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ENERGY CONSUMPTION IN WOOD PELLETS PRODUCTION

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SYNOPSIS. Wood pellets production is characterized by high energy consumption due to the need of drying, reducing size and granulation of the material. Therefore, the energetic and ecological effects of wood pellets combustion may be even 30% lower as compared to burning wood without prior granulation. The required wood drying is a source of unnecessary losses of energy. Thus, it is questionable if incurring additional costs of pellets production may be balanced by only convenience of transport, storage and combustion.

KEY WORDS: biomass, drying, net calorific value, burning, ecological effect

INTRODUCTION

The technology of small wood wastes densification before their burning, i.e. wood briquettes production, is known and applied for many years. For some time production of mini briquettes, often called pellets, is more and more popular. The pellets differ from the traditional briquettes in substantially smaller dimensions (i.e. diameter of ca. 6-14 mm), which allows full automation of the burning process. Presently the market of pellets develops rapidly. The yearly production of the fuel is estimated in Europe as equal to ca. 1,000,000 Mg and the productive capacity is even two times higher (Wach and Kołacz 2003). Also in Central-European countries (incl. Poland and Slovakia) there were established numerous companies producing pellets for both export as well as for more and more developing domestic markets. It results in noticeable and growing demand on sawdust and chips (Świgoń 2004 a).

Pellets production is related to high energy consumption. Therefore, a question arises if energy consumption in pellets production is balanced by energetic benefits

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of the pellets burning as compared to burning of unprocessed wood wastes. The objective of the paper is to explain the problem energetic benefits as compared to energy consumption in pellets production.

PRODUCTION PROCESS OF WOOD PELLETS

The scheme of the typical installation for wood pellets production is presented in Figure 1. Small wastes products (sawdust, particles etc.) as well as so-called fuel chips obtained by preliminary size reduction of thicker wastes (wood pieces) are raw materials for the pellets production. There is also more and more popular preparation of chips from wood of fast growing energetic plants. The raw material is stored in a container (1) and often transported through an indirect container (2) into a mill (3) in which the material is reduced in its sized. The reduction in size, except dust and small particles, is required due to small dimensions of the pellets.

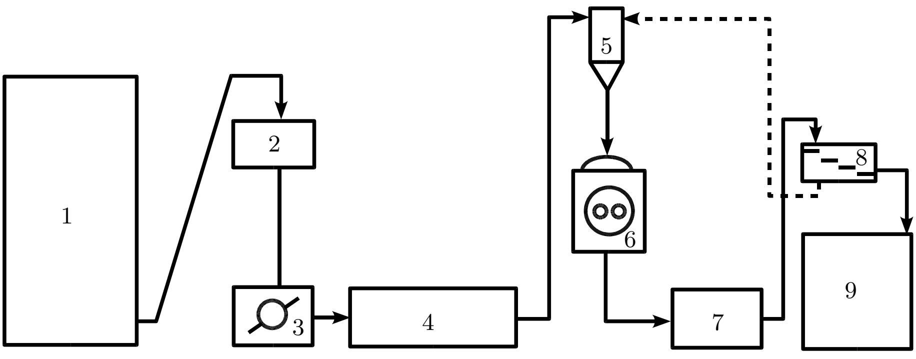

Fig. 1. Scheme of the typical installation for wood pellets production (according to Wach and Kołacz 2003) – description in the text
Rys. 1. Schemat typowej instalacji do produkcji granulatu drzewnego (według Wacha i Kołacza 2003) – opis w tekście

The technological process of granulation requires delivering the raw material of low moisture content, usually at the level of 10-12% (Kowalik 2003). The target moisture content of the raw material is obtained only for the wastes which are formed during processing of the previously dried wood. The majority of the wastes, including fuel chips, usually have much higher moisture content. Therefore, the material after its size reduction is directed from the mill (3) to a drier (4), which is a direct-contact apparatus, pneumatic or direct-heated one. The dried material is separated from heating and transporting gasses in a cyclone (5) and next directed to a press (6), where the densification (i.e. granulation) process is made without adding any adhesive substances, but in the presence of high friction forces, i.e. with heat generation increasing temperature of the pellets. The generated heat is transferred from pellets in a cooler (7). Next, the product goes through a screen

(8), in which small fractions are separated and again directed to the cyclone (5). The pellets are transported to a container (9) and next to a storehouse.

ADVANTAGES AND DISADVANTAGES OF WOOD PELLETS

As compared to ungranulated small wood wastes, pellets are characterized by low moisture content and high bulk density. Therefore, it makes easier to store pellets as well as to distribute them. The constant moisture content of the fuel helps to organize the burning process. The similar properties also characterize traditional wood briquettes. However, the pellets' advantage over the briquettes comes down to their much smaller dimensions, thus it allows full atomization of the burning process similarly as for burning gaseous, liquid and pulverized fuels.

The pellets are often compared to fossil fuels and it is emphasized that pellets are regarded as the renewable energy source and usually have lower prices (Wach 2003). It has to be mentioned that not only granulated biomass but also its any form is a renewable energy source. Moreover, the pellets production is related to consumption of energy usually obtained from sources which are not renewable. Therefore, the ecological effect of pellets burning may be lower as compared to ungranulated wastes.

It is often emphasized as the advantage that drying the raw material before manufacturing pellets as well as briquettes causes the increase of the net calorific value. However, it is forgotten about energy consumed during drying.

Some of the listed characteristics of wood pellets, having influence on energy consumption during the production process, are analysed in more detailed way in the further sections of the paper.

INFLUENCE OF MOISTURE CONTENT ON NET CALORIFIC VALUE

It is most often assumed that heat amount which can be obtained from a fuel burning is a product of the fuel mass and the net calorific value depending on the fuel chemical composition at oven-dry state and the moisture content. For a given fuel changes of its chemical composition are usually minor, while moisture content may change in a very wide range.

The moisture content of the green wood, including chips from energetic plantations, depends among others on wood species as well as on a season and usually varies from 80 to 100% (oven-dry mass basis) which corresponds to the values of 44-50% for the wet mass basis. The air dried moisture content of wood ranges from 15 to 25% depending on a season. Also moisture content of wood wastes may vary in a considerable way, i.e. from values close to the green moisture content (wastes after wood mechanical processing in sawmills) to several percent after drying applied in manufacturing processes (Longauer et al. 1987, Guzenda and Świgoń 1997, Dzurenda and Slovák 2001, Świgoń 2002).

Figure 2 presents the dependency between the net calorific value of wood of the typical chemical composition and wood moisture content (both oven-dry and wet mass basis). The higher wood moisture content, the lower net calorific value, which can be obtained during the wood burning.

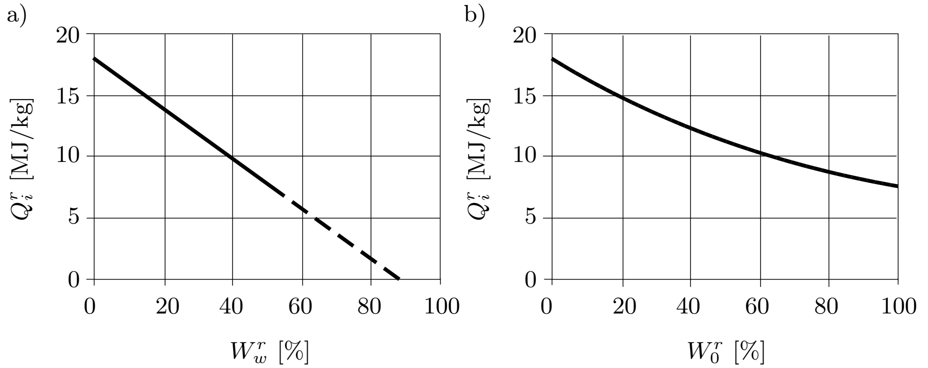

Fig. 2. Dependence of wood net calorific value on moisture content: a) wet mass bassis, b) oven-dry mass bassis (Świgoń 2004 a)
Rys. 2. Zależność wartości opałowej drewna od jego wilgotności: a) względnej, b) bezwzględnej (Świgoń 2004 a)

USEFULNESS OF FUEL WOOD DRYING

The relations presented in Figure 2 are not the sufficient justification of the usefulness of drying fuel wood. It can be revealed that energy consumption during wood drying is always higher than the additional energetic effect obtained after wood burning (Świgoń 2003). The thermodynamic analysis of the problem justifies only air drying of fuel wood with the use of natural circulation of ambient air as the drying medium and wood protection against rain falls. The costs of air drying are reduced to the costs of labour and storage. However, drying time is much longer as compared to drying (Świgoń 1998).

ENERGY CONSUMPTION DURING WOOD PELLETS PRODUCTION

According to the data available for drum driers for wood chips the energy consumption of wood in the form of particles may be assumed as equal to ca. 3.5 MJ of heat per kilogram of evaporated water (Świgoń 2004 b). When assuming that the raw material is dried from the initial moisture content of 90% (oven-dry basis) to the final moisture content of 12% (oven-dry basis), the dryer has to evaporate 780 kg of moisture per each 1000 kg of oven-dry mass of wood and consume ca. 2.7 GJ of heat.

Except the drying process the highest energy consumption in pellets production is related to milling raw material before drying as well as to wood densification after drying. The electricity consumption during the both operations in pellets production from plantation wood may be related to 1000 kg of oven-dry mass and estimated as follows: chipping ca. 40 kWh, milling ca. 20 kWh, granulation ca. 80 kWh and total ca. 140 kWh (Wach and Kołacz 2003, Pasyniuk 2004). Assuming the efficiency of electricity production as equal to ca. 20% it is equivalent to ca. 2.5 GJ of heat. It may be assumed that energy consumption in the remaining operations comprises in the range of inaccuracy of the performed estimation.

As the net calorific value of dry wood is equal to ca. 18.1 MJ/kg (Fig. 2), it is theoretically possible to obtain ca. 18.1 GJ from burning 1000 kg of dry wood. However, after subtracting the heat consumption during drying as well as for producing electricity used during milling and granulating the effective heat obtained from burning 1000 kg of dry pellets made of plantation wood is only 12.9 GJ, i.e. almost 30% less. Certainly, the unfavourable effect will be lower when the raw material is obtained not from plantation wood chips but from small wood wastes formed especially during mechanical processing of dry wood. Wood air drying can be at least partially used in order to increase the energetic effect of pellets burning. Another method of increasing the effect may be related to the improvement of the technological process by heat recovery from the cooler of pellets. However, the highest improvement of the effect can be associated with recently patented granulation technology of the raw material of moisture content as high as 35% (Wach 2003).

ECOLOGICAL EFFECT OF WOOD PELLETS BURNING

It is very often assumed that wood pellets burning creates the ecological effect resulting from burning reduction of fossil fuels of the equivalent product of mass and net calorific value. It is true in the case of burning wood wastes which were not granulated and technically dried. The analysis performed in the previous section shows that the real ecological effect of pellets burning may be even 30% lower because heat obtained from fossil fuels is used for electricity production in power plants and partially for driving dryers.

CONCLUSIONS

1. Wood pellets production is an energy-consuming process. The highest energy consumption is related to raw material drying, milling and granulation. Therefore, the energetic effect of pellets burning may be even 30% lower as compared to burning wood without granulation. This fact has to be considered in assessing the ecological effect of wood pellets burning.

2. The requirement of the material drying before granulation is a source of unnecessary energy wastes because energy consumption during technical drying is always higher than the energetic effect of the net calorific value increase due to moisture content decrease of the fuel.
3. It seems to be arguable, if the energy outlay for producing pellets is worth to incur, especially if the measurable effect consists of facilitation of transport, storage and burning, which is accompanied with distinct lowering of energetic and ecologic effects.

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ENERGOCHŁONNOŚĆ PROCESU PRODUKCJI OPAŁOWEGO GRANULATU DRZEWNEGO

Streszczenie

Proces przygotowania opałowego granulatu drzewnego jest bardzo energochłonny ze względu na konieczność suszenia, rozdrabniania i granulowania surowca. Dlatego efekty energetyczne i ekologiczne spalania granulatu mogą być nawet o 30% mniejsze niż przy spalaniu drewna bez uprzedniego granulowania. Konieczność suszenia surowca jest źródłem niepotrzebnych strat energii. Zatem jest sprawą dyskusyjną, czy warto ponosić takie koszty wytwarzania granulatu, jeśli wymiernym tego efektem jest tylko ułatwienie transportu, magazynowania i spalania.

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