ARTICLE IN PRESS

Alexandria Engineering Journal (2016) xxx, xxx–xxx

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Alexandria Engineering Journal

www.elsevier.com/locate/aej
www.sciencedirect.com

ORIGINAL ARTICLE

An investigation on the performance of sawdust briquette blending with neem powder

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Received 9 July 2015; revised 19 March 2016; accepted 11 July 2016

KEYWORDS

Thermogravimetric analysis;
Biomass briquettes;
Neem powder;
Sawdust;
Performance study

Abstract This paper discusses the performance of the sawdust and neem powder briquette and its blends. In the first set of experiments, the sawdust and neem powder briquettes are produced by manually operated hydraulic pelletizer in the pressure range of 7–33 MPa. The strength of briquettes is investigated by the shatter index, impact resistance, durability index and water resistance test. The calorific value and water boiling tests have been also conducted to study the performance of the briquettes. The result shows that the neem powder briquette has significantly higher strength, but lower calorific value compared with the sawdust briquette. Also the performance of the briquettes increases with increase in pressure. Thus the maximum pressure of 33 MPa is used for the second set of experiments. In the second set of experiments, the neem powder is blended with the sawdust in the ratio of 100:0, 75:25, 50:50, 25:75, 0:100 (Sawdust:Neem powder). The study shows that the sawdust with neem powder as binding agent has considerably increased the strength of the briquette with a little reduction in burning rate.

1. Introduction

The renewable energy sources should be effectively utilized in order to meet the rapidly increasing energy demand. Biomass energy has greater prospective than the other form of energy, since it is renewable, in contrast to the nature of the fossil fuels. One of the major limitations of using biomass as a feedstock is its low bulk density, which typically ranges from 80 to 100 kg/m^3 for agricultural straws and grasses and 150 to 200 kg/m^3 for woody resources such as wood chips and sawdust [1].

Saidur et al. [2] have discussed the several aspects of burning the biomass in boilers and found that utilizing biomass in boilers may offer the economical, social and environmental benefits such as conservation of fossil fuel resources, financial net saving, CO_2 and NO_x emissions reduction and job opportunities creation. Combustion characteristics and different biomass conversion technologies have been studied by Demirbas [3] and concluded that the co-firing of biomass with coal helps to reduce the total emission compared to the single coal firing. Gonzalez et al. [4] have studied the optimization of combustion process for domestic heating system for four different pellets (tomato, olive stone, cardoon and forest). The optimum residue mixture of 75:25 (tomato:forest) resulted in a boiler efficiency of 92.4%.

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Peer review under responsibility of Faculty of Engineering, Alexandria University.

http://dx.doi.org/10.1016/j.aej.2016.07.009
1110-0168

Dong et al. [5] have reviewed the development of small and micro scale combined heat and power (CHP) system technologies based on the biomass energy and listed the advantages and disadvantages of the CHP systems. They have further recommended that significant research efforts are needed in order to commercialize the next generation stand-alone small-scale and micro-scale biomass fueled CHP systems. Míguez et al. [6] have reviewed the different technologies available in the European market for the small scale biomass combustion system and reported that solid fuel boiler usage has been continuously increasing across Europe. The different factors that affect the strength and durability of the densified biomass products have been reviewed by Kaliyan and Morey [7]. The compressive resistance, impact resistance, water resistance, and durability are the important parameters used to determine the strength of the densified products [7].

Chin and Siddiqui [8] have experimentally investigated the characteristics of different biomass briquettes (sawdust, rice husks, peanut shells, coconut fibers and palm fruit fibers) under different die pressures. The result shows that the sawdust briquette has better overall handling characteristics than others. Li and Liu [9] have investigated the performance of binderless compaction of the wood processing residue waste at high pressure in the range of 34–138 MPa. The result shows that the strongest logs are made with the oak sawdust, cottonwood sawdust next and the least log with pine sawdust. Yaman et al. [10] have produced fuel briquettes from olive refuse and paper mill waste at different die pressures (150–250 MPa) and suggested that it can be used as an alternative energy source. Coates [11] has made briquette from cotton plant residue and the result demonstrates that it can replace the waste paper used by the factory as an ingredient when producing pecan shell briquettes, with minimal decrease in briquette quality.

Zhang et al. [12] have reported that the briquette strength is improved by adding the bentonite, coal tar and/or polypropylene amide into rice straw-based binder. Ndiema et al. [13] have investigated and concluded that die pressure has a considerable effect on the size of biomass. Srivastava et al. [14] have found that increasing the pressure from 5 to 44 MPa increased the wafer durability rating of grass hay from 5 to 91%. Mani et al. [15] have investigated the specific energy required to produce the compact corn stover briquette and reported that the density increases with increase in pressure.

The addition of binders with biomass materials might have a positive outcome on the strength of the wood pellets, in a similar way to the adhesive resin used in the production of particle and fiber-boards. Starch, protein, fiber, fat/oil, lignosulfonate, bentonite and modified cellulose have been investigated as binders to positively influence the durability of densified products [16–21]. Ahn et al. [22] have investigated the effect of different binder contents (rapeseed flour, coffee meal, bark, pine cones, and lignin powder) on durability of wood pellets. In the production of wood pellets, binders can be used to make strong interparticle bonds in the presence of heat and moisture. Numerous organic and inorganic binders could be employed for the densification process of wood pellets [22].

The literature shows the importance of the biomass energy in today's scenario. In previous works, researchers made investigations to improve the performance of the briquettes by varying the applied pressure and different binder materials such as adhesive resin, starch, protein, fiber, fat/oil, lignosulfonate, bentonite, modified cellulose, rapeseed flour, coffee meal, bark, pine cones, and lignin powder. The literature shows that, the strength is a very important parameter in handling, transportation and steady combustion of biomass briquettes. This present work investigates the way to improve the strength of the sawdust briquette with neem powder as a new binding agent. Two sets of experiments are carried out in this work. In the first set of experiments, the performance of the sawdust and neem briquette is investigated individually. In second set of experiments, the sawdust is blended with neem powder in the ratio of 100:0, 75:25, 50:50, 25:75 and 0:100. The performances of the briquettes have been studied in terms of its shatter index test, impact resistance test, durability index test, water resistance test, calorific value and water boiling test.

2. Materials and methods

A manually operated hydraulic pelletizer has been used to produce the briquette as shown in Fig. 1. The die has an internal diameter of 44 mm with a height of 70 mm. The pelletizer can operate in the range of 0–52 MPa. However, for flexible and safety operation the maximum pressure is limited to 33 MPa. Each briquette is produced with 30 grams of sawdust or neem powder and five different pressures in pelletizer (7, 13, 20, 26 and 33 MPa). The thickness of the briquette will vary with the pressure, which affects the performance of the briquette. In the first set of experiments, strength of the sawdust and neem powder is investigated individually by shatter index, impact resistance, durability index and water resistance test.

The second sets of experiments are carried out based on the result of the first set of experiments. The strength of sawdust is improved by blending the sawdust with neem powder in

Figure 1 Photographic view of manually operated hydraulic pelletizer.

Please cite this article in press as: T. Rajaseenivasan et al., An investigation on the performance of sawdust briquette blending with neem powder, Alexandria Eng. J. (2016), http://dx.doi.org/10.1016/j.aej.2016.07.009