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Energy potential from gasification of agricultural residues in Burdur, Turkey

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ABSTRACT

Gasification is one of the major waste to energy technologies for renewable energy production. Agricultural residues have high potential to be used as significant source of renewable energy in Turkey. In this study, different gasification systems are compared to estimate the bioenergy potential of agricultural residues in Burdur province. Syngas produced from gasification process can be used as renewable fuel in internal combustion engines, turbines and boilers. Syngas energy potential of agricultural residues from air gasification of agricultural residues are evaluated in up-draft fixed bed, down-draft fixed bed and circulating fluidized bed systems. The results revealed that down-draft gasifier has shown the highest annual energy production potential of 402 MW in Burdur province.

1. INTRODUCTION

The demand for energy has been steadily increasing in the last decades due to rapid growth in population and industrialization. Energy security is one of the main drivers of national energy policies in any country of the world today. Greenhouse gas emissions from fossil fuels have resulted in environmental pollution and global warming [1]. To reduce the negative impact of fossil fuel combustion, biomass is considered as one of the most promising routes for renewable energy production and for alleviating the environmental hazards [2-4].

Biomass resources are carbonaceous materials derived from agricultural crops, forestry, agro-industrial and urban waste. Biomass energy has advantage of being stored and transformed into heat and electricity, unlike the other renewables. Utilization of agricultural residues have several advantages such as recovering energy from waste materials, using local renewable energy source, providing environmental protection, etc. In the view of these issues, using the energy potential of these residues gain more importance in terms of sustainable development.

Gasification is an attractive energy production alternative from organic waste materials [5-7]. It is an environmentally friendly way of using bio-wastes for energy purposes [8]. Gasification results in higher energy recovery and heat capacity with respect to combustion and pyrolysis of biomass due to the optimum utilization of available biomass feedstock [9]. In gasification process biomass is converted into syngas by the partial oxidation of the solid fuel at high temperature, in the range of 800-1000 °C [10].

The gasification efficiency strongly depends on the operational parameters such as moisture content of biomass, gasifying agent, equivalence ratio, gasifier temperature, particle size of biomass, etc. [11]. Gasification can be carried out by using air, oxygen and/or steam as a gasifying agents. Product gas from gasification is the syngas which contains hydrogen, carbon monoxide, carbon dioxide, methane and nitrogen [12, 13]. Vast literature is available on the investigations of biomass gasification by using different gasifying agents, temperatures and gasifiers [14-18]. Air is widely used as gasifying

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agent and among the alternatives such as steam, air/steam, oxygen, air gasification is the most economical and operationally advantageous option [19].

High economic contribution of agricultural activities in Turkey signify the availability of agro residues for energy production. Burdur province which is located in the West Mediterranean Region of Turkey. The economy of the city strongly depends on agricultural activities and livestock farming. Hence, there is high bio-waste potential. In this study, gasification energy potential of agricultural residue inventory in Burdur province has been evaluated with different types of gasifiers by using the previously published syngas composition data [11, 18].

2. MATERIALS AND METHODS

In this study, agricultural residue based gasification performance and syngas energy production potential is estimated for Burdur province by using different air-gasification technologies. The agricultural production data provided from Turkish Statistical Institute is given in Table 1 [20]. Variety of gasifiers have been developed for partial oxidation of the solid fuels such as fixed bed downdraft, fixed bed updraft, fluidized bed. Schematic description of the gasifier types used in this study is demonstrated in Fig. 1. As can be seen from the figure, in the updraft gasifiers, the gasifying agent enters the system from the bottom part of the gasifier and leaves from the top. Biomass on the other hand, enters the system from the top of gasifier and move toward the bottom where it gets oxidized and generate flue gases. In downdraft gasifiers both biomass enters the system from the top and biomass and air move in the downward direction of the gasifier unit. Fluidized bed gasifiers are known by their fuel flexibility characteristics. In circulating fluidized beds, biomass circulates within the gasifier and the cyclone separator. Table 2 reports indicative variation of syngas composition for different air-gasifiers.

Table 1. *Agricultural production in Burdur [20].*

Agricultural Products	Production Rate (ton/year)
Wheat	135661
Corn	369643
Barley	70435
Rye	7131
Oat	20023
Sugar Cane	186801
Tomato	1449623
Olive	271
Walnut	2511

Table 2. *Experimental results of woody biomass gasification using different types of gasifiers [18].*

Gas composition (% vol, dry basis)	Updraft	Downdraft	CFB
H_2	11	17	14.1
CO	24	21	18.7
CO_2	9	13	14.7
CH_4	3	1	3.5
N_2	53	48	47.7

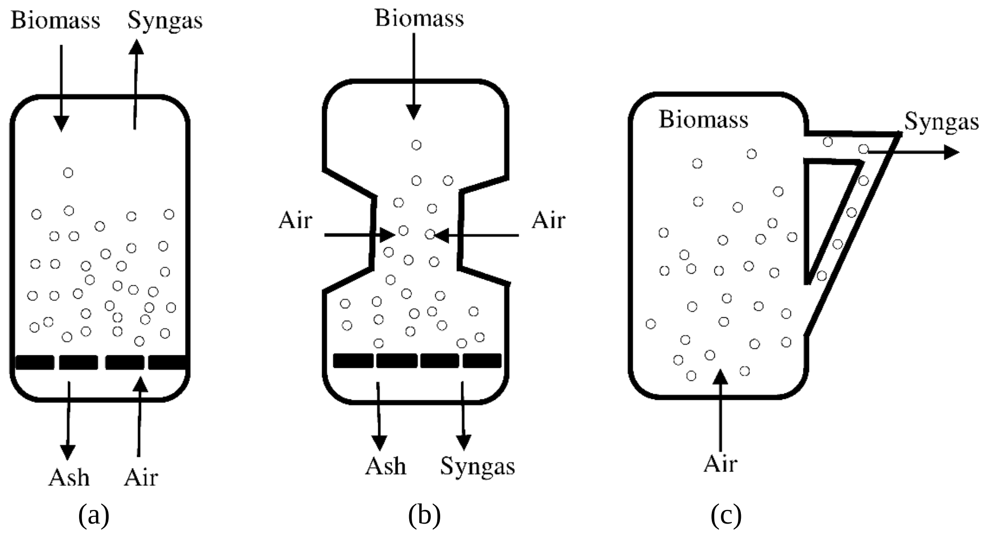

Fig.1. *Different gasification technologies (a) updraft, (b) downdraft, (c) circulating fluidized bed (CFB)*

3. RESULTS AND DISCUSSION

Biomass gasifiers convert solid biomass into gaseous products to be used for energy production. Gasification performance and syngas composition of biomass strongly depend on the operating parameters and type of the gasifier system. Energy content of the produced syngas is generally expressed by its heating value (MJ) generated from 1 Nm^3 of syngas [11]. Agro residue energy potential of Burdur province has calculated by using the previously published experimental data. Estimated syngas composition of the biomass residues are shown in Fig. 2. As can be seen from the figure downdraft gasifier has shown to have higher hydrogen, carbon monoxide, carbon dioxide and nitrogen emission indicating higher energy production performance compared to updraft and circulating fluidized bed systems.

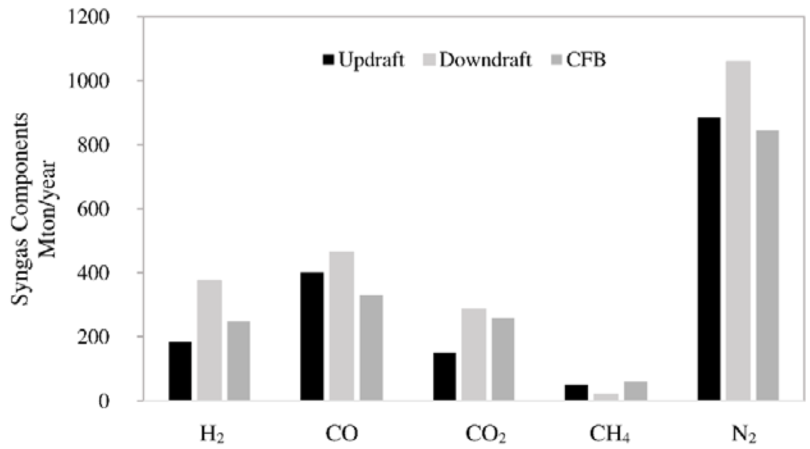

Fig.2. *Production rate of different syngas components from updraft, downdraft and CFB systems*

Influence of the reactor type (updraft, downdraft and circulating fluidized bed gasification systems) on energy production are presented in Table 3. The results revealed that downdraft gasifier system can provide higher potential of energy generation from agricultural residues in Burdur province with respect to updraft and fluidized bed technologies.

Table 3. *Energy production from different air-gasification systems estimated for agricultural residue potential of Burdur province*

	kWh
Updraft	293,788
Downdraft	401,902
CFB	254,795

4. CONCLUSION

Biomass gasification is a well-known technology pathway to convert biomass to hydrogen and other products, without combustion. The influence of various gasification systems in the final composition of syngas was evaluated for Burdur province based on the previously published experimental data. Conlusions can be drawn that there is significant potential of agricultural residue in the Burdur province. Comparisons have shown that downdraft gasifier has higher energy production capacity than those of updraft and circulating fluidized bed systems. Burdur province has shown to have 402 MW annual thermal energy production potential from downdraft air-gasification of agricultural residues.

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REFERENCES

[1]. Winley, T. M. L. (2018). The Paris warming targets: emissions requirements and sea level consequences. *Climatic Change*, vol. 147, no.1, p. 31-45, DOI: 10.1007/s10584-017-2119-5.
[2]. Hegazy, A., Ghallab, A. O., Ashour, F. H. (2017). Integrated gasification combined cycle using Egyptian Maghara coal–rice straw feedstock. *Waste Management and Research*, vol. 35, no. 6, p. 656–68, DOI: 10.1177/0734242X17702728.
[3]. Wielgosiński, G., Łechtańska, P., Namiecińska, O. (2017). Emission of some pollutants from biomass combustion in comparison to hard coal combustion. *Journal of the Energy Institute*, vol. 90, no. 5, p. 787-96, DOI: 10.1016/j.joei.2016.06.005.
[4]. Vakais, A., Sotiropoulos, A., Moustakas, K., Malamis, D., Baratieri, M. (2016). Utilisation of biomass gasification by-products for onsite energy production. *Waste Management & Research*, vol. 34, no. 6, p. 564–71, DOI: 10.1177/0734242X16643178.
[5]. Gohlke, O. (2009). Efficiency of energy recovery from municipal solid waste and the resultant effect on the greenhouse gas balance. *Waste Management and Research*, vol. 27, no. 9, p. 894- 906, DOI: 10.1177/0734242X09349857.
[6]. Van De Kaa, G., Kamp, L., Rezaei, J. (2017). Selection of biomass thermochemical conversion technology in the Netherlands: A best worst method approach. *Journal of Cleaner Production*, vol. 166, no. 10, p. 32-39, DOI: 0.1016/j.jclepro.2017.07.052.
[7]. Burra, K. G., Hussein, M. S., Amano, R. S., Gupta, A. K. (2016). Syngas evolutionary behavior during chicken manure pyrolysis and air gasification. *Applied Energy*, vol. 181, p. 408-415, DOI: 10.1016/j.apenergy.2016.08.095.
[8]. Ismail, T. M., El-Salam, M. A., Monteiro, E., Rouboa, A. (2018). Fluid dynamics model on fluidized bed gasifier using agro-industrial biomass as fuel. *Waste Management*, vol. 73, p. 476-486, DOI: 10.1016/j.wasman.2017.06.018.
[9]. Sansaniwal, S. K., Pal, K., Rosen, M. A., Tyagi, S. K. (2017). Recent advances in the development of biomass gasification technology: A comprehensive review. *Renewable and Sustainable Energy Reviews,* vol. 72, p. 363-84, DOI: 10.1016/j.rser.2017.01.038.
[10]. Lopes, E. J., Queiroz, N.,, Yamamoto, C. I., Neto, P. R. C. (2018). Evaluating the emissions from the gasification processing of municipal solid waste followed by combustion. *Waste Management*, vol. 73, p. 504-510, DOI: 10.1016/j.wasman.2017.12.019.
[11]. La Villetta, M., Costa, M., Massarotti, N. (2017). Modelling approaches to biomass gasification: A review with emphasis on the stoichiometric method. *Renewable and Sustainable Energy Reviews*, vol. 74, p. 71-88, DOI: 10.1016/j.rser.2017.02.027.
[12]. Gungor, A. (2011). Modeling the effects of the operational parameters on H2 composition in a biomass fluidized bed gasifier. *International Journal of Hydrogen Energy*, vol. 36, no.11, p. 6592-600, DOI: doi.org/10.1016/j.ijhydene.2011.02.096.
[13]. Gungor, A., Yildirim, U. (2013). Two dimensional numerical computation of a circulating fluidized bed biomass gasifier. *Computers & Chemical Engineering*, vol. 48, p.234-50, DOI: 10.1016/j.compchemeng.2012.09.012.
[14]. Sutton, D., Kelleher, B., Ross, J. R. H. (2001). Review of literature on catalysts for biomass gasification. *Fuel Process Technology*, vol. 73, no. 3, p. 155–73, DOI: 10.1016/S0378-3820(01)00208-9.
[15]. Saxena, R. C., Seal, D., Kumar, S., Goyal, H. B. (2008). Thermo-chemical routes for hydrogen rich gas from biomass: a review. *Renewable Sustainable Energy Review*, vol. 12, no. 7, p. 1909–27, DOI: 10.1016/j.rser.2007.03.005.
[16]. Chhiti, Y., Kemiha, M. (2013). Thermal conversion of biomass, pyrolysis and gasification: a review. *International Journal of Engineering Science*, vol. 2, no. 3, p. 75–85.
[17]. Hu, P., Hu, M., Shao, Z., Cheng, Y. (2018). Thermodynamic analysis of steam gasification of municipal solid waste. *Energy Sources: Part A: Recovery, Utilization and Environmental Effects*, vol. 40, no. 3, p. 623-629, DOI: 10.1016/J.ENG.2017.03.004.
[18]. Couto, N., Rouba, A., Silva, V., Monteiro, E., Bouziane, K. (2013). Influence of the biomass gasification processes on the final composition of syngas. *Energy Procedia*, vol. 36, p.596-606, DOI: 10.1016/j.egypro.2013.07.068.
[19]. Salami, N., Skála, Z. (2015). Use of the steam as gasifying agent in fluidized bed gasifier. *Chemical and Biochemical Engineering Quarterly*, vol. 29 no. 1, p. 13-18, DOI: 10.15255/CABEQ.2014.2120.
[20]. Turkish Statistical Institute Database, from http://www.tuik.gov.tr/ (accessed November 19, 2018)

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