PELLETING HAZELNUT HUSK RESIDUES FOR BIOFUEL

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Abstract

In this study evaluation possibilities of hazelnut husk agricultural residue as a solid bio-fuel in the form of pellets were investigated, which comes out of hazelnut production every year in our country. Researches were done with the material at ≤ %12 moisture content and with 10 mm particle size. Optimum pelleting parameters for hazelnut husk residue regarding to physical-mechanical properties (pellet bulk density, pellet particle density, mechanical durability, and pellet moisture content), gas emissions, heating value, and ash content after burning were determined. In conclusion, hazelnut husk agricultural residue was found to be very suitable as a solid bio-fuel in the form of pellets both in environmental and in fuel properties aspects.

Key words: differential biofuel, pellet, renewable energy, hazelnut, agricultural residue.

INTRODUCTION

Hazelnut production is one of the major agricultural products for Turkey, especially in Black Sea region. The husk of hazelnut is outer part of the shell which binds it to the branch. The shelled hazelnut is taken out of husk during harvesting. It's reported that Turkey has produced more than 70 % of the world's hazelnut need with 549 000 tons in 2013 (FAO, 2013). Out of this production it's estimated that 200 000 tons of husks were obtained per year. But, this huge amount generally is not evaluated for any purpose, just a small amount of it is used as litter in animal barns and most of them are just burnt randomly on the field or left for natural deterioration. Therefore, this should be considered as a big economical and environmental loss.

Shaping the grinded material under pressure to smaller sizes (approx. 30 mm) is called pelleting (ÖZTÜRK, 2012). Pellets can be produced from sawdust, wood chips, tree barks, agricultural products, straw, hazelnut shell, almond shell, walnut shell and even from waste papers. The density of material is increased and the transportation and storing costs are decreased by pelleting process. Moreover, homogeneity is provided in size and shape which make them more suitable for automatic feeding systems and effective usage of material is provided (WERTHER ET AL., 2000; MANI ET AL., 2003; HOLM ET AL., 2006; NILSSON ET AL., 2011; THEERARATTANANOON ET AL., 2011; CELMA ET AL., 2012).

Fig. 1. – Arbitrarily burnt hazelnut husk in the village

Fig. 2. – Hazelnut harvester

Generally, hazelnut shells are used as a solid biofuel in our country. However, hazelnut husks with its big potential can be used as source of solid biofuel, also. For this reason, evaluation possibilities of hazelnut husk agricultural residue as source of solid biofuel in the form of pellets were investigated in this study. In this study, some physical-mechanical and thermal properties of hazelnut husk pellets were determined and their suitability as a solid biofuel was investigated.

MATERIALS AND METHODS

This study was carried out in the workshop and labs of Agricultural Machines and Technologies Engineering Department at Ondokuz Mayis University. Up to date European standard EN 14961-2 (Solid biofuels- Fuel specifications and classes- Part 2: Wood pellets for non-industrial use) was taken as a reference for this study.

Hazelnut husk agricultural residue which has a big potential in the Black Sea Region of Turkey was used a material for pelleting. The husks obtained after harvesting were brought to labs and they were left under sun during the day for natural drying. The moisture content of the material was decreased down to 12% and the dried materials were grinded by a 3 kW powered hammer mill having 8 blades and with 2850 r.min^{-1} rotation speed. For the homogenization of particle size a sieve having 10 mm sieve diameter was used during grinding.

Laboratory type pelleting machine was used for pelleting. Tests for determining physical-mechanical and thermal properties of pellets, chimney gas emission values were measured for determining the quality of pellets.

Volume density of pellets was calculated according to the EU norms EN 15103 in kg.m^{-3}, where the pellets were poured in a pot and the ratio of mass to the volume of the filled pot was calculated.

Pellet density of pellets were calculated by stereometric method according to EN 15150 EU standards in kg.m^{-3}, as well.

Fig. 3 – Hazelnut husk pellets

Fig. 4 – Laboratory type pelleting machine

Fig. 5 – Determining some physical properties of pellets

Mechanical durability of pellets was calculated according to EN 15210-1 EU standards. For this, 500 g sample was poured into the testing chamber and rotated with 50 r/min speed for 10 minutes. Then the pellets were sifted out by a sieve having 3.15 mm sieve holes and the oversized pellets were weighed and durability of pellets was calculated as follows:

$$D_U = \frac{M_A}{M_E} \times 100$$

Where,

D_U= Mechanical durability of pellets (%)

M_A= Pellet mass before testing (g)

M_E= Mass of oversized pellets (g)

Moisture content of pellets were defined as in EN 14961-2 EU standards by using a desiccators. Pellets were burnt in a pellet stove and the chimney gas emission values such as; O_2, CO, CO_2, NO and NO_x were measured by a gas emission device. Lower heating values of pellets were determined by a calorimeter device according to EN 14918 EU standards. Ash contents then calculated according to EN 14775 EU standards.

RESULTS AND DISCUSSION

The husks which were brought directly from the gardens were dried and the moisture content of the husks decreased down to 12 %. Some physical properties of grinded material are as shown in Tab. 1 and some physical-mechanical properties of hazelnut husk pellets are given in Tab. 2.

Tab. 1. – Some physical properties of grinded husk material

Particle size	Bulk density of material	Geometrical mean diameter of material
10 mm	211.94 kg.m^{-3}	2.28 mm

Tab. 2. – Some physical-mechanical properties of hazelnut husk pellets

Bulk Density (kg.m^{-3})	Particle Density (kg.m^{-3})	Mechanical Durability (%)	Moisture content of Pellet (%)
552.40	1309.87	89.57	11.54

It's been reported that the volume density of pellets for EN plus-A1, EN plus-A2 and for EN-B classes must be ≥ 600 kg.m^{-3} in EN 14961-2 European Union standards. However, the standards covers just the pelltes made from woodchips the volume density of hazelnut husk pellets were found to be lower than this amount. Besides, there were no definitions or limitations for particle density in EN 14961-2 EU standards.

TABIL AND SOKHANSANJ (1996) and TABIL AND SOKHANSANJ (1997) reported that the pellet quality is higher when the pellet durability is 80% or higher. Mechanical durability of hazelnut husk pellets indicated that they are in high quality. But, the value of it was lower than the values suggested in EN 14961-2 EU standards for EN plus-A1, EN plus-A2 (≥ %97.5) and for EN-B classes (≥ %96.5).

Some amount of moisture absorbed in the material for pelleting evaporated due to heating up of mould caused by friction between the mould and disc. Hence, the moisture content of the pellets changes a little bit. It's been reported in EN 14961-2 EU standards that the moisture content of pellets for EN plus-A1, EN plus-A2 and for EN-B classes should be ≤%10. The moisture contents of pellets produced from hazelnut husk residues were lower than the value given in standard. Ash content, heating value and gas emissions of pellets are shown in table below.

Tab. 3. – Heating value, ash content and gas emissions of hazelnut husk pellets

Ash content dry (%)	Heating value dry (MJ.kg^{-1})	CO (ppm)	CO_2 (%)	O_2 (%)	NO (ppm)	NOx (ppm)
7.19	18.35	1383.67	0.90	19.17	121	61.67

Ash content values in EN 14961-2 EU standard are given as ≤ %0.7 for EN plus-A1 class, ≤%1.5 for EN plus-A2 class and ≤ %3.0 for EN-B class. Ash content of pellets made from hazel husk residue was more than the values reported in the particular standard. The reason for this is the pellets given in EU standard is

made from wood chips. But, the heating value of hazelnut husk pellets was conformable to the value ($Q \leq 19$ MJ.kg^{-1}) given in that standard.

Tab. 4. – Heating values of some residues

Residue	Heating value (MJ.kg^{-1})
Stem of wheat- barley	18.07
Stem of sunflower	16.90
Stem of rice	15.18
Stem of maize	17.86
Stem of tobacco	17.36
Hazelnut pruning residue	18.80
Kiwi pruning residue	18.36
Pruning residues of other fruits and vineyard	17.99
Paddy husk	15.14
Tea dust	19.37
Wood	17.57

Chimney gas emission values of hazelnut husk pellets after burning were found to be lower than the permitted limit according to the regulations for air pollution control due to heating.

CONCLUSIONS

Evaluation possibilities of hazelnut husk agricultural residue as source of solid biofuel in the form of pellets were investigated in this study. Some physical-mechanical and thermal properties of hazelnut husk pellets were determined. In conclusion, hazelnut husk agricultural residue was found to be very suitable as a solid biofuel in the form of pellets both in environmental and in fuel properties aspects. Many researches on this topic are needed to be done, especially from the point of view of search for an alternative renewable energy sources. We believe in that these kinds of studies will help agricultural engineers, scientific researches, farmers and even the policy makers to think more globally and wisely for the future and will definitely have a positive contribution to sustainable development in the world.

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