OPERATION OF BRIQUETTING ROLLER PRESSES WITH AN ASYMMETRICAL COMPACTION UNIT

Key words: briquetting, roll press, asymmetrical compaction unit.

Abstract: The key issue in the briquetting process in a roll press is to properly customise the working surface. The conventional symmetrical compaction units employed in roller presses are often unsuitable for the consolidation of materials that show quasi-plastic properties or those which show significant elastic deformation after the pressure is removed. This is caused by the fact that ready-made briquettes tend to remain in moulding cavities or crack along the parting plane. This problem can be solved by using asymmetrical compaction units. They make it possible to expand the range of fine-grained materials, especially those which are hardly consolidable in a roll press and which can be used to make briquettes with satisfactory quality indexes. This article outlines the basics of the operation of roller presses equipped with asymmetrical compaction units and their current evolution.

Introduction

Pressurised agglomeration carried out in roller presses is presently a key process employed in the heavy [1–5], chemical [6–8], pharmaceutical [9–11] and power [12–14] industries. The major advantages of this type of machines include their constant operability with relatively low demand for energy and a longer life span of moulding components as compared to other briquetting machines (e.g., screw or stamping ones) or pressurised granulators [15–17]. This is why this process is in constant development [18]. The current research activities mainly aim at determining process and geometrical parameters of the machine in order to enable the consolidation of hardly briquettable materials in the roll press. The basis for this issue includes, among others, a proper choice of the feed supply system [19] and the ring moulding surface [20]. They determine the course and the effects of the loose material consolidation process [15, 21]. In most cases, the working surfaces provided on both rings to mould briquettes at a given moment are a mirror reflection of each other. In the case of hardly briquettable materials, they are preferably differentiated, that is, an asymmetrical compaction unit is preferably employed [20, 22]. The purpose of this
study is to analyse the current state of the knowledge in
the field of design and operation of briquetting machines
equipped with asymmetrical compaction units.

1. Basics of Operation of Briquetting
Roller Presses Equipped with an
Asymmetrical Compaction Unit

The briquetting process in roller presses in asymmetrical systems has been developed since the
1980s. It was related to inventing a more economic
method for the briquetting of lignite [21]. The then used
agglomeration of that fuel in stamp presses showed
high energy demand per end product unit coefficient;
moreover, the idle movement which occurred in operation
significantly reduced their output. The first attempts to
briquette lignite in roller presses were unsuccessful.
When the conventional symmetrical compaction unit
was used, the ready-formed drop-shaped briquettes
became delaminated within the parting plane (Fig. 1).

![Fig. 1. View of a briquette consolidated in a roll press with
a symmetrical compaction unit and delaminated along the parting plane](image)

This problem was successfully solved by using an
asymmetrical compaction unit. The essential property
of this system is that the moulding components of the
briquetting machine have circumferential grooves and
notches alternately formed on the working surface (Fig.
6). The rings are arranged on the rollers in such a way
that the grooves and the notches are positioned against
each other, forming a split mould. This prevents the
briquettes from getting split in half along the parting
plane after they leave the moulding cavities. The research
has shown that the maximum unit pressure value
registered while briquetting material in an asymmetrical
compaction unit occurs in the central part of the notch
and in the corresponding zone of the circumferential
groove surface. The unit pressure differentiation that
was observed was not as high as it was in the case of
a symmetrical system (Fig. 2) [21]. The research also
proved that the asymmetrical compaction units offer
a smaller gradient of deformations than the symmetrical
systems (Fig. 3) [23, 24]. This shows that the briquettes
are moulded in more preferable conditions, which may
give them higher mechanical strength.

![Fig. 2. Unit pressure value distribution during
the briquetting process in a roller press [21]:
a) symmetrical compaction unit, b) asymmetrical
compaction unit](image)

Positive results of experiments have contributed
to the designing of industrial presses equipped with
an asymmetrical system. This resulted in focusing
the research on the need to verify whether a roll press
can consolidate other raw materials that were not
briquettable in symmetrical systems. Over the years,
technologies have been developed to briquette several
dozens of materials in roller presses equipped with
asymmetrical systems. These include the following:
métallurgical industry waste, chemical industry waste,
fuels of different composition and origin, municipal
waste and other, mainly inorganic, materials [11, 12, 15,
18, 25, 26]. The experiences gained while consolidating
these materials in asymmetrical compaction units have
allowed us to define the purpose of this type of solutions.
They have been qualified mainly for the briquetting of
materials showing high elastic deflection following
a discontinued pressure or demonstrating quasi-plastic
properties [15]. In the case of raw materials with a high
elastic deflection rate reaching 10%, the briquettes
that are no longer under pressure have a tendency to get
split into halves along the parting plane. In the case
of quasi-plastic materials, the ready-made briquettes
more easily go out of the moulding cavities and do not
block the moulding surfaces. In order to get a wider
understanding of the briquetting process in asymmetric
systems, the motion of material in the working zone
was tested. The experiments were performed with the
use of a gravitational feeder, with one of its walls being
made of acrylic glass. The consecutive layers of the feed
were contrasted by being composed of two materials of
different colours. Copper ore concentrate and calcium hydroxide were used for the tests. The experiments were carried out with different gaps between the rollers, different rotational speeds, and with one or two rollers being driven. The first row of moulding cavities had moulding cavities on the left-side ring, while there was a groove made on the right-side ring, and the second row of cavities was inverted (Fig. 7). The outcome of the analysis of all research has resulted in producing Figure 4, which shows the way in which the material moves in the feeder during the briquetting process in an asymmetrical system. In the first phase of the motion, a layer is formed on the roller working surface with notches, and it adheres to it (the yellow area on Fig. 4a).
It moves with the same rotational speed as the roller, but the feed next to the grooved roller moves at a slower speed. After about 1 second, a layer taken by the second roller also appears next to it, but the thickness of the layer is a little smaller. The flow becomes symmetrical after a few seconds (Fig. 4b). The middle part of the feed (the brown area, Fig. 4) falls down vertically under gravity and additionally exerts pressure on the material in the central part of the compaction unit. When a single roller was driven, the difference that was observed was the smaller thickness of the layer being formed by the profiled roller in the initial motion phase.

Following the observation of briquetting tests in asymmetrical systems where there is only one row of moulding cavities, it is concluded that the inflow of material in such a system is not symmetrical like at the beginning of the press start-up phase. The symmetricity of the material flow in the further sequence of experiments was caused by an alternate arrangement of notches and grooves in the consecutive rows of cavities. Therefore, it can be concluded that it is not preferable to use moulding rings for briquetting in an asymmetric system where there are only grooves made on one roller and only notches made on the other one (Fig. 5).

The long-lasting operation of asymmetrical saddle-shaped rings has also led to an observation that this kind of moulding surfaces is subject to wear. Conventional saddle-shaped cavities, the most intense wear rate affects grooves in places where thresholds separating the moulding cavities of the second ring adhere to the grooves (Fig. 6). This is related to very high pressures exerted in these places and the occurrence of a relative motion of both surfaces that result from the difference in the diameters of the inner part of the groove and the outer part of the notch (Fig. 7). Over the ring life time, the edges of the moulding cavities also become visibly rounded. This is shown on Figure 6.
2. Evolution of Asymmetrical Compaction units for Briquetting Machines

The amount of experience gained over several dozen years when roller presses were used for briquetting has proved that there exists a preferable briquette volume related to a specific diameter of moulding rings [15, 20]. This determines the amount of moulding cavities distributed on the perimeter. As the research has shown, there exist two methods to increase the volume of cavities for a given diameter of rollers while maintaining the satisfactory quality of the briquettes. The first of them is to use a screw feeder, and the second consists in increasing the briquette dimension along the generatrix (Fig. 8).

The knowledge which was gained in the course of the laboratory and industry scale research has led to the development of further asymmetric compaction unit concepts which are presented on Figure 9. In this case, there are grooves and notches situated in protrusions that are made along generatrixes on the moulding ring sides. The grooves and notches, which are opposite each other, form a split mould. Apart from the known advantages of the asymmetric system, the rings have been designed so as to enable only one roller to be driven and the torque to be transmitted onto the other roller through friction coupling. This concept was verified in laboratory conditions.

The experiments have demonstrated the possibility to obtain durable saddle-shaped briquettes by the application of the a.m. moulding surface solutions. The laboratory research has proved that it is also possible to have one roller driven in conventional saddle-shaped moulding rings (Fig. 6), and that the solution, which is the subject matter of Patent No. PL 222229 B1 (Fig. 9b) is achievable. When only one roller was test-driven, the moulding surface of the rings presented on Figure 9a was destroyed (Fig. 10).
3. Summary and Final Conclusions

The use of asymmetrical systems in roller presses has made it possible to expand the portfolio of raw materials which can be consolidated in roller presses. This primarily concerns materials considered to be hardly briquettable in roller presses used mainly in the energy, chemical, pharmaceutical, and heavy industries. Presumably, both the design and the process technology of the asymmetric systems in roller presses will continue to be developed due to their advantages. Probably, the objective will be to design and test new asymmetrical moulding surfaces.

References


