

# Research Journal of Pharmaceutical, Biological and Chemical Sciences

## Rotary Machines for Production of Ceramic Wall Materials.

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### ABSTRACT

This paper deals with an analytical study of design and operating principle of machines for molding plastic materials, using clay as an example. It has been shown that screw press, which has separated transportation and molding functions, can not reduce metal and power consumption of the pressing process. The directions of constructive-technological improvement of machinery for the manufacture of rough ceramics has been determined, in order to reduce the power consumption of the molding process and improve the quality of finished products. There is a design of rotary machines, which combines both transportation and molding functions, and the compression process is near to manual molding process, eliminating streaking in the structure of the clay timber.

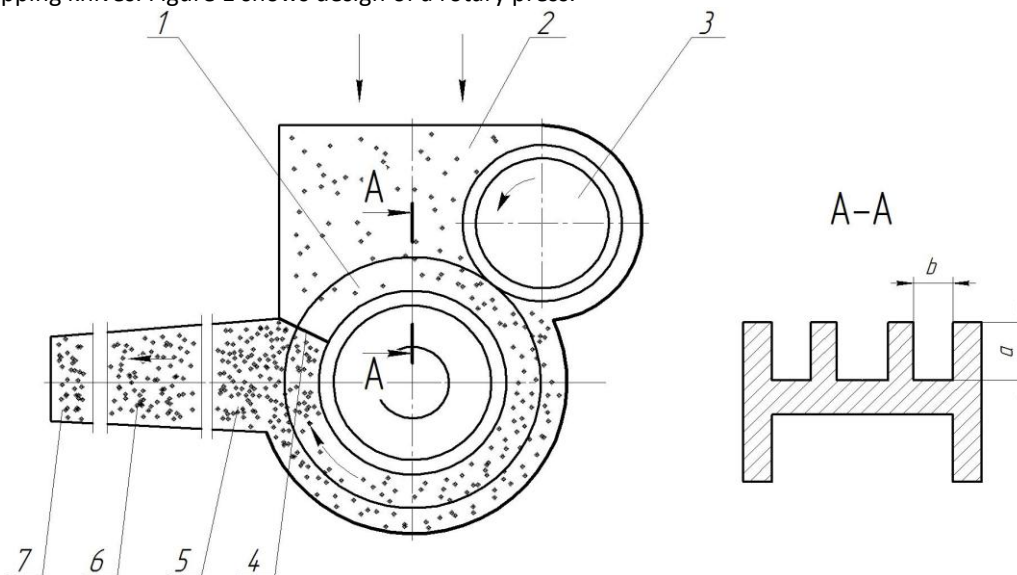
**Keywords:** molding, plastic materials, screwless belt press, variable cross section chamber, streaking.

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**INTRODUCTION**

Energy saving problems in the production of, perhaps, one of the most demanded wall building materials such as a ceramic brick are usually solved unilaterally, namely changing the production process to a semi-dry one. This results in losing the advantages of plastic method of production such as increased frost resistance, application in foundation structures, increased operational reliability when using in facing. Preparation of batch for semi-dry molding requires using high-performance units [1, 2] for grinding and homogenization. Processing and molding machines used in the production of wall materials, have characteristics, which do not meet modern energy saving requirements, due to their increased metal and power consumption [3, 4]. Molding of large products, which include ceramic bricks and stones, has its own features, however, the general trends inherent to molding of both powder [5, 6] and plastic materials [7] remain unchanged. In recent years, an increasing attention is paid to the production of ceramic bricks by rigid method, which combines all advantages of plastic method of production and excludes one of the most energy-intensive technological operations such as raw brick drying. The existing equipment applied, such as screw and plunger presses and paddle mixers, however, are not suitable enough for new technologies. Thus, the working parts of the screw presses for rigid molding shall be made of high-strength steel and have a high finish purity, and their drives shall be equipped with a high-power motors (up to 700 kW). Design engineering of fundamentally new machines was launched in the end of the last century, which further gave interesting results and presented new designs of clay-processing and molding machines. The known designs of screwless presses for plastic molding of clay mass may be divided into rotary and endless belt ones.

In 1972, West German company Rieterwerke produced Europress having a rotor instead of screw with a ring-shaped troughs, from which the clay mass is removed with a comb, and the material is transported to the compaction area of the press, practically no moving in slots [8]. Compaction of mass starts directly before the scrapping knives. Figure 1 shows design of a rotary press.



**Figure 1: Rotary press diagram:**

**1 – rotor; 2 – extruder housing; 3 – feeding roller; 4 – scrapping knife; 5 – transition element; 6 – head; 7 – die.**

Feeding efficiency coefficient of the Europress is 70-80% This is achieved due the fact that Europress has almost no reverse flows in the rotor channels.

The main disadvantage of rotary presses is relatively low specific pressing pressure in the compaction chamber due to insufficient adhesion force of the rotor chamber walls to a moldable mass, as the transporting capacity and pressure is generated by friction against the walls of the rotor circular paths having constant cross section along its entire length. One of the surfaces has a fixed wall, which maintains a significant resistance to movement of the mass along the chamber. Hence, it is more preferable to use rotary presses for molding high-humidity mass (18-25%), which is their major disadvantage.

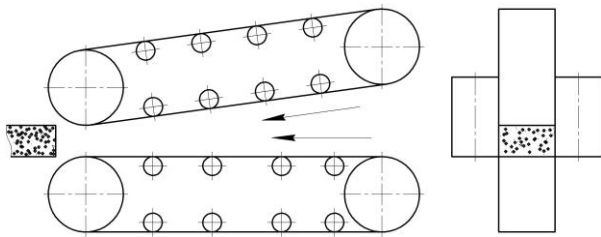


Figure 2: Screwless press diagram:

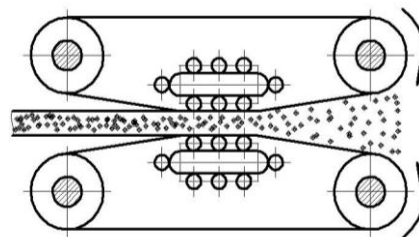


Figure 3: Belt tightening unit

Both rotary and screw presses perform transportation and molding of clay mass separately, for molding the die is also used, therefore, it is impossible to fully avoid streaking in products when using these machines. At the same time, there is a minimum or no reverse flow of clay mass in the troughs of the rotary presses, which undoubtedly reduces the power consumption for transportation of clay mass and allows considerably increasing the productivity of the machine without a large increase in drive power.

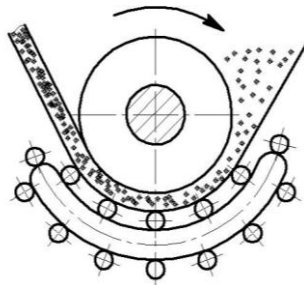


Figure 4: Belt tightening unit

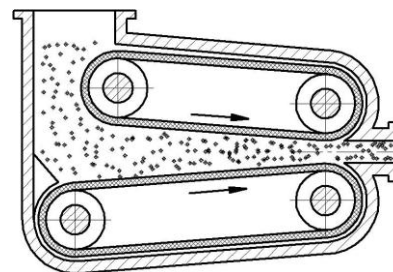


Figure 5: Riterwerke press.

Presses with endless belts are rather perspective. The first press with such design (Fig. 2) was developed in Russia and has been operated for many years at the Kotelsky brick factory, and included four molding belt conveyors - two horizontal and two side ones, forming in cross-section a rectangle with sides equal to the output size of a brick. This press had a production capacity of approximately 4 thousand bricks per hour at specific energy consumption of 1.8-2.5 kW per one thousand bricks. A screw press has 17-20 kW per one thousand bricks.

There is a patent DE #923172 (author Peter Vollskow) on the devices for endless belt presses (Fig. 3, 4), which produce the proper pressure on the moving belt, improving thereby conditions for molding a timber while transporting the molding composition. There is also a known design of press with endless belts of the West German company "Rieterweke", Fig. 5 [8]. A distinctive feature of presses with endless belts is the ability to combine transportation and molding processes in one working channel of variable cross-section formed by constantly moving surfaces. It has been proposed and developed several designs of screwless presses with endless belts, forming a cross-sectional chamber with moving walls and eliminating the necessity to install a head and a die in order to obtain a timber of the set section. Figure 6 shows a schematic diagram of the screwless press according to the inventor's certificate (I.C.) #588117 [8].

The press consists of a driven molding roll with annular groove having a width corresponding to the same of the molded timber, the cylinder 6 and the rollers 10 which are covered with the pressure belts 8, and their width corresponds to the width of the annular grooves of the roll 1 as well as the width of the rollers 10. Rollers 10 and a belt 8 are inserted into the annular grooves of the roll 1 and form cross-section compaction chambers having input sizes larger than output ones. Output size corresponds to the width of the molded timber. Belt 8 has a supporting device, rollers 7 and roller 9 for the regulation of the belt tension. Press is equipped with the feeding unit 5 and the feed roll 3, scrapping knives - top 12 and bottom 11, and is enclosed in a housing 2, the upper part of which forms the vacuum chamber and has a nozzle 4 for connecting to a vacuum pump.

The belt press operates as follows: plastic mass is moved by the feeding device 5 and the feed roll 3 to a space formed by annular grooves of the molding roll 1 and the pressure belt 8, then entrained into the compaction chambers in the form of finished timbers with cross-section specified, and guided by scrapping knives 11 and 12 to the outgoing conveyor. The speed of belt 8 is taken equal to the circumferential speed of the inner diameter of the roll 1 annular groove. Thus, the clay mass is compacted and rolled when moving in the screwless press into the space between the rotating roll and the moving belt, resulting in timbers of size required.

Quality of timber compaction is ensured by selecting an appropriate length of the compaction chamber, namely, roll 1 diameter and the dimensions of inlet and outlet cross-section. The proposed screwless belt press has the following main advantages: a significant increase in performance and reduce in power consumption of molding processes with a significant improvement in molded products.

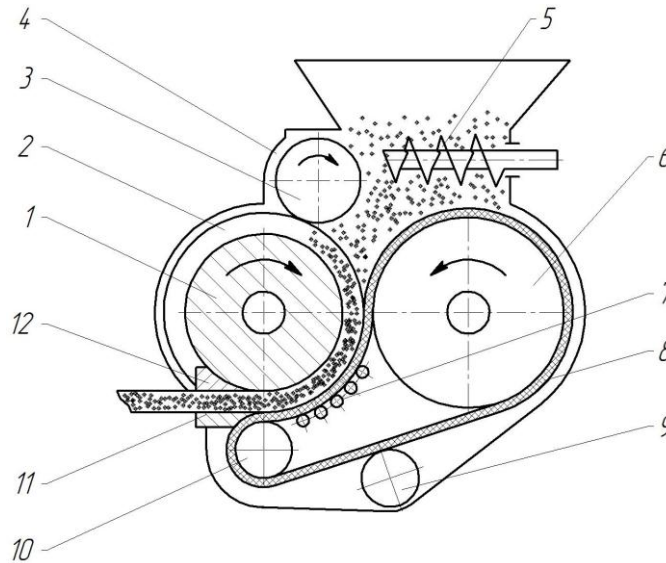
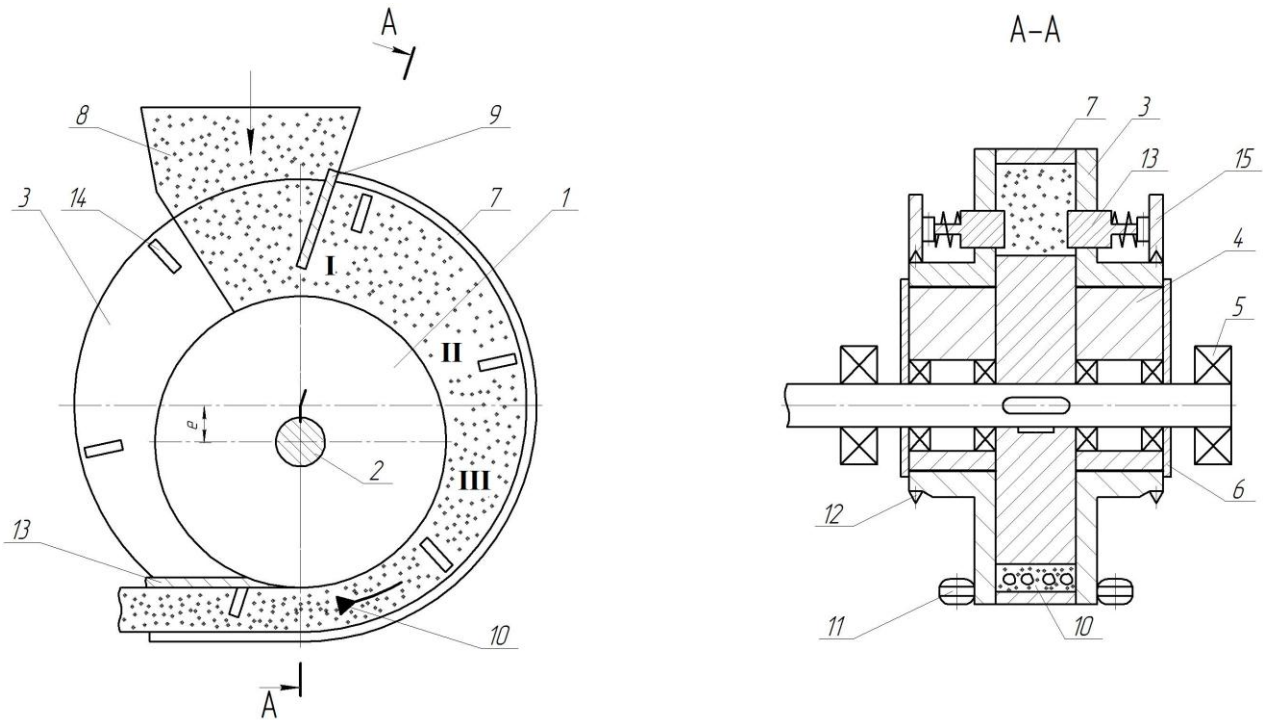


Figure 6: Screwless press diagram:

- 1 – molding roll; 2 – housing; 3 – feeding roll; 4 – branch pipe; 5 – feeding unit; 6 – cylinder; 7 – rollers; 8 – pressure belt; 9 – belt tension regulating roller; 10 – rollers; 11 – lower scrapping knife; 12 – upper scrapping knife.

Screwless press with cross-section chamber is made according to rotary configuration of the compaction chamber. Press consists of pressing mechanism, a drive, a frame, an intermediate shaft and the receiving roll table. Pressing mechanism consists of a central shaft, with the inner cylinder installed on it, which is one of the three molding walls of the variable cross-section chamber. The central shaft is supported by bearing assemblies mounted on the press frame. The same shaft has eccentric bushings, fixed on it and secured to the press frame through bearing assemblies, and these bushings have side disks mounted on them through bronze sleeve bearings and used as two movable walls of the variable cross-section chamber. In order to eliminate slippage during transportation of clay mass in the variable cross-section chamber, the side disks have pushers installed, which come on the follower inside and out of the pressing chamber, overlapping the last, and do not allow the clay coming back to the loading end of the compression chamber. The follower is made in form of annular cam and fixed on the press frame. The variable cross-section chamber is closed with a fixed clip installed between the side disks and lined with fluoroplastic plates in order to reduce the coefficient of friction. To remove the molded timber from the inner cylinder, there is a scrapping knife at the end of the variable cross-section compression chamber, which can be adjusted using spacers. The end of the fixed clip flows to horizontal rolling table, which transports a clay timber to a mechanism cutting it into individual bricks.

There is a design of screwless belt press I.C. #1031731. The purpose of the invention is to increase press capacity by increasing the injection ability. Figure 7 shows the design solution proposed [9]. Belt press consists of inner molding cylinder 1 with a shaft 2, connected to a drive, and two side disks 3 mounted on the eccentric bushings 4. The shaft is supported by bearing supports 5, the eccentric bushings 4 preventing cranking are fixed with brackets 6 on the supports 5.



**Figure 7: Belt press diagram:**

- 1 – inner molding cylinder; 2 – shaft; 3 – side disks; 4 – eccentric bushings; 5 – supports of eccentric bushings; 6 – brackets; 7 – pressing clip; 8 – hopper; 9 – gate valve; 10 – rod blockouts; 11 – follower tracks; 12 – drive spockets; 13 – scrapping knife; 14 – moving blades; 15 – profile cam.**

Pressing clip 7 is installed between the side disks 3 and fixed on the frame. Pressing clip 7 has a hopper 8 with gate valve 9 and rod blockouts 10 installed. Side disks are kept from being displaced with the fixed follower tracks 11. To start the rotation of side disks 3 the spockets 12 are fixed on them. A scrapping knife 13 is adjacent to the lower part of the molding cylinder 1, side disks 3 and pressing clip 7. There are six pairs of moving blades 14 on the side disks 3, which are kinematically connected to the semiannular profile cam 15 mounted on the press frame.

The belt press operates as follows: clay mass passes from feeding part of the hopper 8 into the pressing chamber formed by surfaces of the cylinder 1, side disks 3 and pressing clip 7. The moving surfaces of the rotating disks 3 and cylinder 1 move the clay mass to the outlet. The profile cam at the top of the pressing chamber starts to input the moving blades 14, which also move the clay mass lingering at the fixed clip 7. The blades are completely put in after  $30^{\circ}$  from the beginning of their input, and put out starting from  $120^{\circ}$  and completely ending at  $140^{\circ}$ . In order to increase press capacity by increasing the injection ability, the press is equipped with moving blades mounted in the drive side disks, and with fixed follower tracks placed on both side of the drive side disks. Despite the obvious advantages of the design of new molding machines, the main aggregates are the traditional presses, which is associated with high costs for re-equipment of engineering plants and reconstruction of existing facilities.

I.C. #667400 proposes further development of the design of screwless machines, aimed at improving the quality of products by cladding two layers [10]. This is achieved by that the belt press is provided with the additional rotor installed in housing parallel to the first rotor, and the additional comb with working faces placed in tangential planes of the rotors and forming the molding chamber.

Figure 8 shows the design solution proposed.

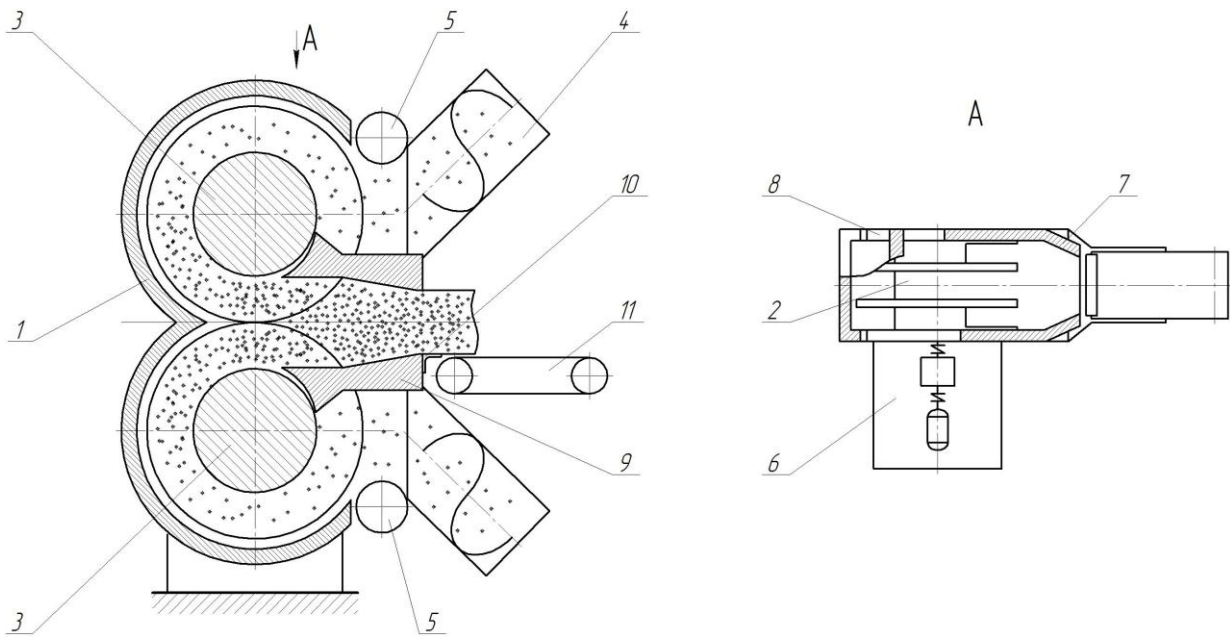


Figure 8. Belt press diagram:

1 – housing; 3 – rotors; 4 – feeding unit; 5 – feeding rollers; 6 – drive; 7, 8 – drive gears; 9 – chaser active faces; 10 – supporting bracket; 11 – transporter.

Unit consists of housing 1, rotors 3 are installed on the drive shaft, and the rotor axis may be positioned between a distance equal to the sum of their radii in order to activate the diffusion process of particles in the contact of two layers. Feeding of material is performed with feeding units 4 equipped with feeding rollers 5 to facilitate operation of the press. Drive 6 consists of electric motor and reducer, connected with rotors 3 through gears 7 and 8. Press molding chamber is formed by working faces of the combs 9 located in tangential planes of the rotors. Supporting bracket 10 and transporter 11 are mounted at the outlet for a timber.

Press operates as follows: clay mass is moved by the screw of the feeding unit 4 towards the delivery unit, and further - to the pressing chamber with the help of feeding rollers 5 and rotors 3. After removing a fixed part of housing, a kind of slowdown is eliminated, the linear speeds of timber cross-section are adjusted, one timber diffuses into another due to the combined timber rolling instead of indenting a textured layer at an angle of 90° to the moving direction of the main timber. A clay timber obtained is then fed onto the transporter 11.

Screwless machines for molding plastic masses have held a special niche and their designs have been further developed. A chair of “Technological complexes, machines and mechanisms” of BSTU n.a. Shukhov has taken out a patent for utility model of twin-rotor press RU #83730, which design is shown in Fig. 9 [11]. The laboratory unit has been constructed for studying all the processes in practice. Original material is fed into a hopper 1, which moves towards the pressing chamber with the help of screw 2. Pressing chamber consists of rotors 3, side disks 4 and pressing clip 5. Press thereby has three moving walls, which promote moving the mass towards the outlet. There are knives 6 at the outlet that prevent mass from changing its shape during extrusion from the pressing chamber. Side disks 4 are driven by means of a side disks drive unit 7. The entire structure is mounted on the bed frame 8.

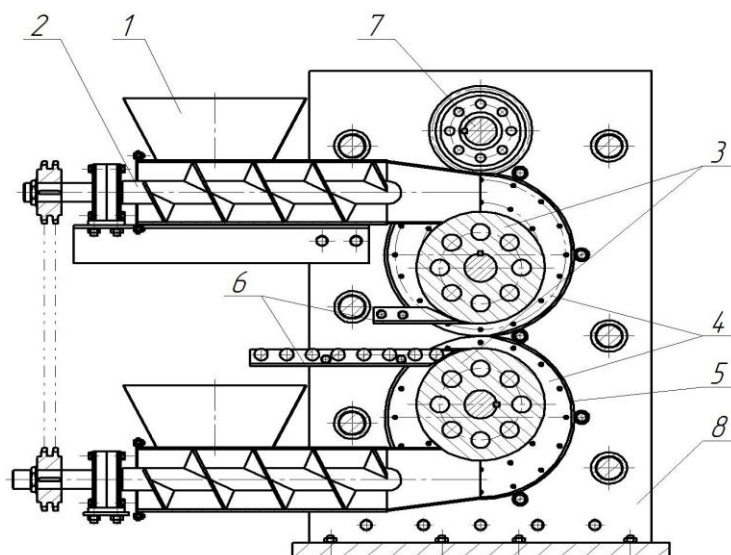


Figure 9: Twin-rotor press:

1 – bunker, 2 – screw feeder, 3 – molding cylinders, 4 – side disks, 5 – pressing clip, 6 – knives - rolling table, 7 – side disks drive, 8 – bed frame.

The above analysis of designs of screwless rotary machines opens up a new vistas for developing the design of processing and molding equipment.

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