Waste Management xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Physical and chemical evaluation of furniture waste briquettes

Ana Isabel Moreno *, Rafael Font, Juan A. Conesa

Department of Chemical Engineering, University of Alicante, P.O. Box 99, E-03080 Alicante, Spain

A R T I C L E I N F O

Article history:
Received 29 October 2015
Revised 20 January 2016
Accepted 31 January 2016
Available online xxxx

Keywords:
Furniture waste
Briquettes
Durability
Physical characterisation
Chemical composition

A B S T R A C T

Furniture waste is mainly composed of wood and upholstery foam (mostly polyurethane foam). Both of these have a high calorific value, therefore, energy recovery would be an appropriate process to manage these wastes. Nevertheless, the drawback is that the energy content of these wastes is limited due to their low density mainly that of upholstery foam. Densification of separate foam presents difficulties due to its elastic character. The significance of this work lies in obtaining densified material by co-densification of furniture wood waste and polyurethane foam waste.

Densification of furniture wood and the co-densification of furniture wood waste with polyurethane foam have been studied. On the one hand, the parameters that have an effect on the quality of the furniture waste briquettes have been analysed, i.e., moisture content, compaction pressure, presence of lignin, etc. The maximum weight percentage of polyurethane foam that can be added with furniture wood waste to obtain durable briquettes and the optimal moisture were determined. On the other hand, some parameters were analysed in order to evaluate the possible effect on the combustion. The chemical composition of waste wood was compared with untreated wood biomass; the higher nitrogen content and the concentration of some metals were the most important differences, with a significant difference of Ti content.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

At the end of its life, furniture is often disposed of in municipal solid wood treatment plants. Furniture waste is mainly composed of different types of treated wood (plywood, engineered wood, melamine fibreboard, painted wood, etc.) and upholstery foams (mainly polyurethane foam). Recycling of this waste would be nearly impossible, due to the oils, glues, paints and varnishes used in the fabrication of the furniture (Khalfi et al., 2000). Nevertheless, energy recovery is a possible way to manage this waste, and its use would improve the management of environmental resources and waste.

The use of lignocellulosic waste is becoming increasingly important in power plants. These plants can make direct combustion of biomass or co-firing biomass with coal. However one inconvenience of some types of waste is that their energy content is limited due to their low density. A possible solution to this is the densification of these biomass feedstocks into pellets or briquettes in order to produce a homogeneous fuel with a high energy density. Some existing coal-fired power plants have been transformed to co-fire biomass and coal, but the difference in density between biomass and coal also causes difficulties in feeding the fuel into the boiler. Good densification of the material has proven to solve these problems (Li and Liu, 2000).

This study focuses on the main materials that compose furniture waste, furniture wood waste and polyurethane foam waste. This foam also has a high calorific value; however its low density (10–80 kg/m^3) is a great disadvantage for its energy recovery. Given the physical characteristics of this material, densification of separate foam is very difficult; however, a solution would be co-densification with furniture wood waste. In addition, densification reduces the costs of transportation, handling, and storage. Uniform shape and sizes of the densified waste is also an advantage for designing the burning appliances.

Biomass briquettes can undergo fragmentation and abrasion during handling, transportation, and storage. Durability (DU) is the most important parameter for evaluating the quality of densified biomass (CEN, 2003). Low DU causes problems in transportation and storage, biomass losses, and can cause dust emissions during combustion. Frequently, another parameter to evaluate the briquette quality is briquette density (particle density) (Križan et al. (2009)). Nevertheless, Temmerman et al. (2006) found no relation between DU and particle density in pellets and briquettes, nor did Obernberger and Thek (2004) find this relation in pellets. The particle density influences combustion behaviour, because denser materials have a longer burnout time (Obernberger and Thek, 2004).

* Corresponding author.
E-mail address: anaisabel.moreno@ua.es (A.I. Moreno).

http://dx.doi.org/10.1016/j.wasman.2016.01.048
0956-053X/© 2016 Elsevier Ltd. All rights reserved.

Some factors that can influence the quality of the densified products are: compaction pressure, material moisture, fraction particle of the initial material, pressing temperature, etc. (Ishii and Furuichi, 2014; Kaliyan and Vance Morey, 2009; Križan et al. (2009); Lee et al., 2013; Stelte et al., 2011).

In densification processes, the mechanical pressure creates bonds between the particulate matter and moreover the presence of natural binders (such as lignin, proteins, fats, starch, and water soluble carbohydrates) produces solid bridges between the particles. Kaliyan and Morey (2009, 2010) focused on explaining the significance of natural binders to obtain strong and durable bonding during densification processes. Just as densification of separate polyurethane foam presents significant difficulties, these authors also found difficulties to densify switchgrass. They therefore studied some strategies to obtain strong bonding between particles: (a) find the optimum moisture and temperature to activate the natural binders such as lignin, protein and starch in the biomass, (b) adding chemical binders, and (c) mixing switchgrass with other biomass-based binders. They concluded that one important factor was preheating at 100 °C to activate the binders before applying pressure. The mixing of 80% of switchgrass with 20% of corn stover (biomass-based binder) also showed a significant increase in the quality of the briquettes, without the additional cost that the addition of chemical binders would assume. In addition, they also studied the particle bonds in briquettes and pellets of corn stover and switchgrass by micro-structural analysis (SEM technique and Ultraviolet auto-fluorescence microscopy). They were able to conclude that natural binders (mainly lignin and protein) formed strong bonds between the particles.

In the same way, almond shells show elastic recovery after compression, but good quality briquettes were obtained at 70–80 °C or at 180 °C (Font, 2004).

The present work, on one hand, shows a chemical characterisation of furniture wood waste and polyurethane and their values have been compared with those of another three kinds of lignocellulosic waste in order to analyse the effect of the chemical content in the combustion behaviour of these wastes.

On the other hand, furniture wood waste has been subjected to a compaction process at different moisture content, compaction pressures and in the presence of polyurethane foam in different proportions, in order to evaluate the possibility of using this material as a mixed fuel.

2. Materials and methods

2.1. Chemical characterisation

The furniture waste was collected from a municipal solid waste treatment plant. Furniture waste is mainly composed of wood and upholstery foam (mostly polyurethane foam). Representative samples of both types of waste (furniture wood waste and polyurethane foam) were dried at 105 °C and grounded to carry out a chemical characterisation (Tables 1 and 2).

Table 1 shows the elementary properties (calorific value and ash content) and the main chemical composition of furniture wood waste and polyurethane foam analysed previously (Garrido and Font, 2015; Moreno and Font, 2015). Table 2 shows the major and minor elements of different types of waste and wood. These wastes are compared with other three wastes: a clean waste such as solid wood (Moreno and Font, 2015), treated wood such as engineered wood and a dirty lignocellulosic waste such as vine shoots.

2.1.1. Determination of the total content of carbon, hydrogen and nitrogen

The total content of carbon, hydrogen and nitrogen in biomass was measured following the CEN-TS 15104:2011 Standard. The determination was performed in a Leco Micro TruSpec Elemental Analyzer.

2.1.2. Determination of the net calorific values

The determination of the net calorific values was performed in an AC-350 calorimetric bomb (Leco Corporation, Michigan, USA).

2.1.3. Determination of the ash content

The ash content is calculated by the inorganic matter that remains after combustion under controlled conditions at 550 °C according to CEN-TS 14775:2009. The difference should be remembered between the temperature to determine ash content in solid mineral fuels (815 °C according to Standard ISO 1171:2010) and in biomass fuels (550 °C). The reason is that biomass ash, in practice, contains several volatile inorganic compounds.

2.1.4. Determination of the total content of sulphur, chlorine and bromine

The European Standard to determinate the content of sulphur and chlorine in solid biofuels is the CEN-TS 15289:2011. This method consists in the oxidation of the sample by combustion in a bomb containing oxygen under pressure and the liberated inorganic anions were absorbed in water or in an alkali solution, e.g. sodium carbonate/sodium bicarbonate solution, if the content of chlorine or sulphur is high. The bomb combustate solution was analysed by Ion Chromatography. In addition, the bromide was also analysed from the combustate solution (EPA, 1994); the determination of bromine in these types of waste wood is also important, because they can contain Brominated Flame Retardants (BFRs). The determinations were carried out with a Dionex DX 500 ion chromatograph.

2.1.5. Determination of the major and minor elements

A multi-step pressurised digestion was carried out following the CEN-TS 15290:2011 Standard for the determination of the major elements (Al, Ca, Mg, P, K, Si, Na and Ti) and following the CEN-TS 15297:2011 Standard for the minor elements (As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sb, V and Zn). Subsequently, the detection of the major elements was carried out by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) following the CEN-ISO 11885:2007 Standard; the detection of the minor elements was carried out by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) following the CEN-ISO 1729-2:2003 Standard.

2.2. Study of the parameters affecting the quality of waste wood briquettes

In this study, a hydraulic piston press briquette machine (Mega KCK-50) has been employed to compare the physical characteristics of the waste wood briquettes. A 53.0 mm diameter cylindrical mould was used to make the briquettes.

The runs were carried out at room temperature and the parameters studied were: compaction pressure, material moisture and percentage of foam included. Five different compaction pressures were studied: 22, 33, 44, 67 and 88 MPa. Different material moisture was also studied: 6%, 8% and 10%. On the other hand, the material moisture was fixed at 8% (this moisture was demonstrated to be suitable to obtain high quality briquettes) to study the effect of the mixture of the waste wood with different percentages of foam.

The densities of the briquettes were measured immediately after the briquettes were ejected from the mould. After stabilisation for 24 h, the densities were measured once more. During the stabilisation time, the size and parameters of the briquettes change, due to dilatation, as stated in literature (Križan et al.

Download English Version:

https://daneshyari.com/en/article/6353790

Download Persian Version:

https://daneshyari.com/article/6353790

Daneshyari.com