ECONTECHMOD. AN INTERNATIONAL QUARTERLY JOURNAL – 2019, Vol. 08, No. 3, 23 – 26

Impact of various types of soybean cake to soy straw briquettes on the heat of briquette combustion

G. Wcisło[1], *B. Pracuch*[2], *P. Łagowski*[3], *D. Kurczyński*[3], V.*Tomyuk*[4]

[1] *Faculty of Production Engineering and Power Technologies*
University of Agriculture in Krakow, Poland
e-mail: Grzegorz.Wcislo@ur.krakow.pl

[2] *BioEnergia Małopolska Centre for Renewable Energy Sources, Poland*
e-mail: gwcislo@bioenergia.com.pl

[3]*Kielce University of Technology*
DepartmentofAutomotiveVehiclesand Transportation, Poland
e-mail: kdarek@tu.kielce.pl

[4] *Department of Computer Aided Systems*
Lviv Polytechnic National University, Ukraine
e-mail: vasyl.v.tomiuk@lpnu.ua

Received: June 30, 2019, accepted July 19, 2019

Abstract. The paper presents results of research demonstrating the effects on heat of combustion of adding press cake from three varieties of soyben Erica, Mavka and Sirelia to soyben stalk based briquette. The conducted research shows that heat of combustion of soyben stalk was 15.2 [MJ·kg^{-1}], much lower than the heat of combustion of press cake from four. Press cake heat of combustion from the most effective Erica soyben variety was 23.4 [MJ·kg^{-1}], or 54% (w/w) more than that of rape stalk. Press cake heat of combustion from the least effective soyben variety was 19.8 [MJ·kg^{-1}], or 30% (w/w) more than that of soyben stalk. Adding 20% (w/w) of press cake during briquette production Erica varieties resulted in an increase in heat of combustion by approximately 10,5; and a 40% (w/w) addition resulted in a further increase of approximately 20,4%, a 60% (w/w) addition of press cake increased heat of combustion by approximately 31,6 whereas an 80% (w/w) press cake content increased heat of combustion by more than 38,8%.

Keywords: briquette, soyben stalk, press cake, heat of combustion

INTRODUCTION

Briquette is one of the most sought after, as it presents major advantages as compared to pellets. A significantly lower cost of producing briquette as compared to pellets is one of these advantages. Research is underway, which aims to improve briquette parameters, and in particular to increase the bulk density as well as briquette mechanical properties [3,7] and into the possibility of increasing its net calorific value [4,6]. Briquette, next to pellets and woodchips, represents the largest quantity of biomass combusted in power plants as well as combined heat and power plants [1,7,9]. In recent years, there has been an increase in the use of solid biomass to fuel power plants as well as combined heat and power plants. Heat of combustion is the amount of heat obtained as a result of complete and total combustion of biomass, whereas the products of combustion have to be cooled to initial temperatures and steam vaporised. As a result of vaporisation, additional energy is recovered, which improves the heating balance.

Increasing the net calorific value of biomass is achieved through adding other, more energy rich additives to the base briquette [2,6,8]. During production of soyben stalk briquette, it is possible to use a more energy rich press cake, a by-product in the manufacture of soyseed oil.

Research of this type was conducted by the authors of this publication, where rapeseed cake obtained from a number of soyben varieties was added to soyben stalk briquette.

AIM AND SCOPE OF THE RESEARCH

The aim of the research was to determine the effects of adding rapeseed cake to rape stalk briquette on heat of combustion (gross calorific value). As part of the research, a press was used to press oil, and the remaining press cake was used as an additive to briquette. Press cake from four varieties of soyben seed was obtained: Erica, Mavka and Sirelia a summer

annual variety. The first is a complex hybrid, the two other are winter open-pollinated varieties. As part of the works, soyben stalk briquette was produced with a 0, 20, 40, 60, 80 and 100% (w/w) respectively component of press cake (pure press cake). The briquette was produced in the Energy and Biofuel laboratory at the "BioEnergia" Centre for Renewable Energy Sources. The press cake for the briquette was obtained by single-stage cold pressing at the Biofuels Laboratory part of the University of Agriculture in Kraków. The moisture content of straw used to produce the briquette was less than 2% (w/w). Straw moisture content was determined using the oven-drying method.

The press cake for the briquette was obtained by single-stage cold pressing in a modified UNO press made by FARMET, a Czech company - see Fig. 1.

METHODS

Solid biofuels combustion heat is appointed in calorimeter, according to Polish norm PN-86/C-04062 [10,11]. Briquette combustion heat was also appointed according to this norm. According to the standard combustion heat is determined in a calorimeter where fuel sample is burnt in a calometric bomb. The experiments were conducted in KL-10 calorimeter, made in by Precyzja Bit company. Test stand with calorimeter was shown in Fig. 2. According to Polish Standard PN-86/C-04062 and PN-ISO 1928-2002.

CALCULATIONS

Total thermal effect of burned samples of FAME were determined on the basis of formula 1.

$$Q_b = \frac{C_k \cdot \Delta t - Q_2 m_2}{m_o} \qquad (1)$$

where

C_k is a calorific capacity of calorimeter - 12.908 [kJ/^{o}C],

Δt is a corrected increase in temperature during combustion (formula 2)

Q_2 is a combustion heat of ignition wire (kanthal) - 6 704 [kJ/kg],

m_o is a mass of tested fuel sample [kg],

m_2 is a mass of ignition wire - 0.000007 [kg].

$$\Delta t = [(t_n + h_n) - (t_o + h_o)] + a + b \qquad (2)$$

where

t_o is a initial temperature of main combustion period (of sample combustion) [^{o}C]

t_n is a finish temperature of main period (of sample combustion) [^{o}C]

h_o and h_n - corrections for thermometer calibration at temperatures t_o and t_n

a is a correction for calorimeter heat exchange [^{o}C[

b is a correction for protruding mercury column [^{o}C].

Combustion heat of FAME samples was determined on the basis of formula 3.

$$Q_s^a = \frac{C_k \ \Delta t - Q_2 m_2}{m_o} + \Delta Q_s \qquad (3)$$

where

ΔQ_s is a correction for converting fuel combustion heat (acc. to PN-86/C-4062 for diesel oil it is 59 [kJ/kg] and for heating oil 50 [kJ/kg]. In calculations for FAME value of ΔQ_s = 50 [kJ/kg] was assumed.

Fuel value of FAME was computed on the basis of formula 4

$$Q_i^a = Q_s^a - 24{,}42\,(8{,}94 \cdot H - W) \qquad (4)$$

where

H is a hydrogen content in tested FAME % [m/m]

W is a water content in tested FAME % [m/m].

RESEARCH RESULTS

Figure 3 depicts net calorific value calculations for briquette made from straw soy with an added cake Erica soyben. Whereas figure 4 depicts net calorific value calculations for briquette made from straw soy with an added cake Sirelia soyben. on the last drawing, figure 5 depicts net calorific value calculations for briquette made from straw soy with an added cake Mavka soyben.

Fig. 1. Test stand with the UNO press made by FARMET

Fig. 2. Test stand with calorimeter

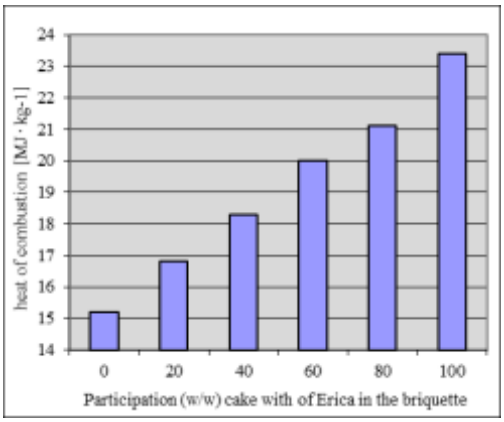

Fig. 3. Heat of combustion of rape stalk briquette with Erica variety of soyseed cake

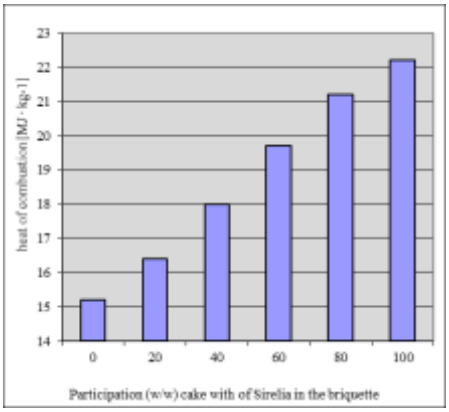

Fig. 5. Heat of combustion of rape stalk briquette with Mavka variety of soyseed cake

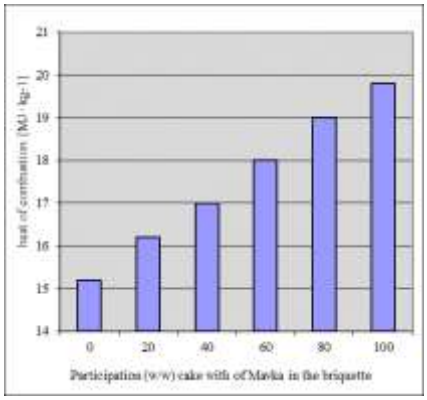

Fig. 4. Heat of combustion of rape stalk briquette with Sirelia variety of soyseed cake

CONCLUSIONS

The conducted research shows that heat of combustion of soyben stalk was 15.2 [MJ·kg-1], much lower than the heat of combustion of press cake from three. Press cake heat of combustion from the most effective rapeseed variety was 23.4 [MJ·kg-1], or 54% (w/w) more than that of soyben stalk.

Erica press cake had the highest heat of combustion 23.4 [MJ·kg-1], with the lowest, 19,8 [MJ·kg-1], recorded for Mavka variety.

The above shows that Erica variety press cake heat of combustion was more than 15,3% (w/w) higher than that of Mavka variety press cake. This resulted from the fact that more oil remained in the Erica variety rapeseed cake than in the Mavka variety soyseed cake.

The highest heat of combustion was recorded for briquette containing Erica variety press cake as the additive to soyben stalk. Adding 20% (w/w) of press cake resulted in an increase in heat of combustion from 15.2 to 16,8 [MJ·kg-1], or by 10,5% and a 40% (w/w) addition of press cake resulted in a further increase to 18.3 [MJ·kg-1], namely by more than 20,4%, a 60% (w/w) addition of press cake further increased heat of combustion to 20 [MJ·kg-1], or by 31.6%, whereas an 80% (w/w) press cake content resulted in an increase in heat of combustion to 21,1 [MJ·kg-1], or by more than 38,8%.

The conducted research shows that use of rapeseed cake as a component of soyben stalk in the production of briquette significantly increases the heat of combustion in such solid biofuels. The power industry is undoubtedly interested in particularity high energy biofuels.

REFERENCES

1. **Adamczyk, F.; Frąckowiak, P.; Mielec, K.; Kośmicki, Z. 2005:.** Trwałość brykietów ze słomy przeznaczonej na opał, uzyskanych metodą zwijania. Journal of Research and Applications in Agricultural Engineering, 51(1), 33-36.
2. **Denisiuk, W. 2008:** Słoma – potencjał masy i energii. Inżynieria Rolnicza, 2(100), 23-30.
3. **Fiszer, A. 2008**: Badania porównawcze współczynnika trwałości brykietów ze słomy. Journal of Research and Applications in Agricultural Engineering, 53(3), 69-71.
4. **Frączek, J. i inni. 2010**. Przetwarzanie biomasy na cele energetyczne. Kraków, PTIR, ISBN 978- 83-917053-9-1.
5. **Hejft R. 2002**. Ciśnieniowa aglomeracja materiałów roślinnych. Białystok. ISBN 83-7204-251-9.
6. **Hejft, R. 2006**: Wytwarzanie brykietów z odpadów roślinnych w ślimakowym układzie roboczym. Inżynieria Rolnicza, 5(80), 231-238.
7. **Niedziółka I., Szymanek M., Zuchniarz A. 2006.** Energetic evaluation of postharvest corn mass for heating purposes. Teka Komisji Motoryzacji i Energetyki Rolnictwa, t. VI(6A), s. 145-150. Podkówka W. 2007.
8. **Niedziółka I, Szymanek M., Zuchniarz. 2007:** Ocena właściwości energetycznych i mechanicznych brykietów z masy pożniwnej kukurydzy. Inżynieria Rolnicza 7(95) s.153-159.
9. **O'Dogherty, M.J.; Huber, A.J.; Dyson, J.; Marshal, C.J. 1995**: A study of the physical and mechanical properties of wheat straw. Journal of Agricultural Engineering Research, 62(2), 133-142.
10. **PN-EN 15103: 2010**. Biopaliwa stałe – Oznaczanie gęstości nasypowej. PN-EN 15210-2: 2011. Biopaliwa stałe – Oznaczanie wytrzymałości mechanicznej brykietów i peletów. Część 2: Brykiety
11. **PN-ISO 1928-2002: 2002.** Paliwa stałe – Oznaczanie ciepła spalania metodą w bombie kalorymetrycznej i obliczanie wartości opałowej.
12. **Wcisło.G. 2007:** Determing the rapseed oil influence on Biodiesel RME top heat volue - 2007. Silniki Spalinowe. Development of Combustion Engines. Vol. 2007-SC3, s. 201-206.