HEAT OF COMBUSTION OF HEMP AND BRIQUETTES MADE OF HEMP SHIVES

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Abstract
The hemp straw production gives 25 % of fibre and 75% of shives. The research, conducted by the Institute of Natural Fibres & Medicinal Plants in Poznan, proved high energetic value (about 18 MJ kg^{-1}) of shives used for briquettes production, which does not require additional drying. A shives burning process emits less sulphur compounds than the burning of oil fuel or coal, which has a positive impact on the environment.
The yield of hemp straw produces 10–15 tons of biomass from 1 hectare plantation. It is estimated that cultivation of 1 ha of hemp absorbs about 2.5 tons of CO_2, which contributes significantly to lessening of the greenhouse effect.
Key words: hemp, shives, briquettes, energy.

Introduction

It is assumed that the main biomass producer for energy purposes will be agricultural industry. The intention is to have in Poland in 2020 the share of energy acquired from biomass on the level of 15% in the balance of energy obtained from renewable sources, while in 2030 that of 20%. It means that in 2020 we should have in Poland 0.5 million ha of energy plants plantations while in 2030 - 0.8 million ha. Nowadays the acreage in Poland is only ca. 10 thousand ha.

The Economics Department is running intense works on preparation of 'Poland's Power Policy until 2030' document. The paper will in details describe strategic directions of action within the area of Poland's power policy.

Hemps in Poland haven't been called power plants until now nor its cultivation for the purposes is allowed (Act on misuse of drugs of July 29th, 2005 as amended). Only waste products obtained from the process of fibre extraction may be used for bio-energy production. The situation is different in other countries of the European Union where hemps are perceived as power plants and their cultivation for power purposes is allowed. Nowadays in Poland intense works are carried out aiming at allowing hemp cultivation for biomass.

Materials and Methods

The analysis of combustion heat was made for the whole hemp plants and for the hurds (waste product) obtained during extracting fibre from hemp straw.

Before the test, the material for analysis was crushed in a cutting-grinding mill of the mesh diameter at 0.25 mm. The test involved burning a precisely weighed sample in oxygen atmosphere under pressure in a calotrimetric bomb device and measuring the temperature increase inside the

Photo 1. **Hemp plantation**

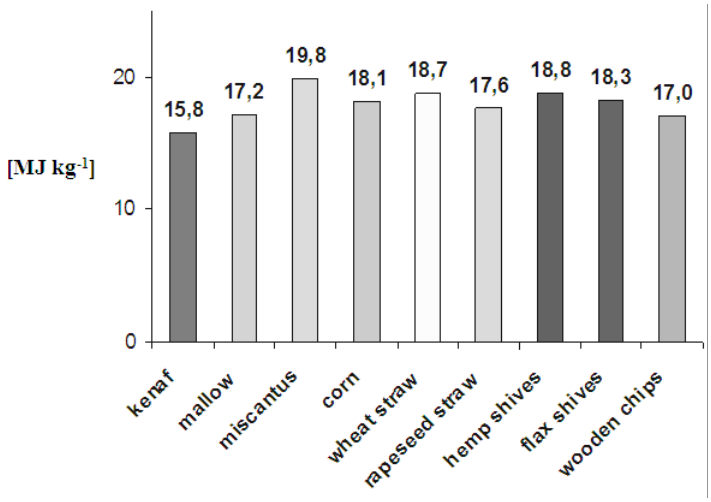

Figure 1. **Heat of combustion of selected vegetable raw materials**

calorimetric container, where the calorimetric bomb is placed.

Results and Discussion

Research run by the Institute of Natural Fibres and Medicinal Plants shows that fibre hemps because of high biomass yield and high heat of combustion amounting to ca. 19 MJ kg^{-1} are perfect for the purposes of bio-energy production. High heat of hemps combustion is confirmed also by other authors in their research, that is 18.8 MJ kg^{-1} (Burczyk H, Kolodziej J. Kowalska M 2008) from 17.5 to 18.8 MJ kg^{-1} for whole plants and even 19.7 MJ kg^{-1} for hemp bunches (Burczyk H., Grabowska L., Kołodziej J., Strybe M. 2008). The heat of combustion for dry straw is from 14 to 15 MJ kg^{-1} (Grzybek A., Gradziuk P., Kowalczyk K. 2001). In literature it is assumed that in terms of power, 1.5 tonne of straw is equal to 1 tonne of hard coal of medium quality (Grzybek A., Gradziuk P., Kowalczyk K. 2001). Straw from 1 hectare of hemp cultivation area corresponds in terms of power to even 11 tonnes of hard coal (Kolodziej J. 2009). It is confirmed by Burczyk (Burczyk H., Kolodziej J., Kowalska M. 2008), who experimentally obtained power yield from one hectare of hemps expressed in tonnes of hard coal on the level from 10.2 to 11.1 t (Burczyk H., Kolodziej J., Kowalska M. 2008). An additional advantage is that they are annual plants cultivated without the necessity of applying chemical means of protection and that leave soil in good culture. Additionally hemps may be cultivated for fibres, used in production of biodegradable composite materials, non-woven fabric and cellulose applied by paper industry and only harls may be used for power purposes (shives making up ca. 70- 75% of plant mass).

Hemps are interesting plants in terms of economy and ecology. In hemp cultivation, there is no need to apply crop protection chemicals, hemps are naturally resistant to diseases, they hamper growth of many weeds, discourage vermin and use nutrients included in soil. Hemp biomass yield is ca. 10 - 15 t ha^{-1} what with high heat of combustion (ca. 19 MJ kg^{-1}) allows to obtain plants power yield amounting to ca. 200 - 260 GJ ha^{-1} (Kolodziej J. 2009). Additionally, hemps, as opposed to other perennial power plants (e.g. energetic willow) may be easily introduced into crop rotation.

Hemps harvested in the full bloom of inflorescence are left on the field until they get dried by air to dry matter (ca. 16% of moisture for the whole plants). The moisture of hemp shives (of harls being wastes after fibre extraction from straw) is ca. 8.5% (Kolodziej J. 2009), while crop straw moisture is 15% and of wooden chips even 40% (Wichrowski R. 1994). In terms of yielding, hemps are inferior to such plants cultivated for energy purposes as kenaf (ca. 24 t ha^{-1}) and miscanthus (ca. 30 t ha^{-1}) (Kozlowski R., Kaniewski R., Mankowski J. 1998). Kenaf heat of combustion is ca. 15,8 MJ kg^{-1} and miscanthus - ca. 19,8 MJ kg^{-1}, but they are plants not very well adapted to our climate or requiring high expenditures for cultivation. They do not compete with hemps, as kenaf and miscanthus plantations are started from seedlings. They are perennial plants, so they are not suitable for cultivation in crop rotation.

The experiments carried out in the Institute of Natural Fibres and Medicinal Plants showed that new hemp types in the trial phase yield on the level amounting to even ca. 22 tonnes of straw from 1 ha of cultivation (Burczyk H., Grabowska L., Kolodziej J. Strybe M. 2008), so they have great potential for biomass production for energy purposes.

Heat of combustion for hemp biomass is comparable with the corn heat of combustion (ca. 18 MJ kg^{-1}). Hemp yields in relation to corn are more stable and in lesser degree depend on atmospheric conditions. Experiments carried out

Photo 2. **Briquettes made of hemp shives**

show that in the years which characterize with less rainfall, hemp energy efficiency was greater than corn energy efficiency. Hemps in comparison to corn characterize with a shorter vegetation period that is why it is easier to include them in the crops rotation. As far as corn is concerned, it is necessary to additionally spend energy for the purposes of drying it, as because it is harvested in autumn it is not possible to dry it on the plantation.

Hemp heat of combustion is greater than *Helianthus tuberosus* heat of combustion (16.5 MJ kg^{-1}) (Grabowska L., Kolodziej J., Burczyk H. 2007) and only slightly lower than miscanthus heat of combustion, which is ca. 19.8 MJ kg^{-1}).

In order to make transportation and storage easier, hemp harls may be subjected to briquetting or pelletization process.

Briquettes and pellets make a fuel obtained by compressing of dry waste materials. No chemical additives are used in the production process. Shives get stuck together as a result of the action of steam and high pressure. The material utilized during shaping of briquettes and pellets is lignin.

Hemp briquettes are characterized by faster loss of mass during combustion, compared with commonly used briquettes made of wood chips. This results from the fact that heat release from hemp briquettes is considerably faster. Measurements carried out on briquettes made of hemp shives have pointed to their considerable heat of combustion that is about 18000 kJ kg^{-1} (in the case of wood: 17000 KJ kg^{-1}). Combustion of shives results in significant reduction in the emission of sulfur compounds that is lower than that observed during combustion of heating oil and coal.

Conclusions

Hemps are the raw materials of multi-directional usage for textile, technical, food and pharmaceutical purposes. Together with the increasing ecological awareness and searching for alternative actions for agricultural industry, hemps were rediscovered as a plant attractive for many branches of economy. Hemps produce yearly a great amount of environmentally friendly biomass which may be used almost 100% in clothes production, technical textile, paper production, non-woven materials production, insulation, construction, composite materials production, hygienic, food, pharmaceutical articles production and for bio-energy.

References

1. Burczyk H., Grabowska L. Kolodziej J., Strybe M. (2008): Industrial hemp as a raw material for energy production. Journal of Industrial Hemp volume 13, number 1. (eng.)
2. Burczyk H., Kolodziej J., Kowalska M. (2008): Konopie – roślina energetyczna. [Hemp - Energy plant]. Czysta Energia 9. (pl.)
3. Grzybek A., Gradziuk P., Kowalczyk K. (2001): Słoma energetyczne paliwo. [Straw fuel energy]. Akademia Rolnicza w Lublinie. Warszawa. (pl.)
4. Grabowska L., Kolodziej J., Burczyk H. (2007): Zastosowanie energetyczne konopi włóknistych. [Energy use of hemp fiber]. Problemy Inżynierii Rolniczej 2. (pl.)
5. Kolodziej J. (2009): Efektywność energetyczna konopi w zależności od czynników agrotechnicznych. [Energy efficiency of hemp, depending on agronomic factors]. Praca doktorska Uniwersytet Przyrodniczy w Poznaniu. (eng.)

6. Kozlowski R., Kaniewski R., Mankowski J. (1998): New trends in harvesting, processing and application of hemp used for production of textiles and cellulose. Proceedings and Abstracts. The 1 st Nordic Conference on Flax and Hemp Processing. Tampere, Finland. (eng.)

7. Wirchowski R. (1994): Wykorzystanie słomy jako źródła energii odnawialnej w rolnictwie na przykładzie Danii. [The use of straw as a source of renewable energy in agriculture on the example of Denmark]. Seminarium Krajowe Wykorzystania Energii w Rolnictwie. Wydawnictwo IBMER. (pl)