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PRESSURE AGGLOMERATION OF PLANT MATERIALS – TECHNOLOGICAL AND TECHNICAL INNOVATIONS. PART III: A NEW SOLUTION FOR THE STABILIZING AND COOLING TRACK FOR BRIQUETTES

Summary

This paper presents a new prototype solution for the stabilizing and cooling track for briquettes from plant materials that enables a more intensive process of briquette cooling; at the same time, its design does not differ significantly from the existing ones. As a cooling factor, the designed stabilizing and cooling track uses, in addition to air, water flowing in the water jackets that surround the briquette. In the track's design, a system of briquette press by means of a movable upper jacket equipped with a lever pressure system was used. Owing to the use of a counter-flowing cooling medium (water), the track's construction allows to obtain good cooling conditions and does not cause briquette damage.
Key words: *briquetting, cooling, stabilizing and cooling track, water jacket*

CIŚNIENIOWA AGLOMERACJA MATERIAŁÓW ROŚLINNYCH – INNOWACJE TECHNOLOGICZNO–TECHNICZNE. CZĘŚĆ III: NOWE ROZWIĄZANIE TORU STABILIZUJĄCO-CHŁODZĄCEGO DLA BRYKIETÓW

Streszczenie

W pracy przedstawiono nowe prototypowe rozwiązanie toru stabilizująco-chłodzącego dla brykietów z materiałów roślinnych, który pozwala na bardziej intensywny proces chłodzenia brykietu, a jednocześnie jego konstrukcja nie odbiega znacząco od istniejących konstrukcji. Zaprojektowany tor stabilizująco- chłodzący jako czynnik chłodniczy, oprócz powietrza, wykorzystuje wodę płynącą w płaszczach wodnych, okalających brykiet. W konstrukcji toru uwzględniono system docisku brykietu za pomocą ruchomego płaszcza górnego, wyposażonego w dźwigniowy system docisku. Dzięki zastosowaniu przeciwprądowego przepływu czynnika chłodzącego (wody), zaprojektowany tor pozwala na osiągnięcie dobrych warunków chłodzenia i nie doprowadza do uszkadzania brykietu.
Słowa kluczowe: *brykietowanie, chłodzenie, tor stabilizująco-chłodzący, płaszcz wodny*

1. Introduction

According to numerous researchers [2, 3, 4, 5, 9, 10], briquetting is one of the forms of pressure agglomeration of bulk materials most commonly used in industrial practices.

Despite the high cost (high production costs of the working system, high energy consumption of the process, and costs relating to the fast wear of the working system) [9, 10], briquetting and pelleting are becoming increasingly popular due to the number of advantages they possess [9, 11], i.e. improvement of storage conditions, possibility of transport without packaging, longer shelf life, reduction of bacteria and fungi, volume reduction (a reduction of 10-30 times in the case of sawdust), increased energy value (which exceeds as much as 70% of the calorific value of the best types of coal), lower transport cost, increased resistance to moisture assimilation from air, and non-susceptibility to self-ignition (increased ignition temperature), the process of combustion of heating briquettes can be automated. In addition, in the opinion of Lewandowski and Ryms [11], briquetting is a method of utilization of fine-grained waste and dust of plant origin, which are harmful to the environment.

Chiefly density as well as mechanical durability are the main parameters that describe briquette quality [12]. This is confirmed by Niedziółka [13], who believes that optimization of the process of briquette production from various plant materials needs to be performed due to its utilization at a later time, whereas obtaining high throughput and a high product quality are significant as far as its production process is concerned. Depending on its intended use, it should be durable, not crumble, and have a high density.

After the briquetting process is completed, however, neither briquette density nor its mechanical durability is adequate. After the completion of the briquetting process and leaving the briquetting press, the heating briquettes have a high temperature and elevated moisture content. According to Grover and Grover and Mishra [8], and Adzić and Savić [1], briquette temperature may in some cases reach as much as 200°C. In order to preserve the characteristics acquired in the course of the briquetting process, the product must be cooled and slightly dried. These procedures are carried out mainly in order to increase the durability of heating briquettes (which has a positive influence on their kinetic durability.

Adzić and Savić [1] claim that cooling briquettes is usually a natural process and it receives little attention in literature reports.. In their research, they tested experimentally changes in wood briquette surface temperature during the cooling phase along the cooling line. They concluded that the temperature of briquette surfaces fell from 68 to 34°C after 7 minutes on the cooling line.

According to Grochowicz [6], pellets and briquettes durability increases very visibly during the first 6-10 min. Grochowicz [6] believes that the cooling medium should counter-flow in all briquette cooling methods. On the cooling path, the cooling medium gradually increases its temperature as a result of heat transfer from the briquette. Contact between heated briquettes and a cooling medium whose temperature is too low may cause the briquette to crumble.

As claimed by Grochowicz [6, 7], during the cooling process, the proportion of steam in air increases, as a result of which the processes of drying and cooling occur simultaneously. Drainage of water from the inner briquette layer creates stronger bindings between particles inside the agglomerate. Too fast cooling causes not only crumbling of the material, but may also result in rapid hardening of the outer briquette layer, which in turn leads to water being retained inside the briquette and biological processes to be accelerated.

2. Stabilizing and cooling tracks for briquettes

Grochowicz [6] reports that the process of cooling of heating briquettes with small nominal dimensions may occur in cooling devices dedicated to pellets cooling, i.e. in vertical (column, counter-flow) or horizontal (belt) coolers, or after slight modifications to them. The process of forced cooling of large briquettes has not found a practical application.

In industrial practice the process of heating briquette cooling is carried out in stabilizing tracks, where exchange of heat between the product and the environment occurs in a non-forced manner and is characterized by a small intensity of cooling, that why designing tracks where the cooling process would occur more intensely should be aimed at.

According to the Asket company [15], the process of briquette cooling in stabilizing tracks can be intensified by modifying their design by additional exchangers, making use of the process of forced convection.

For the process of briquette cooling, stabilizing tracks of a specific length and shape, using air from the environment to lower its temperature, are used the most commonly. The main advantage of using stabilizing tracks is also the possibility of transport of briquettes to storage sites without the need for additional devices.

Stabilizing tracks differ from one another in a range of construction solutions such as [15]:
- track length,
- track shape,
- rail type,
- number of rails,
- method of rail pressing.

Stabilizing tracks of various lengths are shown in fig. 1.

According to Asket [15], the length of a stabilizing track depends on its intended use. Short tracks are used when briquette is not directed straight for packing. Short tracks are characteristic for low-throughput briquette presses. Long stabilizing tracks are used with high-throughput presses, in which there is the need for fast transport of the product from the briquetting device's area. In stabilizing tracks of a considerable length, briquette lowers its temperature to the level at which it can undergo packing directly after leaving the track.

Stabilizing tracks often have various shapes. Tracks with shapes other than straight are used when there is a need to extend the stabilizing track in a small room. Such a solution also allows to transport briquette to a higher level, e.g. onto a trailer. Track curvature should have an adequate bending angle that would prevent briquette crumbling [15].

Fig. 2 shows stabilizing tracks with rails bent in different manners.

a)

b)

Fig. 1. Stabilizing tracks of various lengths: a) short stabilizing track by Asket [15]; b) long stabilizing track by Carboeco [16]

Rys. 1. Tory stabilizujące o różnych długościach: a) tor stabilizujący krótki firmy Asket [15], b) tor stabilizujący długi firmy Carboeco [16]

a)

b)

Fig. 2. Stabilizing tracks with rails bent in different manners: a) tracks bent upwards by Asket [15], b) track bent multiple times by Carboeco [16]

Rys. 2. Tory stabilizujące różnych sposobach wygięcia prowadnic: a) tor wygięty do góry firmy Asket [15], b) tor wygięty wielokrotnie firmy Carboeco [16]

The stabilizing track shown in fig. 2b has an additional element in the form of a bent metal profile, which makes it possible to divide briquette into smaller sections.

As reported by Asket [15], rail pressure is realized in various manners. The most commonly used solution is pressing down the upper rail by means of springs (fig. 3a). The aim of using pressure springs is to achieve constant rail pressure on briquettes with a tendency towards deviations during product expansion.

Fig. 3 shows solutions of stabilizing tracks for briquettes with different systems of rail pressure.

a)

b)

Fig. 3. Stabilizing tracks with different systems of rail pressure: a) with a spring-based system of rail pressure connected to a Pol-lux briquette press [17], b) by Asket, with a lever system of rail pressure [15]

Rys. 3. Tor stabilizujące z różnym systemem docisku prowadnic: a) ze sprężynowym systemem docisku prowadnic połączony z brykieciarką firmy Pol-lux [17], b) firmy Asket z dźwigniowym systemem docisku prowadnic [15]

In industrial practice, a lever pressure system is also used (fig. 3b), Asket being one of the users. This system presses down the rail by means of a lever with a weight mounted to it. Pressure degree is adjusted by placing the weight in the appropriate place on the lever (fig. 3b). The weight is set depending on the type of raw material and the quality needs of the briquette, e.g. its length and hardness [15].

The pressure system proposed by Pol-lux [17] is characterized by a pressed-down rim with rails mounted to it by means of a set of four springs. The force of pressure is adjusted by means of nuts that cause compression of springs. Both in the Asket [15] and the Pol-lux [17] solution, the system of rail pressure only exists on the straight section of the track.

3. The aim of the paper

The aim of the paper was to present a concept of a stabilizing and cooling track that would enable a more intense briquette cooling process, with a design that would not differ significantly from the existing ones.

4. A new solution of a stabilizing and cooling track for briquettes

The main idea behind the proposed solution of the stabilizing and cooling track for briquettes from plant materials is using such a design of the track that would enable a more intense cooling of briquettes leaving the briquetting press.

The scheme of the new design of the stabilizing and cooling track design is shown in fig. 4.

The main idea behind the solution of the stabilizing and cooling track for briquettes that is the subject of the invention is using three specially designed water jackets (3), (12) and (13) for the construction of its rails, instead of classic rails in the form of rods. Using water jackets (3), (12) and (13) instead of rod rails for the construction of the track enables much faster briquette cooling in comparison with traditional stabilizing tracks, in which the process of cooling is characterized by low intensity due to the non-forced flow of the cooling medium (air).

In the described solution of the stabilizing and cooling track for briquettes, water flowing in water jackets (3), (12) and (13) surrounding the briquette is used in addition to the air that envelops the briquette.

Fig. 5 shows cross-sections of the track through supporting bracket (4) and through spigot (11) that supplies the water to the jacket (3).

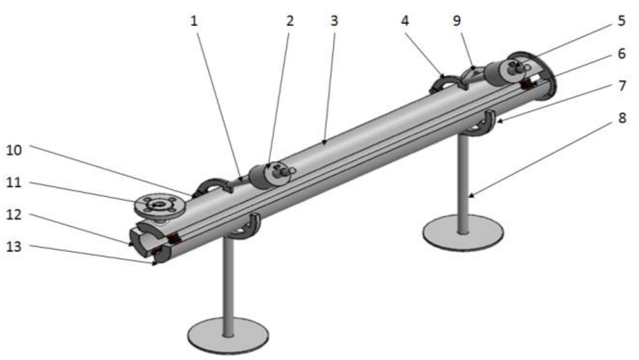

Fig. 4. Stabilizing and cooling track [14]: 1- lever, 2- weight, 3- upper jacket, 4- upper bracket, 5- screw, 6-elastic connection pipes, 7- bottom bracket, 8- supporting leg, 10- articulated mechanism screw, 11- entry spigot, 12, 13- upper jacket

Rys. 4. Tor stabilizująco-chłodzący [14]: 1- dźwignia, 2- ciężarek, 3- płaszcz górny, 4- obejma górna, 5- śruba, 6- elastyczne rury łączące, 7- obejma dolna, 8- Stopa podporowa, 10- śruba mechanizmu przegubowego, 11- króciec wlotowy, 12, 13- płaszcz górny

Cold water reaches the stabilizing and cooling track through entry spigot (11) mounted on upper jacket (3) and then it is distributed to the other exchangers (jackets) by means of elastic connection pipes (6). Heated water flows out through exit spigot (9) placed on water jacket (12).

Water in water jackets (3), (12) and (13) counter-flows in relation to moving briquettes, making them not susceptible to cracking as a result of thermal shock.

Water jackets (12) and (13) are permanently mounted to immovable bottom bracket (7), while upper jacket (3) is mounted to movable upper bracket (4). Brackets (7) and (4) articulate in relation to each other by means of pin (10), owing to which upper jacket (3) has a freedom of deflection.

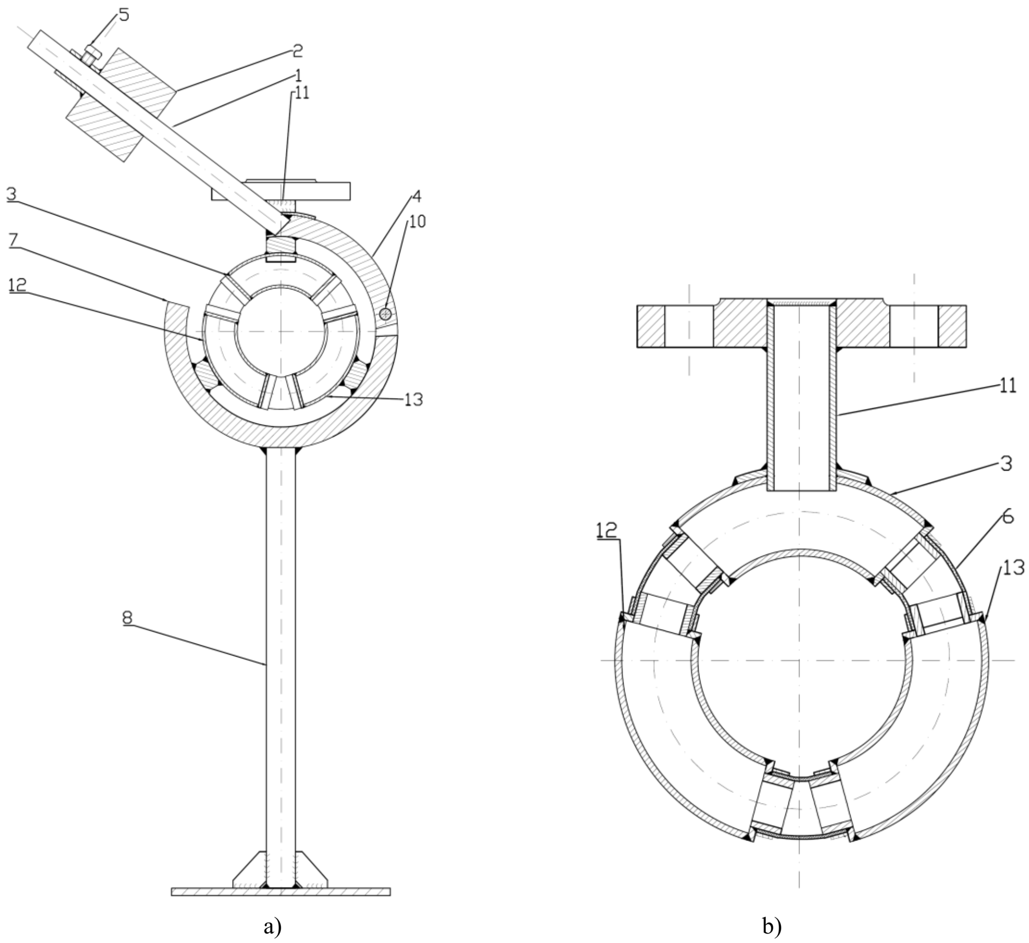

Fig. 5. Cross-sections of the stabilizing and cooling track: a) through support bracket (4), b) through spigot (11), supplying water to jacket (3) [14]: 1- lever, 2- weight, 3- upper jacket, 4- upper bracket, 5- screw, 6- elastic connection pipes, 7- bottom bracket, 8- supporting leg, 10- articulated mechanism screw, 11- entry spigot, 12, 13- upper jacket

Rys. 5. Przekroje toru stabilizująco-chłodzącego: a) przez obejmę mocującą (4), b) przez króciec (11), doprowadzający wodę do płaszcza (3) [14]: 1- dźwignia, 2- ciężarek, 3- płaszcz górny, 4- obejma górna, 5- śruba, 6- elastyczne rury łączące, 7- obejma dolna, 8- stopa podporowa, 10- śruba mechanizmu przegubowego, 11- króciec wlotowy, 12, 13- płaszcz górny

Pressure of upper jacket (3) is realized through appropriate placement of weight (2) on lever (1). Weight (2) is immobilized on lever (1) by means of screw (5).

The whole of the track is supported on legs (8), connected on bottom bracket (7).

The whole of the track is made from stainless steel, owing to which the track can be in use for a very long time.

5. Summary

Companies manufacturing devices that are part of briquetting production lines intend to modernize their machines, aiming at increasing production throughput and briquette quality. None of the companies, however, has implemented a device that would enable fast cooling of large-sized briquettes. In the current solutions of stabilizing and cooling tracks, the cooling process is characterized by low intensity of cooling owing to non-forced flow of the cooling medium (air). In addition to air, the designed stabilizing and cooling track uses water flowing in the water jackets surrounding the briquette as a cooling medium.

The track's design incorporates a system of briquette press by means of a movable upper jacket, equipped with a lever pressure system. Owing to the use of counter-flow of the cooling medium (water), the designed stabilizing and cooling track creates good cooling conditions and does not damage the briquettes.

The solution of the track presented in this paper is the subject of the author's patent application [14].

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