Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VI, 2017
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

BRIQUETTING OF ROSE OIL PROCESSING WASTES WITH TWO DIFFERENT DIES USING HYDRAULIC PRESS MACHINE

Kamil EKINCI[1], Oral ERTUĞRUL[1], Haşmet Emre AKMAN[2], Murat MEMICI[1], Davut AKBOLAT[1]

[1]Suleyman Demirel University, Isparta, Turkey
[2]Akdeniz University, Antalya, Turkey

Corresponding author email: kamilekinci@sdu.edu.tr

Abstract

Rose oil processing wastes (ROPW) resulted from water distillation process from petals of R. damascena Mill, which is a by-product of rose oil producing industry leads to environmental problems such as odor and visual pollution. Since these wastes are rich in organic matter, it could be considered as a briquetting material to produce bioenergy. A hydraulic press was used for briquetting process in this study. Two different hexagonal dies with the height of 150 mm were used. No binding material was mixed with ROPW. The resultant briquettes were full hexagonal briquettes with the height of 100 mm and the outer diameter of 60 mm and hollow-core hexagonal briquettes with the height of 100 mm and the outer diameter of 80 mm with 20 mm inner diameter of central hole were produced. All briquettes were stored under ambient conditions for 7 days before testing. Shattering resistance, abrasive resistance, air humidity resistance, water intake resistance tests, thermo-gravimetric analysis, and flue gas emissions (CO_2, CO, SO_2, and NO_X) were performed. The results were discussed in the paper.

Key words: *briquetting, hexagonal briquettes, rose oil processing wastes.*

INTRODUCTION

Industrial developments in recent years have brought with it the problems of environmental wastes. Elimination or utilization of environmental wastes (industrial, domestic and agricultural) has become inevitable for the modern society. In many developed countries, solid wastes by biomass briquetting are converted to usable, economical and saleable products. Agricultural wastes emerge from agricultural production and agro-industrial operations. Despite being an important source to meet energy needs especially in developing countries, it can be stated that utilization of these wastes are not at the desired level. Briquetting of agricultural wastes or residues is one of the methods used effectively for utilization of biomass. Since agricultural wastes have high moisture content and low density, they are not very efficient for direct combustion in the industrial area or residential heating. Furthermore, the direct use of these wastes is not economical due to transportation, storage and processing operations. In addition, bulk storage of these wastes cause soil, air, water and visual pollution. Briquetting, compression of sufficiently fragmented materials, improves volumetric heat value and combustion characteristics of biomass, reduces storage costs, decreases particulate emissions to atmospheric, and provides homogenous solid fuel with the same size and shape. Physical properties of briquettes obtained from hydraulic type presses are dependent on the material types, material particle size, moisture content, compaction pressure, the pressure application time, the compression temperature, addition of heating system to the mold and the adhesive materials (Li and Liu, 2000; Suhagar et al., 2006). In order to obtain briquettes with higher shatter resistance, abrasive resistance, water and air resistance, these wastes should be compressed at higher pressure and material with low moisture content and smaller particle size. The addition of heating system to the mold release lignin contained in the biomass and serve as adhesive material. Therefore, the quality of briquettes is improved (Akman and Bilgin, 2012). Rose oil processing wastes (ROPW) are suitable to produce briquettes without adhesive material using hydraulic press machine. The resultant briquettes could be utilized in traditional stoves for domestic heating and cooking purposes. In addition, these briquettes can be used in advanced heating systems in the greenhouse (Akman and Bilgin, 2012). This study aimed to determine effects of two different dies on briquetting of rose oil processing wastes using hydraulic press machine.

MATERIALS AND METHODS

Experiments were carried out in the Department of Agricultural Machinery and Technologies Engineering, Suleyman Demirel University, Biomass Laboratory, Isparta, Turkey. ROPW was received from Biolandes Rose oil Industry and Trade Incorporation Company in Isparta Province. Chemical and physical characteristics of ROPW are given in the Table 1. There was no binding material used for briquetting.

Table 1. Properties of ROPW used in experiment

Properties	ROPW
Moisture content (wb.,%)	81.68±0.57
Ash content (%)	31.55±1.52
C (%)	49.58±0.11
N (%)	4.92±0.02
S (%)	0.39±0.02
Higher heating value(kcal/kg)	4599.48

The moisture contents of materials were determined using an oven set at 105 ± 1 °C for 24 hours. Ash contents of materials were analyzed based on ISO 1171-1981 at 550 ºC. Elemental analysis (C, N, and S) was performed using an elementary analyzer (Elementary vario MACRO CUBE, Germany). The higher heating value of materials was measured using a calorimeter IKA C4000 (ISO-1928-89). A hydraulic type briquetting machine with maximum compression of 100 tons was used for briquetting process. It has 1 kW electric motor power. Compression was gradually increased to 10 tons for 2-3 seconds, and then the hydraulic system was stopped. In order to produce full and hollow-core hexagonal briquettes, two different hexagonal dies with height of 150 mm were used. No binding material was mixed with ROPW. The full hexagonal briquettes and hollow-core hexagonal with centered shaft are presented in Figure 1. The resultant briquettes were full hexagonal briquettes with the height of 100 mm and the outer diameter of 60 mm and hollow-core hexagonal briquettes with the height of 100 mm and the outer diameter of 80 mm with 20 mm inner diameter of central hole were produced (Figure 2).

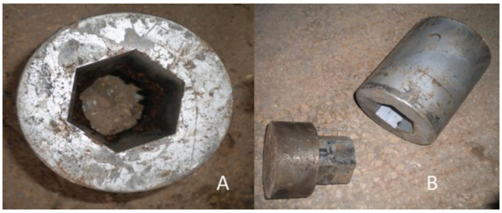

Figure 1. (A) Die for hollow-core hexagonal briquettes with the centered shaft; (B) die for full hexagonal briquettes

Figure 2. (A) Hollow-core hexagonal briquettes; (B) full hexagonal briquettes

Tests for the quality of briquettes

Shattering resistance, abrasive resistance, air humidity resistance, water intake resistance, and density measurement of the briquettes were carried out. Before the tests, briquettes were kept under indoor conditions for 7 days.

Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

Shattering resistance

In shattering resistance test, the mass of briquettes was measured initially and dropped on a hard surface from the height of 1 m for ten times. After this process, mass of briquettes was measured again. Shattering resistance (%) depending on the loss due to breakage of briquettes on the surface was calculated (CRA, 1987).

Abrasive resistance

Abrasive resistance (%), which is also called as "durability test" simulate mechanical or pneumatic handling. To examine mechanical robustness, briquettes were subjected to durability tester described by ASAE S269.4. Durability tester used in the experiment is given in Figure 3.

Figure 3. Durability tester for briquettes in experiments

In the experiments, masses of briquettes (6) determined initially, were placed in a cage of tester unit and rotated 40 min^{-1} for 3 minutes as described by ASAE S269.4. At the end of rotation, briquettes were weighed again and the mass was recorded.

Water intake resistance

Water intake resistance is a measure of the amount of water absorbed by briquette immersed in the water. Before soaking briquettes into water, the masses were measured initially. Then, each briquette was immersed in tap water at the temperature of 18°C for 2 minutes. Water intake resistance depending on the increase in mass after 1 and 2 minutes, consecutively was recorded as a percentage (CRA, 1987).

Air humidity resistance

In this test, after the briquettes are sun-dried in the ambient air conditions, they were kept in a room at the temperature of 20 °C for 21 days. Mass of briquettes was weighed and recorded after and before drying process. Depending on the increase in weight of briquettes, equivalent moisture content was calculated as a percentage (Akman, 2012).

Density measurement

For the density measurement, briquettes were weighed and their masses were recorded. Then, inner and outer diameters and length of the hexagonal briquettes were measured by calipers and briquette volume was calculated. Briquette density was determined by dividing mass of briquette by its volume (Akman, 2012).

Termogravimetric analysis

Thermogravimetric analysis (TGA), the most useful and quick technique for evaluating combustion characteristics of solid fuel, was carried out on Perkin Elmer Diamond TG/DTA model termogrametric analyzer.

All combustion experiments were conducted at atmospheric pressure, using temperature range from 25 to 900°C with a heating rate of 10°C/min and an air flux of 20 ml/min (N_2 environment).

Determination of flue gas emissions

Briquettes were combusted in a traditional bucket type stove to determine flue gas emission resulted from combustion.

The emissions (CO, CO_2, NO_X and SO_2) and O_2 consumption were analyzed by a flue gas analyzer (TESTO 350 M XL-454). Measurement of combustion flue gas emission was performed based on Regulation on Air Pollution Caused by Heating (OG, 2005). In the experiments, the measuring probe of flue gas analyzer was located at the point opened on the vertical pipe of stove.

Statistical analysis

All data were submitted for statistical analyses using Minitab (Minitab Inc., USA). The mean and standard deviation were reported for all measured parameters. Turkey test was performed to compare differences among means of two different treatments. Statistical significance was defined as $p < 0.05$.

RESULTS AND DISCUSSIONS

Tests for the quality of briquettes

The test results on quality of briquettes are presented in Table 2 for both types of briquettes. No significant differences were detected on shattering resistance, abrasive resistance, water intake resistance, air humidity resistance, and density for full and hollow-core hexagonal briquettes ($p < 0.05$). Shattering resistances (%) for full and hollow-core hexagonal briquettes were 84.44 and 86.38%, respectively. Shattering resistance test may simulate the forces encountered during unloading briquettes from trucks onto ground (Kaliyan and Morey, 2009). Abrasive resistances were 93.01 and 88.43 % for full and hollow-core hexagonal briquettes, respectively. Abrasive resistance test gives an idea about quality of briquettes. Eriksson and Prior (1996) reported that abrasive resistance of briquettes ranges from 50% to 100%. While water intake resistance (%) for the first minute were 59.42 and 65.87 for full and hollow-core hexagonal briquettes, respectively, water intake resistance (%) for the second minute were 38.60 and 42.82 %. It has been reported that the increase in weight of briquette at the end of each minute should be less than 50% of the initial weight of briquette for the acceptable briquette quality (CRA, 1987). Air humidity resistances (%) were 97.37 and 97.29% for full and hollow-core hexagonal briquettes. The results indicated that briquettes can be stored for long time without structural changes occurred at the suitable environmental conditions. Densities of full and hollow-core hexagonal briquettes were 1150 and 1119 kg/m^3, respectively. It can be concluded that densities of the briquettes obtained from this study is within the range of values (1000 - 1400 kg/m^3) reported in the literature (Grover and Mishra, 1996).

Table 2. Properties of full and hollow-core hexagonal briquettes

Parameters	Full hexagonal briquettes	Hollow-core hexagonal briquettes
Shattering resistance (%)	84.55±1.19	86.38±7.98
Abrasive Resistance (%)	93.01±1.17	88.43±6.08
Water intake resistance (%) for the first minute	59.42±11.43	65.87±10.29
Water intake resistance (%) for the second minute	38.60±11.93	42.82±14.20
Air humidity resistance (%)	97.37 ± 0.20	97.29 ± 0.85
Density (kg/m^3)	1150.21±24.11	1119.21±15.11

Flue gas emissions

The maximum CO_2, CO, and NO_X emissions obtained from this study are presented in Table 3. These values were compared to Turkish Regulation on Air Pollution Caused by Heating (OG, 2005). Furthermore, CO_2, CO and NOx emission values, has remained below the limit values described by the Turkish regulations. It should be pointed out that although SO_2 was measured as a function of time, there was no SO_2 emission recorded for both briquettes in this study.

Termogravimetric analysis

TGA analysis is the fast determination method of combustion characteristics of biomass briquettes (Chandrasekaran and Hopke, 2012; Gil et al., 2010). Thermal gravimetric (TG) and differential thermal gravimetric (DTG) profiles depicting the combustion process of samples taken from full and hollow-core hexagonal briquettes are presented in Figure 4. Initial (Ti) and final (T_f) combustion temperatures and temperature at maximum weight loss rate (T_{max}) are given in Table 4 for full and hollow-core hexagonal briquettes. Results of thermo-gravimetric and differential thermo-gravimetric analysis (T_i, T_f, T_{max} and maximum weight loss rate) showed that there is no statistical difference between two types of briquettes since briquetting by hydraulic press machine is physical process and does not influence chemical and combustion characteristics. Future studies should focus on the optimization to determine appropriate mixture ratios based on the desired briquettes qualities.

Table 3. Limit values specified in Turkish Regulation on Air Pollution Caused by Heating and maximum flue gas emissions of pellets

Emission	Limits	Full hexagonal briquettes	Hollow-core hexagonal briquettes
CO_2	20.5 (%)	5.62 A	5.50 B
CO	4000 (mg/Nm^3)	1809 A	1196 B
NO_X	400 (mg/Nm^3)	195.2 A	210.5 B

Values in the same row with different lower-case letters (A-B) are significantly different at $P < 0.05$

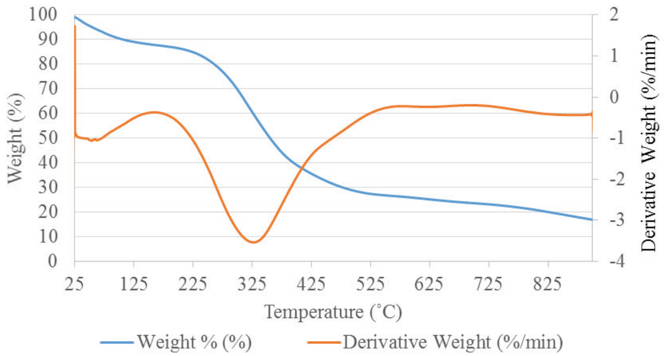

Figure 4. TG and DTG curves for hollow-core hexagonal briquettes

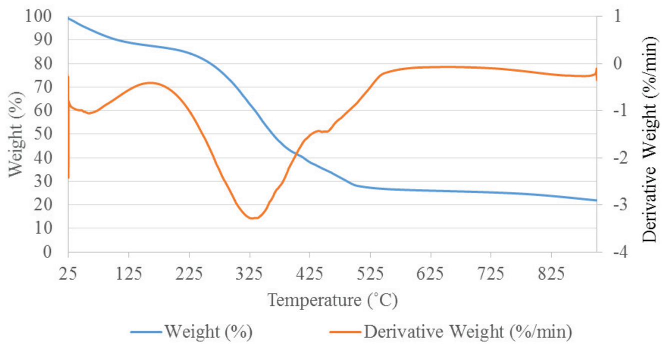

Figure 5. TG and DTG curves for full hexagonal briquettes

Table 4. The characteristic combustion parameters for the briquettes

Briquettes	T_i (°C)	T_{max} (°C)	T_f (°C)	Maximum weight loss rate (%/min)
Hollow-core hexagonal	160.45	327.37	524.12	-3.54
Full hexagonal	163.75	330.69	553.60	-3.29

CONCLUSIONS

Full and hollow core hexagonal briquettes were obtained from rose oil processing wastes using a hydraulic press machine. Briquettes were tested for shattering resistance, abrasive resistance, water intake resistance, and air humidity resistance.

The results showed the quality of briquettes were in the range reported. However, briquettes should be improved for water intake resistance. Density of the briquettes was in agreement with those reported in the literature. In terms of flue gas emissions, hollow core hexagonal briquettes emitted lesser CO_2, CO and NO_X compared to full hexagonal briquettes.

Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

The maximum emission recorded was in accordance with Turkish regulation.
As for thermo-gravimetric analysis of briquettes, both of them yielded similar results. In conclusion, the briquettes can be burned in a traditional stove and advanced combustion system for greenhouse heating and residential heating. Additionally, the briquettes can be used in combined heat and power system as source of biomass.

REFERENCES

Akman H. E. and Bilgin S. 2012. Pamuk saplarının hidrolik tip preste briketlemesi üzerine bir çalışma. 27. Ulusal Tarımsal Mekanizasyon Kongresi 2012, Samsun.

Akman H.E., 2012. A Research on the briquetting of Rose Oil (Rosa Damascena Mill.) Distillation Wastes (in Turkish). Master Thesis Akdeniz University.

Chandrasekaran, S.R. and Hopke, P.K. 2012. Kinetics of switch grass pellet thermal decomposition under inert and oxidizing atmospheres. Bioresour. Technol. 125, 52–58.

CRA, 1987. The la densification de la biomass. Commission des Communuates Europeennes. Centre de Recherches Agronomiques.

Eriksson S. and Prior M. 1990. The briquetting of agricultural wastes for fuel. FAO Environment and Energy Paper 11, FAO of the UN, Rome.

Gil M.V., Oulego, P., Casal, M.D., Pevida, C., Pis, J.J., Rubiera, F., 2010. Mechanical durability and combustion characteristics of pellets from biomass blends. Bioresour. Technol. 101 (22), 8859–8867.

Grover P.D. and Mishra, S.K. 1996. Biomass Briquetting: Technology and Practices. Bangkok.

Kaliyan N. and Morey, R.V. 2009. Factors affecting strength and durability of densified biomass products. Biomass and Bioenergy, 33: 337-359.

Li Y. and H. Liu, 2000. High-pressure densification of wood residues to form an upgraded fuel. Biomass and Bioenergy, 19: 177-186.

OG, 2005. Regulation on Air Pollution Caused by Heating (In Turkish). Republic of Turkey, Official Gazette, No: 25699.

Suhagar M., Lope, G.T. and Shahab S. 2006. Specific energy requirement for compacting corn stover. Bioresource Technology, 97: 1420-1426.