy Fuels 1997, 11: 1048-1055.
12. Lapuerta M, Acosta A, Pazo A. Fouling deposits from residual biomass with high sodium content in power plants. Energy Fuels 2015, 29: 5007-5017.
13. Li G, Li S, Xu X, Huang Q, Yao Q, Dynamic behavior of biomass ash deposition in a 25 kW one-dimensional down-fired combustor, Energy Fuels 2014, 28: 219-227.
14. Deng L, Jin X, Long J, Che D. Ash deposition behaviors during combustion of raw and water washed biomass fuels. Journal of the Energy Institute 2019, 92(4): 959-970. https://doi.org/10.1016/j.joei.2018.07.009
15. Namkung H, Lee YJ, Park H, Song GS, Choi JW, Kim JG, Park SJ, Park JC, Kim HT, Choi YC. Influence of herbaceous biomass ash pre-treated by alkali metal leaching on the agglomeration/sintering and corrosion behaviors. Energy 2019; 187: 115950. https://doi.org/10.1016/j.energy.2019.115950
16. Yao XW, Xu KL, Yan F, Liang Y. The influence of ashing temperatures on ash fouling and slagging characteristics during combustion of biomass fuels. Bioresources 2017; 12: 1593-1610. https://doi.org/10.15376/biores.12.1.1593-1610
17. Billen P, Creemers B, Costa J, Van Caneghem J, Vandecasteele C, Coating and melt induced agglomeration in a poultry litter fired fluidized bed combustor, Biomass and Bioenergy 2014;

71-79. https://doi.org/10.1016/j.biombioe.2014.07.013
18. Scala F, Salatino P, Chirone R. Fluidized bed combustion of a biomass char (Robinia pseudoacacia). Energy and Fuels 2000; 14: 781-790.
19. Purbasaria A, Samadhia TW, Bindar Y. Thermal and Ash Characterization of Indonesian Bamboo and Its Potential for Solid Fuel and Waste Valorization. Int. Journal of Renewable Energy Development 2016, 5 (2): 95-100.
20. Gómez-Hernández J, Serrano D, Soria-Verdugo A, Sánchez-Delgado S, Agglomeration detection by pressure fluctuation analysis during Cynara cardunculus L. gasification in a fluidized bed", Chem Eng J 2016, 284: 640-649. Doi:10.1016/j.cej.2015.09.044.
21. Smith AM, Ross AB, The Influence of Residence Time during Hydrothermal Carbonisation of Miscanthus on Bio-Coal Combustion Chemistry, Energies 2019, 12: 523. Doi:10.3390/en12030523
22. Vamvuka D, Zografos D, Alevizos G, Control methods for mitigating biomass ash-related problems in fluidized beds, Bioresource Technology 2008, 99: 3334-3344. https://doi.org/10.1016/j.biortech.2007.07.049
23. Dayton DC, Jenkins BM, Turn SQ, Bakker RR, Williams RB, Belle-Oudry D, Hill LM, Release of inorganic constituents from leached biomass during thermal conversion, Energy and Fuels 1999, 13: 860. https://doi.org/10.1021/ef980256e.
24. Niu Y, Zhu Y, Tan H, Hui S, Jing Z, Xu W, Investigations on biomass slagging in utility boiler: criterion numbers and slagging growth mechanisms, Fuel Process Technol 2014, 128: 499-508.
25. Morris JD, Daood SS, Chilton S, Nimmo W, Mechanisms and mitigation of agglomeration during fluidized bed combustion of biomass: A review, Fuel 2018, 230: 452-473. Doi: 10.1016/j.fuel.2018.04.098
26. Liu Z, Zhang T, Zhang J, Xiang H, Yang X, Hu W, Liang F, Mi B. Ash fusion characteristics of bamboo, wood and coal. Energy 2018, 161: 517-522. https://doi.org/10.1016/j.energy.2018.07.131
27. DIRECTIVE (EU) 2015/2193 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2015
28. on the limitation of emissions of certain pollutants into the air from medium combustion plantshttps://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015L2193.
29. Salmenoja K, Field and Laboratory Studies on Chlorine-induced Superheater Corrosion in Boilers Fired with Biofuels, Åbo Akademi, 2000, Faculty of Chemical Engineering, Process Chemistry Group. ISBN: 9521206195, 9789521206191.
30. Vamvuka D, Pitharoulis M, Alevizos G, Repouskou E, Pentari D. Ash effects during combustion of lignite/biomass blends in fluidized bed, Renewable Energy 2009, 34: 2662–2671. https://doi.org/10.1016/j.renene.2009.05.005