Innovations in the construction of pelleting and briquetting devices

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Summary. Waste materials of plant origin: sawdust, shavings, wood dust, corn, rape straw, buckwheat hulls, etc. can be used as a valuable ecological fuel. Combustion of different forms of materials of plant origin, i.e. biomass, is beneficial from the ecological point of view and is a rich source of energy. This paper presents selected issues concerning the modernization of the process of producing heating pellets and briquettes (ecological solid fuel) from biomass. Devices with an immovable flat matrix working system are a beneficial solution in the production of solid fuel in small- and medium-sized plants.

Key words: solid fuels, biomass, waste, pelletisation, pellets, briquettes.

1. INTRODUCTION

Waste materials of plant origin: sawdust, shavings, wood dust, corn, rape straw, buckwheat hulls, etc. can be used as a valuable ecological fuel. Combustion of different forms of materials of plant origin, i.e. biomass, is beneficial from the ecological point of view and is a rich source of energy (for instance, the calorific value of straw is 15-17 MJ×kg^{-1} at a moisture content of approx. 10%).

The production of solid fuels through pelletisation and briquettisation of materials of plant origin (biomass) has found widespread applications. Pelletisation (briquettisation) of materials of plant origin is a process in the course of which shredded material, as a result of external and internal forces, undergoes densification, and the obtained product acquires a specific, permanent geometrical form.

Depending on the size of a product from biomass, it is called pellets (e.g. a diameter of 2 to 12-15 mm) or briquette (over 15-20mm) – fig. 5 [1, 2, 3, 4].

The mechanism of the densification of materials of plant origin is presented in fig.1.

On the basis of fig.1, it can be noticed that as the segment x is increasing, the values of pressure p_x in the densified material are decreasing.

The experimental verification of the distribution of the forces at work in the densification process is shown in fig. 2.

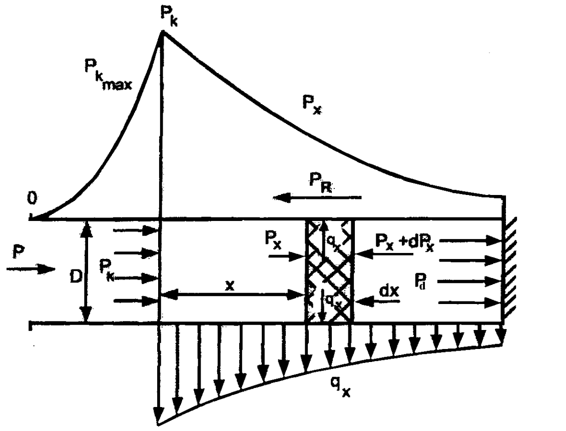

Fig. 1. The scheme of pressures in a densified material [Hejft, 2002]: p_k – densifying pressures, p_x – axial stresses, q_x – lateral pressures, P_d – pressures on the bottom of the chamber, D – chamber diameter, P_R – friction forces

Fig. 2. Destruction of the chamber during densification (p_k – approx. 145 MPa)

Technical and technological progress depends on the details implemented in production plants of pellets (briquettes) in the areas of the design and operation of machines, process engineering, as well as the modification of material characteristics of biomass.

This paper presents selected issues concerning the production of pellets and briquettes.

2. The production of pellets and briquettes

The flow chart of the production of pellets and briquettes from biomass is presented in fig. 3.

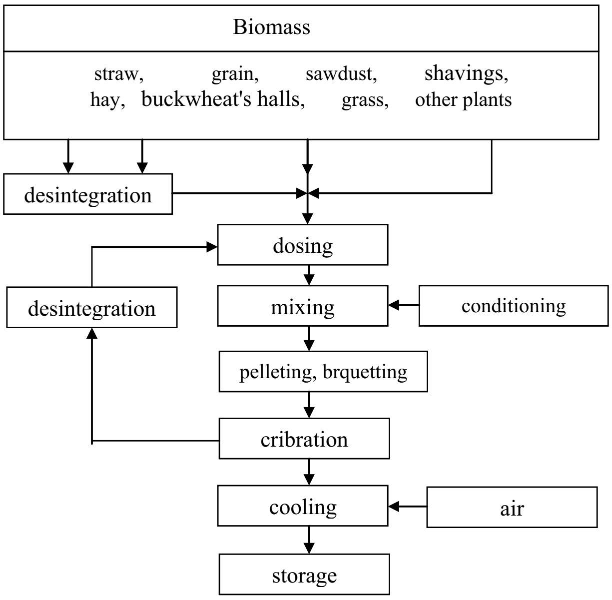

Fig. 3. The flow chart of the production of pellets and briquettes (it was assumed that the moisture content of biomass is lower than 20% and it does not require drying) [2]

Fig. 4 shows a stand for performing the tests of the processes of pelletisation and briquettiation of materials of plant origin (biomass).

The device consists of an immovable matrix 3 and two densification rolls 2. The set of densification rolls is driven by the shaft 9, bearing-supported in the shaft jacket 4, through the belt transmission 6 from the electric motor 8. The device is equipped with a feeder 1, whose position relative to the cone mounted in the upper part of the transmission shaft 9 can be continuously variably adjusted (continuously variable control of the quantity of the fed material). Technical data: power – 15 kW, speed of the set of densification rolls – 210 rpm, roll width – 102 mm, B, D-process temperature recorder, C- power recorder

The example of the matrices using in the universal pelletising and briquetting device shown in fig. 5.

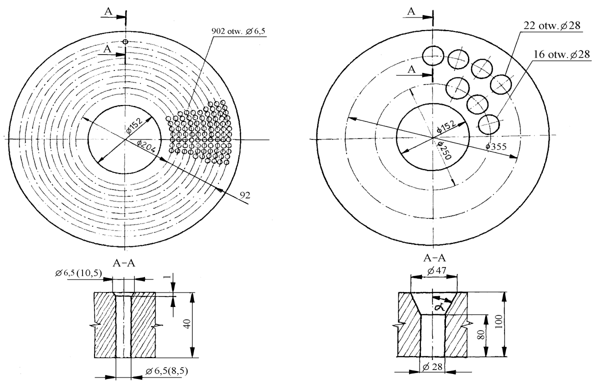

Fig. 5. Example matrices [2]

SHREDDING

The average size of particles undergoing pelletisiation or briquettisation has a significant influence on the course of the processes and the quality of the product. The degree of shredding of biomass needs to be determined in laboratory tests (in pelletising and briquetting devices, e.g. in the one presented in fig. 4). With a certain approximation it can be initially assumed that the average size of particles is about 0.5 of the diameter of the matrix openings.

The high diversity of materials of plant origin, as far as their biological structure, chemical composition, physical properties are concerned, as well as, additionally, their high

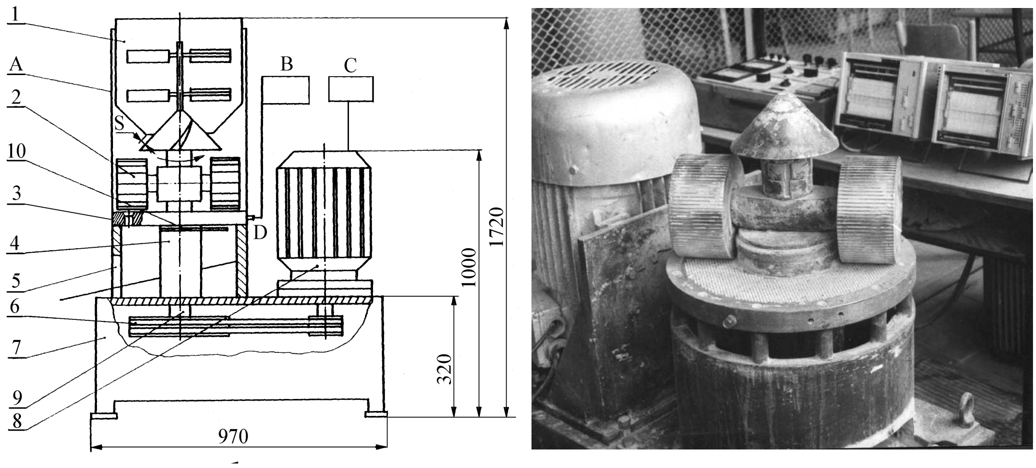

Fig. 4. The scheme and view (without a feeder) of a universal pelletising and briquetting device [2]

changeability during the pelletisation or briquettisation process are make it difficult to determine which of the binding mechanisms would be dominant (this pertains, above all, to mixtures of different components).

For example: during the pelletisation of biomass with a content of e.g. shredded corn grains (starch content – binder additive), the contribution of bindings from the field of cohesion forces is an important factor.

During the briquettisation of shredded straw, there appear mechanical bindings. The durability of agglomerate is influenced by mechanical coupling and locking of particles, internal pressure between particles, binder additives and capillary forces.

For example: in the densification of biomass with a 60% content of straw shredded on a beater shredder using a sieve mesh of a)10 mm and b)6 mm, the proportional content of individual fractions of shredded straw is: a) 0-5 mm – 38.1%, 5-10 mm – 40.3%, 10-20 mm – 17.3%, 20-30 mm – 3.9%, above 30mm – 0.4% and b) 0-5 mm – 58.1%, 5-10 mm – 30.2%, 10-20 mm – 10.9%, 20-30 mm – 0.8) density of briquettes decreases (in the b) case) by approx. 10 kg×m^{-3}.

MIXING

Densified biomass belongs to the so-called difficult materials, i.e. it requires high densifying pressures (from 80 to 150 MPa and higher). Therefore, it would be advisable to create mixtures, e.g. shredded waste paper. This method also allows to eliminate a significant portion of dusty fractions (they appear in smaller or greater amounts during shredding), through their non-pressure agglomeration into particles of sizes multiple times smaller than those of the components (e.g. shredded straw – grain processing and milling industry waste, sawdust, shavings – potato pulp, sawdust – buckwheat hulls – fig. 6).

The mixing process is also significant as far as reducing the moisture content of a biomass mixture is concerned (mixing components of an increased moisture content with components of a low moisture content has a positive influence on the process of pelletisation or briquettisation). Conditioning of biomass by means of superheated water vapour can also be used in the mixing process. Its purpose is to plasticise the particles of plant components.

Fig. 6. Briquettes (from spruce sawdust, from spruce sawdust with a buckwheat hulls content) [2]

PELLETISATION, BRIQUETTISATION

The high dynamic loads of the pelletising and briquetting working systems cause their relatively fast wear, at simultaneously high production costs.

Research studies carried out by a team of authors and their collaborators allow to promote universal low-output devices for the pelletisation and briquettisation of materials of plant origin, which can produce solid ecological fuel (also from waste material) as well as industrial fodder on medium- and big-sized agricultural farms and in small- and medium-sized plants processing materials of plant origin.

Hence, special attention needs to be paid to working systems with a flat immovable matrix (a simple design; in the case of many products both sides of the matrices can be used; the matrix and the densification rolls can be replaced easily; a significantly lower price in comparison with other designs, etc.). Pellets and briquettes obtained in a working system with a flat immovable matrix are shown in fig. 7.

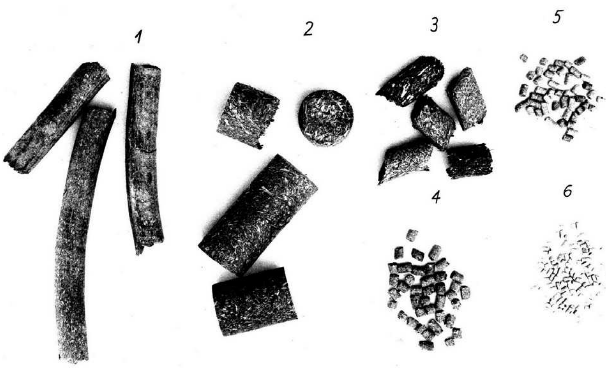

Fig. 7. Examples of pellets (4,5,6 – a diameter of 4;6,5; 8.5mm) and briquettes (1,2,3 – a diameter of 28mm; 50mm) from biomass

For the briquettes with a diameter of 28mm and 50 mm matrices with muffs were used (fig. 8)

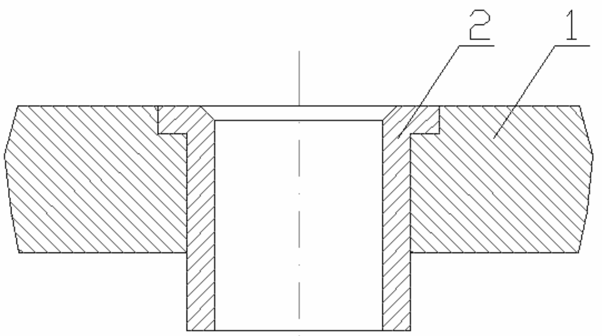

Fig. 8. A cross-section of a matrix with a briquetting muff [2]

SIEVING

The obtained pellets (briquettes) can undergo sieving – the ones that fulfil the norms are cooled, while the rest are shredded and recycled within the process (fig. 3).

COOLING

Pellets, as well as briquettes, undergoing cooling acquire a better durability (a greater resistance to crumbling).

3. SUMMARY

The paper presents selected aspects of the modernization of the process of producing heating pellets and briquettes (ecological solid fuel) from biomass. The presented suggestions are the result of many years of research of both the process of pelletisation and briquettisation and the design solutions of prototype universal pelletising and briquetting devices. The devices with a flat immovable matrix working system are a beneficial solution in the production of solid fuels in small – and medium-sized plants.

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Streszczenie. Odpadowe materiały pochodzenia roślinnego: trociny, wióry, pyły drzewne, słomy zbóż, rzepaku, łuski gryki, itp. mogą stanowić cenny, ekologiczny opał. Spalanie odpadów pochodzenia roślinnego -biomasy, w różnych jego postaciach, jest korzystne ze względów ekologicznych i stanowi bogate źródło energii. W pracy przedstawiono wybrane aspekty modernizacji procesu wytwarzania peletów i brykietów opałowych (ekologicznego paliwa stałego) z biomasy. Urządzenia z układem roboczym płaska nieruchoma matryca, są korzystnym rozwiązaniem przy produkcji paliwa stałego w małych i średnich zakładach.
Słowa kluczowe: paliwo stałe, biomasa, odpady, pelletowanie, pellety, brykiety.

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