DOI: 10.32782/2078-0877-2024-24-1-2
UDC [621.979.6:665.3](048.83)

Ihor Mikulionok[1], Dr. Eng. Sc., Prof. ORCID 0000-0001-8268-7229
[1] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"*
e-mail: i.mikulionok@kpi.ua, phone: +380667486565

CLASSIFICATION AND ANALYSIS OF DESIGNS OF SCREW PRESSES FOR OIL RAW MATERIALS

Summary. The most common method of obtaining high-quality liquid oils is pressing of oil raw materials. A detailed classification of screw presses for pressing oil raw materials has been developed. The designs of the presses were analyzed depending on the type of oil raw material, the temperature regime of its processing, the sequence of raw material processing, the place of oil output, the number of pressing stages, the number of screws, the location of the screw barrel in space, the type of screw channel, the shape of the screw, the degree of assembly of the screw(s) and /or barrel(s), availability of a device for adjusting the output of the cake (back pressure valve), availability of additional means for intensifying pressing, the possibility of movement in space. The analysis of the modern and prospects of the use of screw presses for pressing oil raw materials shows that the most common single- and double-screw presses will be used for the processing of oil crops for a long time to obtain high-quality oils. At the same time, the main efforts of developers of new equipment are aimed are aimed at creating high-performance universal equipment characterized by low material and energy consumption, ease of maintenance and high oil removal (deep oil extraction).

Key words: oil raw materials, oil, screw presses, classification, designs.

Formulation of the problem. Oils obtained from oil crops (sunflower, linseed, hemp, rapeseed, corn, soybean, apricot, plum, cherry, peach, grape, almond, mustard, peanut, castor, palm, coconut, palm kernel, olive, rice [1], as well as mint, caraway, walnut, olive, cotton, safflower and others [2]) are widely used not only in the food industry, but also in other sectors of the economy [3–5]. For example, one of the most common oils – sunflower – is widely used both in the food industry and for technical purposes, in particular in the production of household chemicals, paints and lubricants and oils, various technical fluids, as well as in the production of care products from skin, cosmetics and hygiene products [6–8].

One of the ways of using liquid oils, in particular rapeseed oil, is their use (in their pure form or as products of their chemical processing) as part of motor fuels, in particular for the preparation of biodiesel fuel mixtures [9, 10]. It has been proven that a mixture of 80% diesel fuel and 20% rapeseed ethyl ether, obtained by transesterification of rapeseed oil, is sufficiently effective for the operation of standard diesel engines without

any modification. Such a mixture not only saves diesel fuel, but also reduces harmful emissions into the atmosphere and "softens" the operation of the engine [11].

The most common method of producing high-quality liquid oils from oil crops is pressing, i.e. processing of oil pulp with pressure, which is accompanied by compaction of particles and extraction of oil [3, 12].

Pressing of oil raw materials – seeds of oil crops, as well as oil fruits and nuts – is carried out on hydraulic and screw (worm) presses [3, 13, 14], while screw presses are the most common, which is primarily due to the continuity of their work, and as well as wide possibilities of their structural and technological design [15].

It is worth noting that screw presses are widely used in the processing and food industries not only for extrusion, in particular pressed solid biofuel [16], but also primarily for extrusion grinding and forming of various food products: sweets, protein products, products based on starch, foam products, etc. [15]. At the same time, the extrusion processing of plant raw materials is in many ways similar to the processing of granular polymer raw materials (primarily in the feed section of the screw press) [17–24]. However, if the classification and research of the structural design of the process of extrusion of polymers and plastics has been carried out quite thoroughly, then insufficient attention has been paid to the issue of the structural and technological design of the process of squeezing oil from oil raw materials in screw presses.

Formulation of the aim of work. The purpose of this work is a critical analysis of the structural and technological design of the process of extracting oil from seeds, fruits and nuts of oil crops in screw presses.

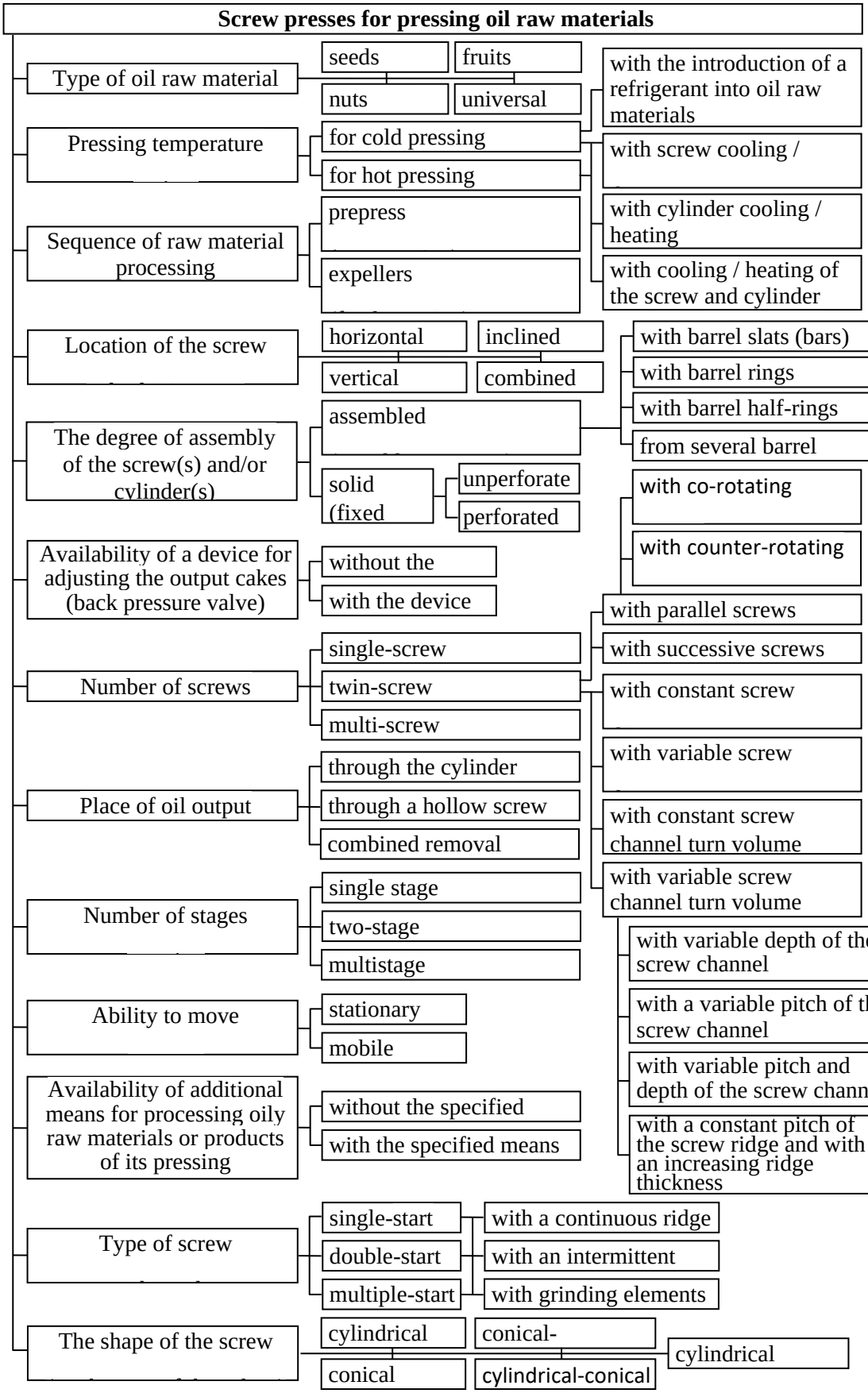
The main part. Wide use of screw presses led to the variety of their designs [25]. At the same time, the creation of new structures is primarily carried out experimentally, since the complex processes in the working channel of the screw, which occur during the pressing of oil raw materials, are quite complex and difficult to amenable to theoretical research [26].

Screw presses for pressing oil raw materials can be classified according to various features (Fig. 1).

According to the sequence of raw material processing, there are prepresses (pre-pressing presses) and expellers (final pressing presses).

First-pressed oil is obtained on prepresses by processing the initial oil raw material, and on expellers, second-pressed oil is obtained by processing the prepress cake subjected to moisture-heat treatment [27].

According to the type of oil raw material, there are presses for processing seeds, nuts and fruits, as well as universal ones.


Screw presses for pressing oil raw materials
Type of oil raw material
seeds
fruits
nuts
universal
Pressing temperature
for cold pressing
for hot pressing
Sequence of raw material processing
prepress
expellers
with the introduction of a refrigerant into oil raw materials
with screw cooling /
with cylinder cooling / heating
with cooling / heating of the screw and cylinder
Location of the screw
horizontal
inclined
vertical
combined
The degree of assembly of the screw(s) and/or cylinder(s)
assembled
solid (fixed
unperforate
perforated
with barrel slats (bars)
with barrel rings
with barrel half-rings
from several barrel
Availability of a device for adjusting the output cakes (back pressure valve)
without the
with the device
Number of screws
single-screw
twin-screw
multi-screw
with co-rotating
with counter-rotating
with parallel screws
with successive screws
Place of oil output
through the cylinder
through a hollow screw
combined removal
with constant screw
with variable screw
with constant screw channel turn volume
with variable screw channel turn volume
Number of stages
single stage
two-stage
multistage
Ability to move
stationary
mobile
with variable depth of the screw channel
with a variable pitch of the screw channel
with variable pitch and depth of the screw channel
Availability of additional means for processing oily raw materials or products of its pressing
without the specified
with the specified means
with a constant pitch of the screw ridge and with an increasing ridge thickness
Type of screw
single-start
double-start
multiple-start
with a continuous ridge
with an intermittent
with grinding elements
The shape of the screw
cylindrical
conical
conical-
cylindrical-conical
cylindrical

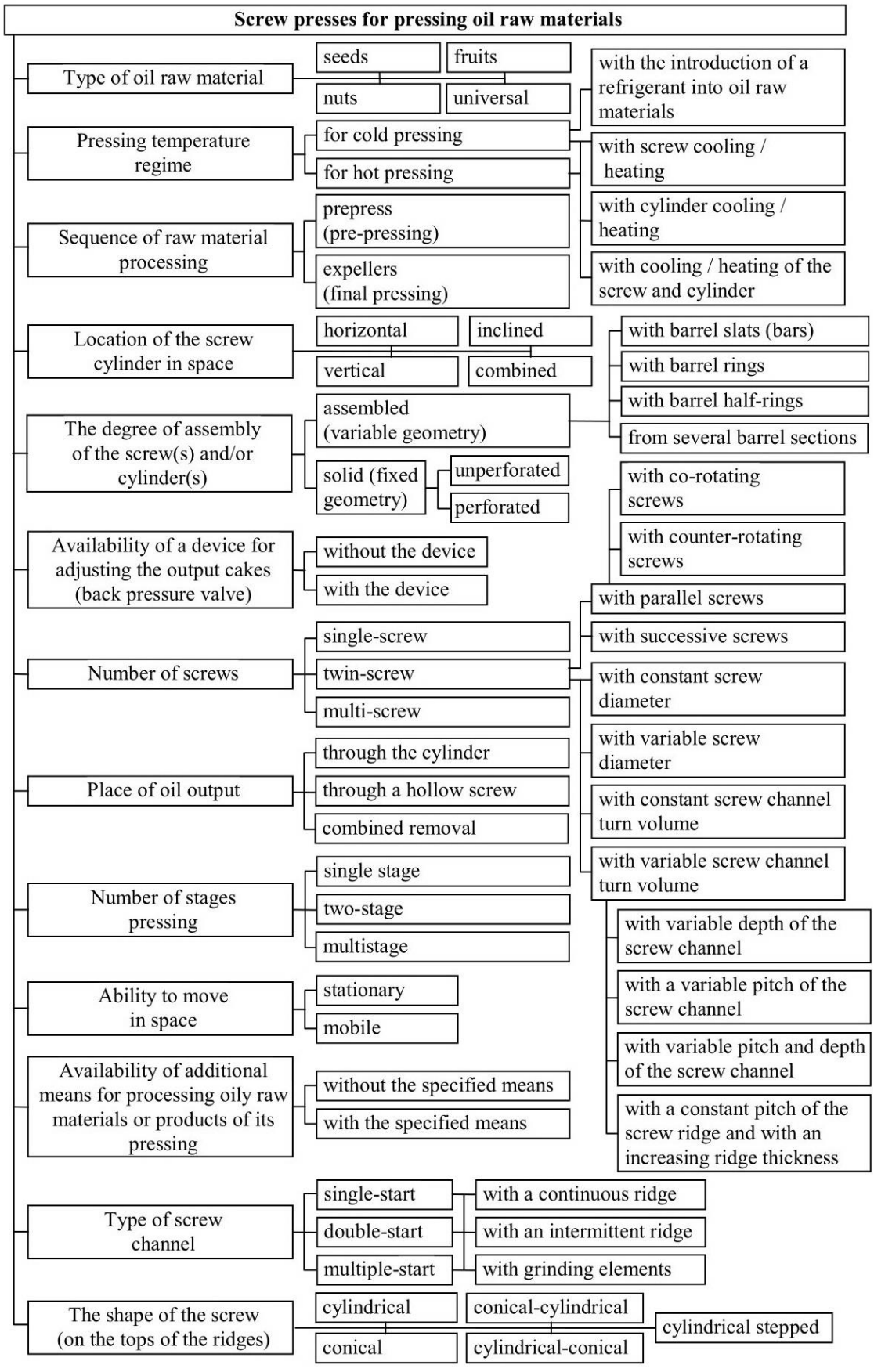


Fig. 1. Classification of screw presses for pressing oil raw materials

At the same time, within each class, the presses may differ in certain parameters: for example, screw presses with barrel chambers with smaller gaps between neighboring grates (barrel (or zeer) rings, half-rings, or slats (bars)) are used for processing rapeseed than in the case of processing sunflower seeds.

According to the temperature mode of pressing, there are presses for cold and hot pressing.

In cold pressing presses (cold presses), oil raw material is pressed without prior heat treatment (at the same time, the raw material arrives at a temperature of up to 80 ºC, and is not fried before entering the press).

The oil obtained by cold pressing is characterized by high organoleptic indicators, and the cake is characterized by high protein quality [28–30], and therefore high nutritional value, but the yield of oil by hot pressing is higher.

In order to prevent an increase in the temperature of the pressing process, the working organs of the cold pressing press – screws and barrel (cylinder) – can be equipped with cooling systems (Patent Nos. US5333556A, JPH02251397A, JPH04323297A, CN108284635A, CN109421307A, CN2789011Y, CN215750928U, CN22814007).

In a single-screw press, cooling water is supplied to each barrel (zeer) ring or each pair of adjacent barrel rings (Patent Application No. DE4109229A1; Fig. 2).

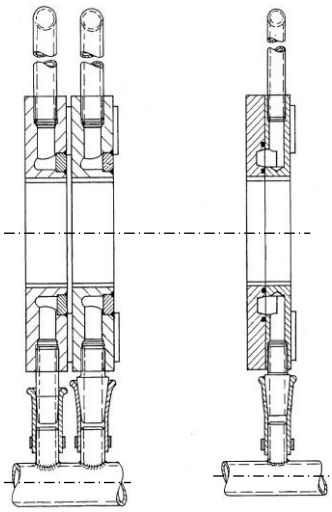


Fig. 2. The cooling scheme of the single screw press barrel rings (Patent Application No. DE4109229A1)

The twin-screw press contains a barrel consisting of sections with solid walls and zeer barrel sections (perforated, rings, half-rings, or slats (bars) sections), which alternate with each other, while each of the sections with solid walls is equipped with electric heaters (Patent Nos. UA3144C2, UA40189A, RU2057022C1). Screws also contain areas with mixing and dispersing cams in the form of convex equilateral triangles with angular

mixing with respect to each other to form a helical channel (Patent No. CN215512387U, Patent Application No. WO2022/270012A1), while these cam areas can be made as pushers and braking (due to the angular displacement of the adjacent cams [31]).

Electric heaters can also be located not only on the press barrel (Patent Nos. CN108556396A, CN109421308A, CN207984055U, CN208497750U), but also inside the screw or screws (Patent Nos. UA35405A, CN110524934A, CN218171498U).

The air, heated with the help of electric heaters, enters the cavity of the screw, and then exits through the radial holes into the working channel of the press (Patent No. CN211105796U; Fig. 3). The disadvantage of the design is the possibility of oil entering the screw cavity under the condition of pressing pressure greater than the pressure of heated air.

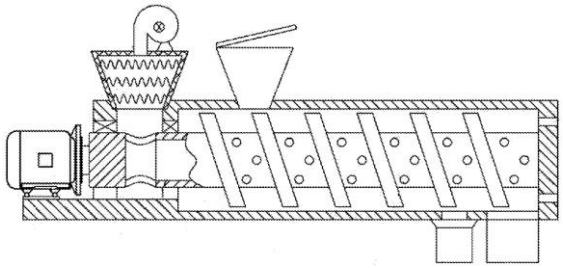


Fig. 3. Press with heating of oil raw materials with heated air through a hollow screw (Patent No. CN211105796U)

An interesting solution to lowering the temperature regime of the sunflower seed processing process is proposed in papers [32, 33]. The authors suggest adding CO_2 granules directly to the treated seeds, which allows for complete or partial rejection of cooling water. The disadvantage of the design is the need for special equipment for grinding, sorting and storing bulk carbon dioxide.

According to the number of screws, there are single-, double-, and multi-screw presses.

As already mentioned, screw presses for pressing oil raw materials are in many ways similar to widely used screw extruders for processing polymers, plastics and rubber mixtures, and not only for forming certain products from the melt, but also for grinding polymer and rubber waste [34, 35].

The simplest screw presses are single-screw, but double-screw and less common multi-screw presses are more versatile from the point of view of processed raw materials [36, 37].

The screw of a single-screw press can be fixed both as a cantilever (Patent No. UA60804U) and with supports at both ends (Patent Nos. CN202669015U, CN208343513U, UA33519U), which reduces the probability of contact between the screw and the barrel during press operation, but makes it difficult its production and operation. To increase

the service life of the screw, a layer of wear-resistant material can be welded to the top of its ridge (Patent No. US4223601A).

A single-screw press, on the inner surface of the barrel of which spiral ribs are made with the direction opposite to the cutting of the screw to prevent turning of the processed raw materials (Author's Certificate No. SU70014A1). The disadvantage of the design is the difficulty of manufacturing and cleaning the inner surface of the barrel.

A single-screw press contains a screw with two oppositely directed screw threads from its central part and a loading area in the central part of the screw (Patent Nos. UA50237U, UA56408U, CN217916906U; Fig. 4). This technical solution increases the productivity of the press and reduces its material consumption, as well as compensates for the axial force acting on a traditional screw (with a unidirectional thread and a loading area near the screw shank).

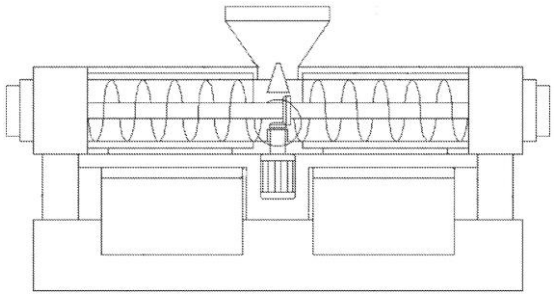


Fig. 4. Single-screw press with two independent press zones (Patent No. CN217916906U)

Presses with a similar principle of action, but with two loading hoppers located at the ends of the screw and a common central exit of the cake (Patent No. GB2601103A, Author's Certificate No. SU1639971A1; Fig. 5).

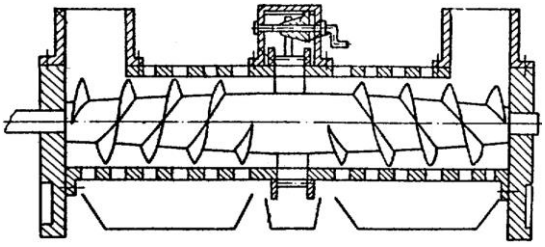


Fig. 5. Single-screw press with two independent press zones (Author's Certificate No. SU1639971A1)

A twin-screw press similar to the previous design is proposed in the Patent No. CN217968535U.

A single-screw press with a cylindrical stepped screw, the diameter of the steps of which gradually increases under the simultaneous condition of decreasing the height of the working channel (Patent No. UA75962C2). This technical solution favors the loosening of oil raw materials during the

transition to another stage, as well as the increase of shear forces in the working channel of the press.

A single-screw press with a cylindrical stepped screw, the diameter of the stages screw core (screw root) of the of which gradually increases with a corresponding decrease in the height of the working channel, while throttle washers are placed between the stages on the screw, and to maintain a low temperature of the process, liquid nitrogen is injected into the processed raw materials (Patent Application No. WO2022/237935A1; Figu. 6).

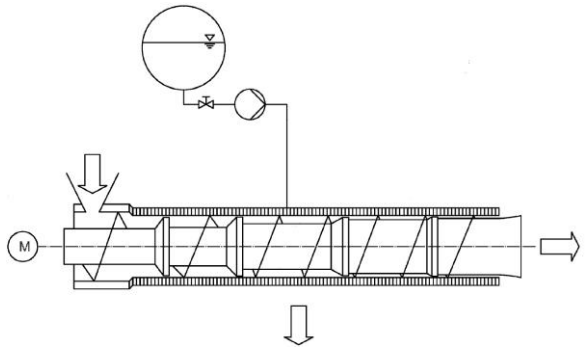


Fig. 6. Single-screw press with a stepped screw and throttle washers between the steps (Patent Application No. WO2022/237935A1)

Screws of a similar design, but with conical steps (both the core and the generating top of the ridge of the helical thread; Patent Nos. CN204869758U, CN205112458U).

A single-screw press with a cylindrical stepped screw, the diameter of the helical cutting ridges of the steps gradually decreases with a corresponding decrease in the height of the working channel (Patent Nos. CN213353643U), while throttle washers can be placed between the steps on the screw (Patent Nos. CN1887586A, CN2820517Y, CN201792507U, CN201998445U, CN201998446U, CN202727368U, CN114939998A; Fig. 7).

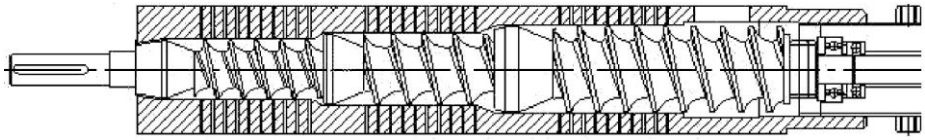


Fig. 7. Single-screw press with a stepped screw and throttle washers between the steps (Patent No. CN114939998A)

Among twin-screw presses, presses with counter-rotating screws (Patent Nos. JPH02251397A, JPH04323297A) and presses with co-rotating screws have become widespread, in which more intense shear deformations are realized in the section of the working channel between the screws (Patent No. JPH02151396A).

To improve the efficiency of the pressing process, the screws of twin-screw presses with counter-rotating can be equipped with cutting sections of the opposite direction, that is, the so-called "reversing cutting" (Patent Nos. CN2594005Y, CN205130454U; Fig. 8).

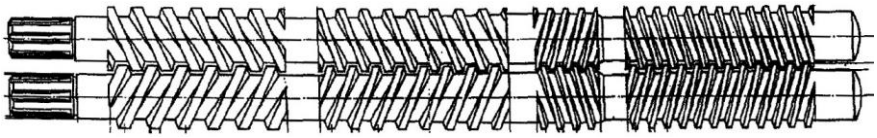


Fig. 8. Scheme of screws of a twin-screw press with multi-directional rotation of screws with cutting sections of the opposite direction (Patent Nos. CN2594005Y, CN205130454U)

Twin-screw press with counter-rotating screws, while each screw rotates not from the side of the shank (Patent No. CN212979331U), but from the side of the tip (Patent No. CN218171496U). This technical solution reduces the equivalent stresses of the screw material, because the greatest resistance to the rotation of the screws is not their feed zone, but the pressing zone.

A similar approach was also used in the designs of single-screw presses (Patent Nos. CN2706312Y, CN213947524U, CN202137967U; Fig. 9).

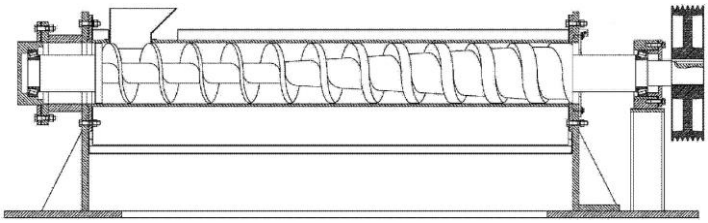


Fig. 9. Single-screw press with a rotation drive from the side of its tip (Patent No. CN202137967U)

A twin-screw press with counter-rotating screws located one above the other, while the press is equipped with two hoppers for feeding oil raw materials into the working channel of each screw (Patent Nos. CN1810497A, CN203305535U; Fig. 10).

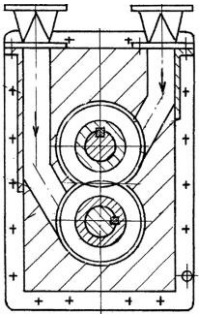


Fig. 10. Cross-section of a twin-screw press with individual screw feeding (Patent Nos. CN1810497A, CN203305535U)

Another technical solution for two-way feeding of a similar twin-screw press is proposed in the Patent No. CN205097582U. In this press, the oil raw material is fed by two screw feeders on both sides of the screw intermeshing area.

For ease of maintenance of presses of this design, the barrel is proposed to be made of two parts, hinged together in the lower part (Patent No. CN201512522U; Fig. 11).

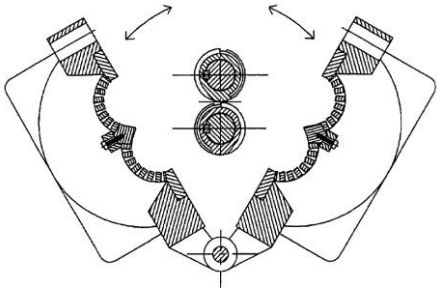


Fig. 11. Scheme of the barrel of a twin-screw press with horizontal screws located in a vertical plane (Patent No. CN201512522U)

In addition to traditional twin-screw presses with partial intermeshing of the screws, compact designs of twin-screw presses with screws in separate housings have been developed. Such presses can also be considered as two paired single-screw presses with a common screw rotation drive. For example, at the end of the 20th century, specialists of OJSC Bilshovyk (Kyiv, Ukraine; since 2018 – the First Kyiv Machine-Building Plant) developed a set of technological equipment for the production of fuel mixtures from mineral fuel and rapeseed oil (from 10 to 30%). The set includes one or more single- or double-screw presses for extracting oil from rapeseed (while each double-screw press contains two screws rotating in separate barrels from one drive), as well as a hydrodynamic mixer for preparing highly stable fuel mixtures using their cavitation processing [38]. At the same time, it should be noted that unlike traditional similar fuel mixtures, the mixtures obtained in the developed hydrodynamic mixer remain stable for a year or more.

Presses of a similar layout are given in Patent Nos. CN201070844Y, CN201579993U, CN203726864U, CN217803501U. In Patent No. CN211195019U describes a compact unit for pressing flax seeds, which on a common frame contains three single-screw presses with individual screw drives, and in the Patent No. CN209022489U is a unit containing four single-screw presses with group screw drive.

Twin-screw press with a combined arrangement of cylindrical stepped screws, the diameter of the steps of each of which gradually decreases (Patent No. UA3845U). In the first section (maximum diameter), the screws are located in a common barrel with partial intermeshing with each other, and in the following sections – in different barrels.

To compensate for the decrease in the volume of pressed raw materials, the volume of the screw channel in the pressing direction is gradually reduced. For this purpose, presses with a variable pitch of the screw channel (Patent Nos. CN209937790U, CN210048727U, CN217395760U), with a variable depth of the screw channel (Patent No. CN211843323U) and less often – with a variable pitch and depth of the screw channel (Patent Nos. CN111634050A, CN113789218A, CN209666365U, UA113259U, [39]).

Screws of single-screw presses with a constant screw pitch, a conical core that expands in the pressing direction, and a constant diameter of the cutting ridge ensure a consistent reduction in the volume of the screw turn (Patent Nos. CN204123354U, CN208646113U).

The continuous reduction of the volume of the screw with a cylindrical core is ensured by the reduction of the height of the screw thread ridge under the condition of its constant pitch, while the screw takes the form of a truncated cone with a larger base on the side of the loading hopper (Patent No. CN211734285U).

A screw press with a constant screw pitch and with a ridge thickness that increases along the screw, although it provides a successive reduction in the volume of the screw turn (Patent No. RU2475167C1). A similar screw is proposed in patent number CN203713107U (Fig. 12), but such screws are distinguished by the complexity of their manufacture.

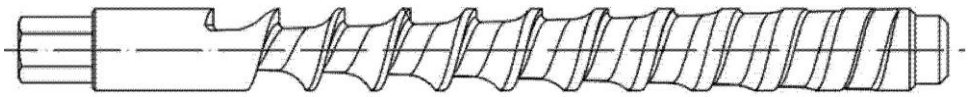


Fig. 12. Screw with a variable thickness of the helical cutting ridge (Patent No. CN203713107U)

The press screw with a constant core diameter and variable cutting pitch, but with a variable screw channel depth to form a stepped screw, is placed in a barrel with a stepped cavity (Author's Certificate Nos. SU757346A1, SU861104A1, SU1021634A1). The volume of the inter-turn space of this screw decreases in the pressing direction.

Each of the screws of the double-screw press with counter-rotating screws is made stepped in the form of a core of constant diameter with variable cutting pitch, while the steps of a larger and smaller diameter form the cutting ridge, and the screws are placed in the stepped cavity of the barrel (Patent No. CN205395237U). Thus, the volume of the screws turns decreases in the direction of pressing due to a gradual decrease in the depth of the cut and a gradual decrease in its pitch along the entire length of the screws.

Also, for this purpose, presses with a variable diameter of not only the core, but also the screw cutting ridge, in particular conical ones, are used.

At the same time, the diameter of the screws in the pressing direction can both decrease (Patent Nos. CN208118490U, CN209794636U, CN210337022U, CN215750928U, CN217671268U) and increase (Patent No. CN203766069U).

Combined screw with a cylindrical feed section and a conical press section (Patent No. CN211165448U).

Combined screws with a cylindrical feed section with a constant volume of the screw channel within it, as well as a multi-stage conical press section, the stages of which are separated by throttle washers (Patent Nos. CN204451280U, CN204451281U).

For continuous renewal of macro volumes of raw materials subject to destruction during pressing, the screw cutting ridge is performed intermittently (Patent Nos. CN209649548U, CN210257372U, Patent Application No. WO2020/104767A1) or the screw is equipped with dispersing and mixing elements of various designs (Patent Nos. US5680812A, UA98920U, UA119024U, Author's Certificate No. SU1043028A1, [31]). But the application proposed in Patent No. CN113789218A of pointed pins on the screw core contributes not so much to the loosening of processed oily raw materials, but to its capture by the screw and rotation with it, which reduces the productivity of the press and makes the effectiveness of this technical solution questionable.

Dispersing and mixing elements in the form of gear wheels fixed in pairs along the length of the screws of the twin-screw press with the possibility of interlocking not only contribute to the intensification of the processing of oily raw materials, but also prevent the screws from twisting along their length, and therefore their jamming during operation (patent Nos. CN111469471A, CN212528813U).

The outer surface of the ridge of the helical cutting of the screw's feed section is made with flats, which with the inner cylindrical surface of the barrel form a clearance (gap) of variable size (in the circular direction), which ensures preliminary crushing of the oily raw material before it enters the press zone (Patent Nos. CN203600634U, CN203600635U, CN204488078U; Fig. 13,a). Such a screw turned out to be especially effective during the processing of the fruits of oil crops. For a similar purpose, the ridge of the helical cutting of the feed section of the screw on several turns is made with one-sided flats (Patent No. CN203739263U; Fig. 13, b).

The ridge of the helical cutting of the feed section of the screw is transformed into a set of cams designed for effective destruction of the oil raw material and its capture by the screw for further advancement in the direction of the press section (Patent No. CN203901770U; Fig. 14).

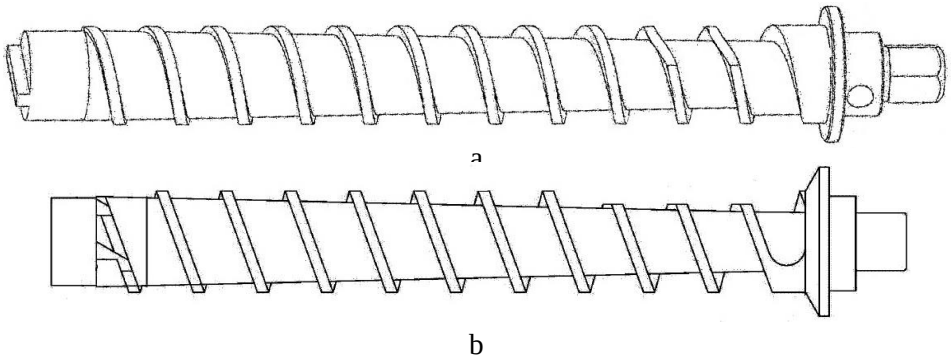


Fig. 13. An improved ridge of the screw cutting of the screw feed section: a – Patent No. CN204488078U; b – Patent No. CN203739263U

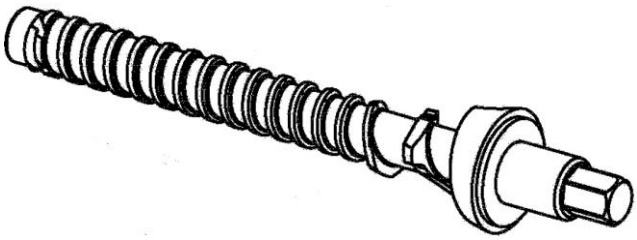


Fig. 14. An improved ridge of the screw cutting of the screw feed section (Patent No. CN203901770U)

For better capture of the oil raw material by the screw and its preliminary grinding on the cylindrical part of the core of the screw under the discharge opening of the loading hopper of the press, a flat is made (Patent No. CN204340262U; Fig. 15,a) or the specified area of the core is made in the form of a prism (Patent No. CN202826482U; Fig. 15,b).

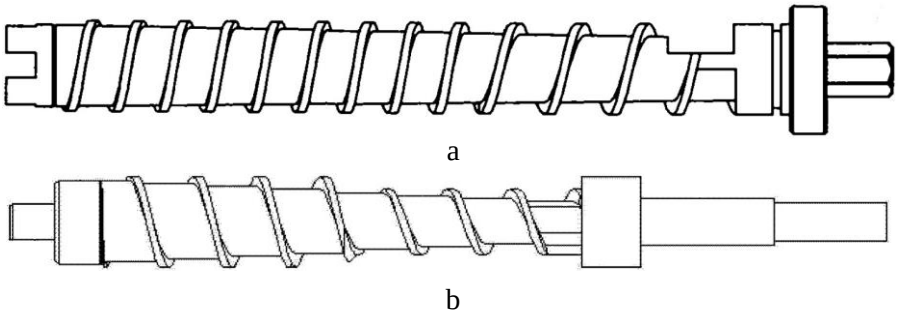


Fig. 15. Improved screw core in its feed section:
a – Patent No. CN204340262U; b – Patent No. CN202826482U

To destroy the cellular structure of the oil raw material and increase the yield of oil in the break of the screw turns of the single-screw press, an intermediate matrix with holes of a fixed (Patent Nos. RU2353522C1, RU2354556C1, RU2399493C1, RU2401199C1) or adjustable live cross-section (composed of two similar parts installed with the possibility of angular displacement relative to each other; Patent No. UA60804U).

By analogy with extruders for the processing of polymeric materials, the barrel of the screw press for pressing oily raw materials contains radial pins that pass through the gaps in the screw ridge and loosen the processed solid phase, which contributes to more complete squeezing of the oil from it ("pin barrel extruder"; Patent Nos. US4901635A, RU2559330C1, RU167408U1). Also, the pins can be installed with the possibility of adjusting the depth of their immersion in the channel of the press (Author's Certificate No. SU547370A1). Also, these pins are sometimes made in the form of counter blades (Patent No. UA2077C1, Author's Certificate No. SU1562152C1).

The technical solution proposed in Patent No. UA97165U, allows you to use the screw without gaps in its ridge, while the radial pins are made movable and equipped with a drive for their reciprocating movement. However, this design significantly complicates the manufacture and operation of the press.

A double-screw press with conical screws makes it possible not only to compensate for the decrease in the volume of processed raw materials during its advance through the press, but also, due to the fact that the shanks of the screws diverge from each other, to use effective thrust bearings (Patent No. UA112793C2).

Twin-screw presses with sequentially located coaxial screws: feeding screw and slower pressing screw, equipped with individual rotation drives (Author's Certificate Nos. SU382522A1, SU725899A1). By adjusting the ratio of the rotation frequency of the screws, it is possible to change the depth of oil extraction.

In a three-screw press, the preliminary extraction of oil takes place in a section with two counter-rotating screws, and the final extraction takes place in a section with one screw located at its exit, which is equipped with an individual drive (Patent No. UA11189C1). The advantage of the press is the wide technological capabilities of this kind of cascade press due to the presence of independent drives of the double-screw and single-screw parts of the press.

In a three-screw press, the screws are located in a horizontal plane, while the adjacent screws have multi-directional cutting and can be made without intermeshing and continuous screw cutting ridges or with intermeshing, but with discrete screw cutting ridges (Patent No. CN101249728A).

In the five-screw press, the horizontal screws in the cross section are arranged in the form of Olympic rings: three in the upper row and two in the lower row, while the screws are made by analogy with the screws of the previous three-screw press (Patent No. CN202462917U).

The multi-screw press contains a main screw of a large diameter, as well as additional screws of a smaller diameter placed in its inter-turn space parallel to the longitudinal axis of the main screw Author's Certificate No.

SU1386485A1; Fig. 16). The disadvantage of the design is its unreasonable complexity.

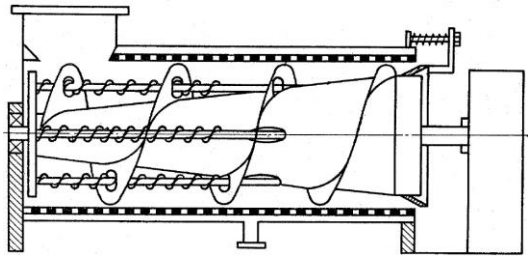


Fig. 16. Scheme of a multi-screw press
(Author's Certificate No. SU1386485A1)

According to the shape of the screws, there are presses with cylindrical, conical, conical-cylindrical, cylindrical-conical and cylindrical stepped screws.

In contrast to traditional cylindrical screws with a continuous or interrupted screw single-start thread, a screw with an intermittent screw double-start thread and throttle washers is proposed, while the thread is made in the form of separate turns of different pitches separated from each other (Patent Application No. WO2020/104767A1; Fig. 17).

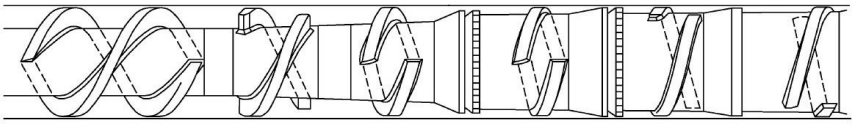


Fig. 17. Single-screw press with a stepped screw and throttle washers between the steps (Patent Application No. WO2020/104767A1)

The work of a universal press with a cylindrical-conical screw, recognized for the processing of various types of olive raw materials, was completed [40]. Cylindrical screw hole with a diameter of 40 mm and a bottom of 550 mm, a larger base of a conical bottom hole of 200 mm and an angle at a top of 45º – 87 mm, screw cutting depth – 9.99 mm. Drive electric motor power 35 kW.

Press with a cylindrical-conical screw is also described in Patent Nos. CN107856337A, CN210553191U, CN210679820U, Author's Certificate No. SU640859A1.

A twin-screw press with parallel cylindrical stepped screws, the diameter of which steps decreases in the pressing direction (Patent No. UA3845U). In the first section (feeding), the screws are located in a common barrel with partial intermeshing with each other, and in the following sections (pressing), each of the screws is located in a separate barrel.

A press with a cylindrical stepped screw, the diameter of the steps of which increases in a straight line pressing (Patent No. UA5032C2,

Author's Certificate No. SU1459936A1). At the same time, between two cylindrical sections, the end section was stashed with pins-fluffers (Fig. 18).

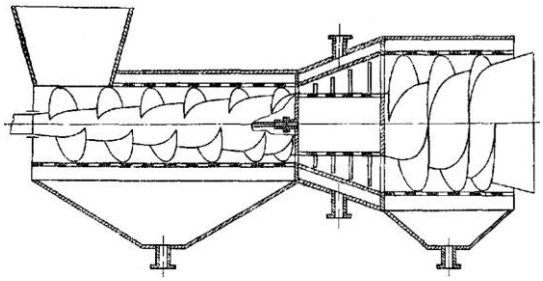


Fig. 18. Press with a cylindrical stepped screw (Patent No. UA5032C2, Author's Certificate No. SU1459936A1)

According to the degree of assembly of the screw(s) and/or barrel(s), there are presses with a solid screw and/or barrel (fixed geometry) and presses with a assembled screw and/or barrel (changeable, adjustable geometry).

A twin-screw press with a barrel made by sintering metal spheres, granules or fibers has a wall with an open porous structure (Patent No. GB1507946A). Such a design is characterized by high strength and rigidity, but it is difficult to clean, since the curvilinear channels of variable cross-section, formed by the gaps between the elements of the barrel wall structure, have a tendency to clog with cake.

Making the screw(s) and/or barrel(s) assembled significantly expands the technological capabilities of the press. In particular, by changing the number, length and type of the working part of the removable sleeves placed on the screw root (screw core), the oil extraction depth and the cake structure are changed (Patent No. CN2210779Y).

The barrel of a single-screw press, consisting of two halves: the lower stationary and the upper folding one, increases the convenience of cleaning the screw during press maintenance (Patent No. CN217891972U; Fig. 19).

In similar presses, the upper part of the barrel is not hinged, but removable (Patent Nos. CN207683005U, CN216968761U).

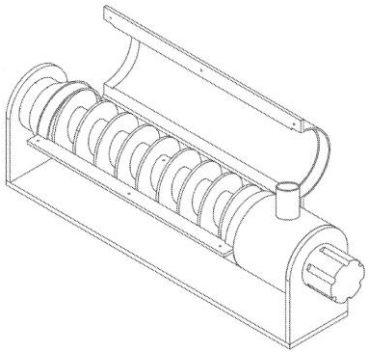


Fig. 19. Scheme of a single-screw press with a detachable barrel (Patent No. CN217891972U)

The twin-screw press barrel consists of two halves: the upper and the lower, which are installed with the possibility of turning relative to each other and "opening" the working area of the press to control its condition (Patent Nos. UA25846C2, RU2108239C1; Fig. 20).

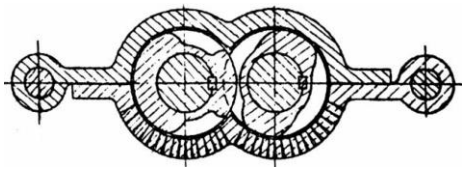


Fig. 20. Cross-section of the working part of a twin-screw press with a assembled barrel (Patent Nos. UA25846C2, RU2108239C1)

A barrel assembled in the longitudinal direction is proposed in the Patent No. UA24490A. The upper stationary part of this barrel is equipped with an electric heater, and the lower (seeing) part is removable (Fig. 21). Similar technical solutions are also proposed in the Patent Nos. UA29972A, RU2146198C1, RU2145925C1.

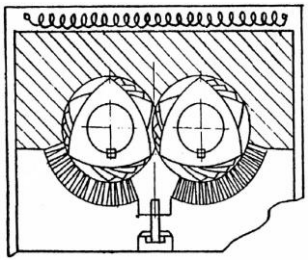


Fig. 21. Cross-section of the working part of a twin-screw press with a assembled barrel (Patent No. UA24490A)

It is worth noting that the zeer barrel usually consists of separate elements located with a gap relative to each other for the release of the received oil: longitudinal – zeer slats (bars) and annular – zeer rings or zeer half-rings.

A two-screw press with assembled screws in the form of a core with a set of removable sleeves with a screw thread or mixing and dispersing elements allows you to effectively form the desired geometry of the screws depending on the parameters of the pressing process (Patent Application No. DE102004037349A1).

Solid barrels are usually made with transverse holes (Patent Application Nos. DE2456187A1, DE19608379A1, DE19921790A1, EP1182030A1, CN217574190U) or slits (Patent Application Nos. US2019/217567A1, US2020/031077A1, US2020/031078A1, US2020/031079A1, US2021/138751A1, DE102007001311A1, KR20140106163A) for oil output. Often, the specified holes and slits are made in such a way that they diverge in the radial direction to prevent them

from being clogged with cake, in particular, the holes are made conical, and the slits are wedge-shaped (Patent No. CN103802346A).

The transverse holes of the solid barrel are located in the diametrical plane at an angle to the radius in the direction opposite to the rotation of the screw, which reduces the probability of clogging of the holes, which are made conical and diverge from the longitudinal axis of the screw (Patent Application No. DE19921790A1).

The inlet sections of the conical radial holes are located in longitudinal grooves on the inner surface of the solid barrel (Patent Application No. WO2020/220096A1; Fig. 22). The specified grooves prevent the processed raw material from turning during its advancement through the press channel.

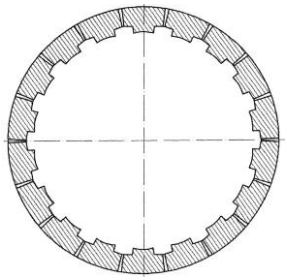
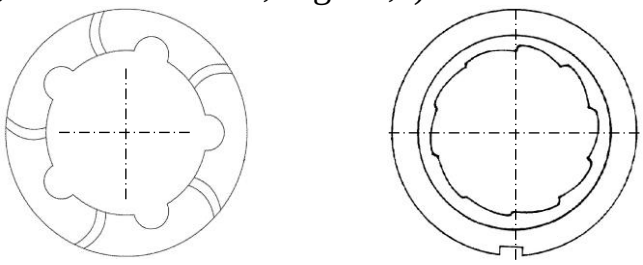


Fig. 22. Cross-section of the single-screw press barrel press section (Patent Application No. WO2020/220096A1)

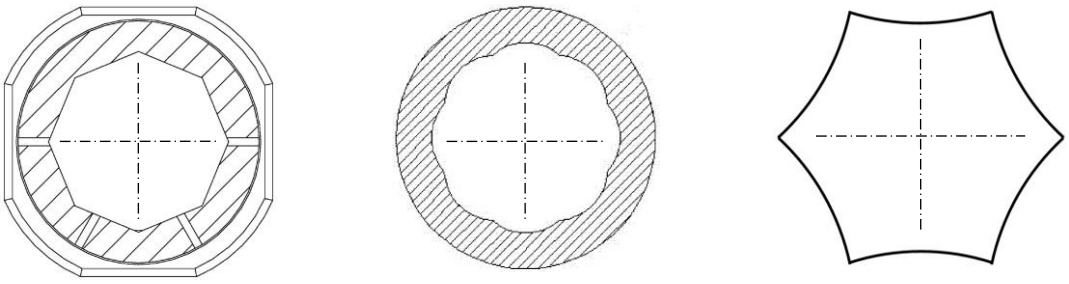
At the same time, the longitudinal grooves can be of various shapes, for example, semi-cylindrical (Patent No. CN209937789U; Fig. 23,a) or sickle-shaped (Patent No. CN2032940U; Fig. 23,b).

Also, to prevent turning of the processed raw material during its transportation through the channel of the press, the surface of the barrel cavity is made polygonal (Patent Nos. CN203580175U, CN208774124U, CN211843323U, Patent Application No. WO2017/121227A1; Fig. 24,a), with longitudinal wide rounded grooves (Patent Nos. CN1044431A, CN202669015U; Fig. 24,b) or in the form of a regular octagonal or hexagonal prism with concave faces (Patent Nos. CN201224188Y, CN203427345U, CN203864058U; Fig. 24,c).



a b

Fig. 23. Cross-section of the single-screw presses barrels press section: a – Patent No. CN209937789U; c – Patent No. CN2032940U



a b c

Fig. 24. Cross-section of the single-screw presses barrels press section:
a – Patent Application No. WO2017/121227A1:
b – Patent No. CN202669015U; c – Patent No. CN203864058U

For a similar purpose, the cavity of the barrel of the single-screw press in the cross section is made in the form of an epicycloid (Patent Application No. EP0017809A1).

Another design of the single-screw press barrel, which is technological in production and convenient in maintenance, is made in the form of a set of slats, tightened on the outside by frames – cylindrical bandages (Patent No. CN210525889U; Fig. 25). These strips not only form channels for the oil to escape, but also prevent the processed oil raw material from turning under the action of the rotating screw, increasing the press's productivity.

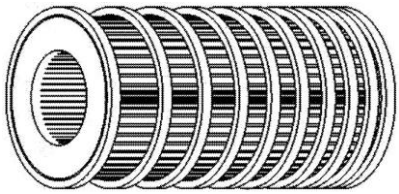
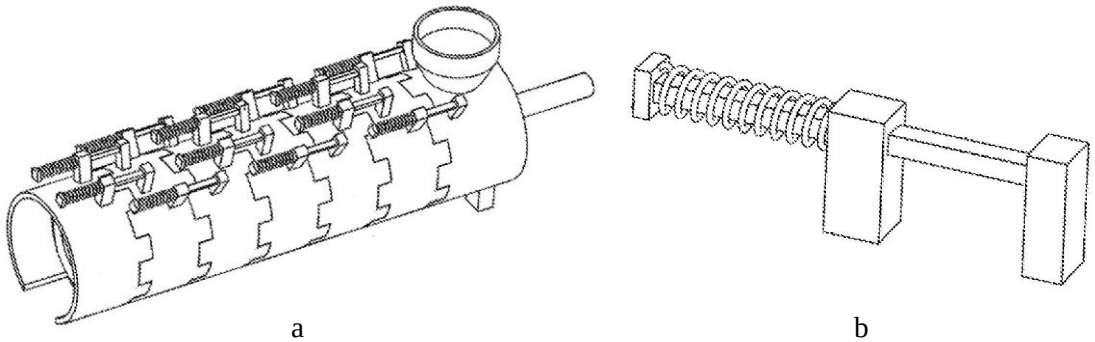


Fig. 25. General view of a barrel made of barrel bars
(Patent No. CN210525889U)

A barrel of a similar design, but with frames connected to each other with the help of slats to form a deck – a rigid cylindrical cage frame for placing in it a set of barrel bars (Patent no. CN114290736A).

Spacer elements in the form of balls are placed between the adjacent barrel bars in their depressions on the side surfaces, which ensure the formation of wedge-shaped gaps of certain shapes and sizes for the oil to escape (Patent No. GB1000773A). At the same time, a number of slats are made of increased height with their edges protruding towards the screw with the formation of peculiar reflective protrusions, which make it impossible to turn the oil raw material under the action of the rotating screw and increase the productivity of the press. The disadvantage of the design of such a barrel is the significant complexity of its manufacture due to the difficulty of fixing the balls during assembly.

A single-screw press with longitudinally movable barrel sections makes it possible to automatically lengthen the barrel and enlarge the oil outlet slots, thus automatically maintaining the required pressing pressure (Patent No. CN113580637A; Fig. 26). At the same time, the pressing pressure can be changed by adjusting the tension of the springs that tighten the adjacent sections of the barrel.



a b

Fig. 26. Single-screw press with constant pressing pressure (a) and an element for tightening adjacent sections of the barrel (b) (Patent No. CN113580637A)

The zeer barrel of a single-screw press is made of plates arranged with gaps (usually 0.5–0.8 mm) relative to each other for oil release. In order to prevent clogging of these gaps with particles of the solid phase, the plates have a trapezoidal cross-section (Patent Nos. GB191300386A, US4384955A, DE870360C, KR102449471B1, Patent Application No. DE19951007A1). A similar solution exists for a twin-screw press (Patent No. FR2644729A1). The disadvantage of zeer barrels is the complexity of manufacturing, and the advantage is the possibility of changing the size of the gaps between adjacent plates, for example, by installing distance washers between them (Patent Application No. DE19644368A1).

The inner surface of each barrel ring is made conical with a smaller base of the cone on the side of the screw tip, which creates additional pressure for the passage of oil raw materials within each ring, helps to increase the depth of oil extraction and reduces the probability of cake particles getting into the oil (Patent Application No. DE19644368A1; Fig. 27).

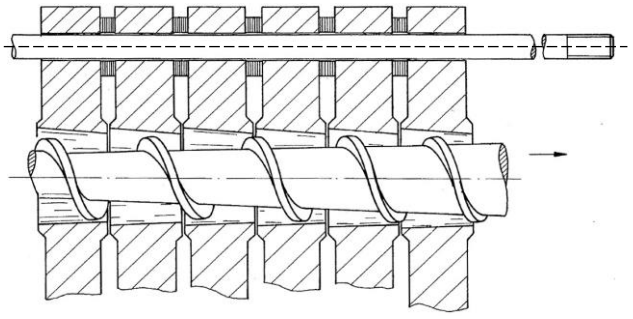


Fig. 27. The design of the single-screw press barrel (Patent Application No. DE19644368A1)

At the same time, in a press of a similar design, the neighboring barrel (zeer) rings are made of different widths and with relief end surfaces to form channels for draining oil from the working channel of the press (Patent Application No. DE19951007A1; Fig. 28). The disadvantage of this design of rings is the complexity of manufacturing.

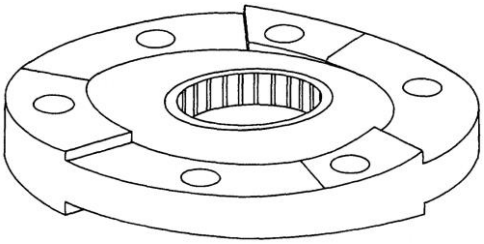


Fig. 28. The barrel ring of the single-screw press
(Patent Application No. DE19951007A1)

Each barrel ring of a single-screw press is made in the form of a cone with bumps on the end surfaces to form annular gaps between adjacent rings (Patent No. UA113259U). The inclined conical annular channels formed by such rings, converging in the direction of pressing, not only ensure the removal of oil from the working channel of the press, but also reduce the probability of cake particles getting into the oil.

A removable throttle washer is installed between the sections of the press barrel, which makes it possible to change the resistance to the advance of the processed raw material and influence the output of oil from the raw material (Patent No. US4271754A, Patent Application No. DE19601128A1).

The barrel of the screw press is made of separate sections with flanges at the ends, which improves the repairability of the press, as it makes it possible to replace not the barrel as a whole, but its separate section (Patent No. FR2396642A1).

The combined barrel of the single-screw press contains a solid body and a removable perforated curved plate (Patent No. CN204801093U; Fig. 29).

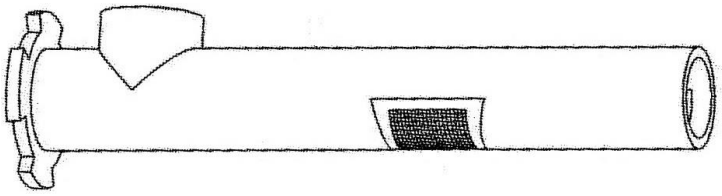


Fig. 29. Solid barrel with a removable perforated curved plate
(Patent No. CN204801093U)

According to the location of the screw barrel(s) in space, there are horizontal, vertical, inclined and combined presses.

Most screw presses are made with a horizontal arrangement of screws, but presses with vertical screws are also used (Patent Nos. CN109624372A,

RU2271931C2, Author's Certificate Nos. SU640859A1, SU670462A1, SU766892A1, Patent Application Nos. WO2014/036882A1, WO2016/008425A1). The disadvantage of presses with vertical screws is the inconvenience of maintaining presses of considerable height.

A twin-screw press with superimposed inclined cylindrical screws facilitates the flow of oil from the feed section towards the press section, but this design is more complex than traditional presses with horizontal screws (Patent No. CN214448773U).

A twin-screw press with a vertically arranged screw of the first stage of pre-grinding and pressing, as well as a horizontally arranged screw of the second stage of pressing (Patent No. CN203994792U). Both screws have a common drive for their rotation, which makes it impossible to independently adjust the rotation frequency of each of them.

According to the number of pressing stages, there are single-, two- and multi-stage pressing presses.

In two- and multi-stage pressing presses, the pressure in the working channel between the stages is reduced to atmospheric, while the processed raw materials are usually degassed (Patent Nos. US4024168A, US4271754A) or water vapor is added (Patent No. US5826500A). The stages can be implemented both on single-screw presses (Patent Nos. US4271754A) and on cascade presses consisting of several single- or twin-screw presses connected in series (Patent Nos. US5826500A, CN211441285U, CN213648783U, Patent Application Nos. WO97/03577A1, EP0840557A1).

The easy-to-maintain two-stage press contains mounted in one unit one above two traditional single-screw presses with oil extraction at each stage (Patent CN214164142U).

In a compact two-stage press, from the outside of the barrels of a traditional single-screw press of the first stage of pressing, a rotating cylindrical die with a spiral winding is mounted on its inner surface to form a second pressing zone (Patent No. CN113927939A). After the first stage of pressing, the cake, passing to the area of the second stage of pressing, significantly loosens, which contributes to the maximum yield of oil.

According to the possibility of movement in space, there are stationary and mobile (mobile) presses.

Mobile presses are usually made portable and used in private households and less often in industry with the possibility of placing them on a vehicle for prompt delivery to the source of oil raw materials that need processing (Patent No. CH686880A5).

Movable single-screw presses are mounted on the wheel track (Patent Nos. CN208324324U, CN213006711U, CN211105799U).

The mobile press unit, which is also mounted on the wheel track, contains two single-screw presses located one above the other and provides a high depth of oil extraction (Patent No. CN205736098U).

The wheel-mounted mobile baler contains one loading hopper and two single-screw balers with a common screw drive (Patent No. CN216941937U). Such a constructive solution significantly reduces overall dimensions and material capacity of the press and increases its productivity.

According to availability of a device for adjusting the output cakes (back pressure valve), there are presses without this device and with such a device.

The most common device for adjusting the cake release (throttle element) is an inverted locking cone, which is fixed directly on the screw in the form of a mandrel and rotates with it (Patent No. UA3682C2) or on the body of the press in the form of a matrix or sleeve (Patent Nos. CN107856337A, CN114290736A, CN201165057Y, CN203792748U, CN214395567U, CN216804522U, CN2644153Y, Author's Certificate No. SU1194689A1). Adjusting the width of the annular channel between the closing cone and the matrix is usually carried out by changing the position of the matrix along the axis of the screw. A screw design with a removable locking cone fixed on the screw core with the possibility of adjusting its position along the screw was also developed; at the same time, it is possible to change the standard size of the locking cone for processing different oil raw materials [38].

To prevent overheating of the cake at the exit from the press, the matrix of the means for adjusting the release of the cake is made cooled (Patent No. CN213291432U).

Also, the closing cone can be made not inverted, but straight (that is, converging in the direction of pressing), however, a straight cone increases the probability of clogging the output channel of the screw with cake (Patent UA29972A). At the same time, the movable conical sleeve is equipped with a hydropneumatic spring (Author's Certificate No. SU643354A1) for adjusting the size of the annular closing gap and automatically maintaining a constant pressing pressure.

The locking cone is fixed on the body of the press with the help of a spring that presses it against the matrix, while the spring is installed with a locking both in the cone and in the adjusting nut (Patent No. UA6535U). By rotating the nut, the force of pressing the locking cone against the matrix is changed. During the operation of the press, under the influence of the pressure from the processed oil raw material, the spring is compressed, and the cone moves away from the matrix, forming an annular gap between the cone and the matrix for the exit of the cake.

The press device for adjusting the cake output is made in the form of a double-conical fixed matrix, in one conical part of which there is a conical tip of the screw, and in the second – a conical tip of a rotating mandrel installed with the possibility of adjusting its axial position (Patent No. RU2430147C1). By changing the axial position of the mandrel and the frequency of its rotation, the hydraulic resistance of the annular channel for the release of cake is regulated. The disadvantage of the design is the significant hydraulic resistance of the confusor-cylindrical-diffuser channel of the matrix.

Also, the locking element can be made in the form of a sphere, a barrel, an ellipsoid, an elliptical paraboloid, a homogeneous hyperboloid, etc. (Patent No. US836701A).

The regulating device at the outlet of the channel of the single-screw press is made in the form of a washer with an adjustable cross-section of the passage channels, which can be blocked individually or in groups (Patent No. DE19715357C1).

In Patent No. GB1506455A, it is proposed to move not the cone, but the matrix, made in the form of an annular nozzle of the barrel, to adjust the exhaust ring nozzle (Fig. 30).

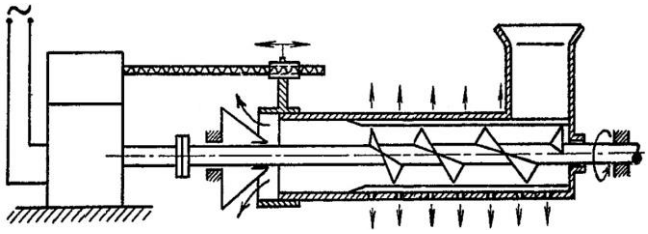


Fig. 30. Device for adjusting the output of the cake from the screw press (Patent No. GB1506455A)

According to the availability of additional means for processing oily raw materials or products of its pressing, there are presses without such means and with such means.

The tip of the screw of the press is connected to the generator of ultrasonic vibrations, which makes it possible to increase the yield of oil from vegetable raw materials (Patent No. RU2296153C1).

It is also proposed to place the generator of ultrasonic vibrations on the barrel of the single-screw press (Patent No. CN213137917U).

A press with a locking matrix equipped with an ultrasonic emitter of electromagnetic vibrations to increase oil removal (Patent No. UA72160U).

To increase productivity during pressing, plant raw materials are recommended to be moistened (Patent No. KZ25818A4). For this, water is fed into the working channel of the press, for example, by spraying through nozzles. Under the influence of high pressure and temperature, water turns into steam, which creates a porous structure of the processed raw material and facilitates deep and easy extraction of oil.

A press with a screw equipped with a rotary impact drive (Patent No. UA27403U). The disadvantage of the design is significant dynamic loads on both the screw and its thrust bearing.

In the loading hopper of the press, a device for atomizing water vapor is mounted, which contributes to the heat-moisture treatment of the raw oil raw material (Patent No. UA147470U).

The single-screw press with the function of sterilizing the received oil contains an ultraviolet lamp for irradiating the oil (Patent No. CN215791927U).

The screw press is equipped with a mesh filter for pre-cleaning the oil from cake particles (Patent No. CN113733630A), while the filter can be vacuumed to improve the filtering process (Patent No. CN201217275Y). Also, with the help of a vacuum, suction of oil from the working channel of the press is accelerated (Patent No. CN212288875U).

The screw press is equipped with a means for pressing oil raw materials in a nitrogen atmosphere (Patent No. CN212219407U). Displacing air oxygen with nitrogen from oil improves its stability and increases its shelf life.

According to the place of oil output, presses with oil output, there are through the barrel, through the screw, and simultaneous output through the barrel and the screw.

Most often, the removal of oil squeezed from oily raw materials is organized through a barrel, but it is proposed to remove oil also through a hollow screw with transverse holes in the hollow core (Patent Nos. UA63203C2, UA16277U).

A press with a simultaneous discharge through the oils of the barrel and screw significantly complicates the design (Patent No. RU2173636C2). At the same time, the core of the screw and the inner surface of the barrel are made in the form of cones with the formation of an annular space between them, converging in the direction of pressing (Fig. 31). A similar technical solution is proposed in Patent No. RU2734521C1.

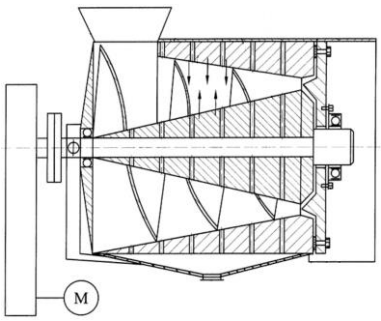


Fig. 31. Scheme of the press with oil removal through the barrel and screw (Patent No. RU2173636C2)

According to the type of screw cutting, there are presses with screws with single-start, double-start and multiple-start cutting. At the same time, cutting can be both continuous and intermittent.

Increasing the number of screw cutting operations on the one hand smooths out the impulsive nature of the cake leaving the press, and on the other hand, it not only complicates the screw production, but also reduces the volume of the working channel of the press, and therefore reduces its productivity.

In addition to the above-mentioned designs of screw presses, other numerous models of suitable equipment for pressing oil raw materials have been developed, but unlike screw presses, they have not yet found widespread use in practice.

Conclusions. Despite numerous developments in the field of press equipment for pressing oil raw materials, single- and double-screw presses that have been proven over many years, equipped with improved working organs – screws and barrels, as well as auxiliary devices that improve the operation of the presses, remain the most popular.

Oil and cake, obtained by pressing oil raw materials on screw presses, are characterized by high consumer properties, therefore the development of universal, as well as specialized (first of all taking into account the peculiarities of oil raw materials) highly efficient designs of screw presses for pressing oil raw materials remains an urgent task.

References

1. ДСТУ 2423–94. Олії рослинні. Виробництво. Терміни та визначення. Київ : Держстандарт України, 1994. 35 с.

2. Леонорм Online: Покажчик стандартів України. URL: http://www.leonorm.com.ua/PORTAL/Default.php?Page=search&TableNumber=1&nodename=lnbod_S12238 (дата звернення 11.01.2024).

3. O’Brien R. D. Fats and Oils: Formulating and Processing for Applications. 2nd ed. Boca Raton : CRC Press, 2004. 616 p.

4. Nde D. B., Foncha A. C. Optimization Methods for the Extraction of Vegetable Oils: A Review. *Processes*. 2020. Vol. 8(2). P. 209. https://doi.org/10.3390/pr8020209.

5. Kaur M., Sharma H. K., Kumar N. Processing of Oilseeds. *Agro-Processing and Food Engineering. Operational and Application Aspects*. 2023. Ch.12. P. 483–533. https://doi.org/10.1007/978-981-16-7289-7.

6. Kaufman K. R. Sunflower Oil as an Alternative Farm Fuel. *Fuels And Chemicals From Oilseeds. Technology And Policy Options*. 1984. Ch. 8. P. 17.

7. ДСТУ 4492:2017. Олія соняшникова. Технічні умови. Київ : ДП «УкрНДНЦ», 2018. 31 с.

8. AGRO-V. Масло подсолнечное для промышленной переработки (2 сорт). URL: https://agro-v.com/ru/podsolnechnoe-maslo-dlya-promyishlennoy-pererabotki/ (дата звернення 23.02.2024).

9. ГОСТ 33131–2014. Смеси биодизельного топлива (В6–В20). Технические требования. Москва : Стандартинформ, 2015. 20 с.

10. Găgeanu P., Găgeanu I., Bunduchi G., Zaica A. Researches on obtaining vegetable oils as a source of alternative energy. *E3S Web of Conferences*. 2019. Vol. 112. e03032. 7 p. https://doi.org/10.1051/e3sconf/201911203032.

11. Рябцев Г. Л., Бурлаков В. М., Литвиненко Є. Ю. Особливості виробництва біодизельного палива. *Вісник НТУУ «КПІ імені Ігоря Сікорського». Серія: Хімічна інженерія, екологія та ресурсозбереження*. 2014. № 1. С. 73–80. https://doi.org/10.20535/2306-1626.1.2014.51635.

12. Ionescu M., Ungureanu N., Biriş S.-Ş., Voicu G., Dilea M. Actual methods for obtaining vegetable oil from oilseeds. *International Conference on Thermal Equipments, Renewable Energy and Rural Development (TE-RE-RD Conference).* 2013. P. 157–172. URL: https://www.researchgate.net/profile/Nicoleta-Ungureanu/publication/281446921_Actual_methods_for_obtaining_vegetable_oil_from_oilseeds/links/55e7f5cd08aeb6516262ee9f/Actual-methods-for-obtaining-vegetable-oil-from-oilseeds.pdf (дата звернення 28.12.2023).

13. Дацишин О. В., Ткачук А. І., Гвоздєв О. В., Ялпачик Ф. Ю., Гвоздєв В. О. Технологічне обладнання зернопереробних та олійних виробництв. Вінниця : Нова книга, 2008. 488 с. URL: http://www.tsatu.edu.ua/ophv/wp-content/uploads/sites/13/ (дата звернення 11.01.2024).

14. Siregar A. N., Ghani J. A., Haron C. H. C., Rizal M., Yaakob Z., Kamarudin S. K. Comparison of oil press for jatropha oil – a review. *Research in Agricultural Engineering*. 2016. Vol. 61(1). P. 13. https://doi.org/10.17221/22/2013-rae.

15. Вольфсон С. А., Сахарова М. Н., Никольский В. Г. Экструзионные технологии в пищевой промышленности и в переработке материалов биологического происхождения. *Пластические массы*. 1998. № 2. С. 36–40.

16. Мікульонок І. О. Стан та перспективи одержання пресованого твердого біопалива. *Енерготехнології та ресурсозбереження*. 2022. № 4. С. 15–34. https://doi.org/10.33070/etars.4.2022.02.

17. Mikulionok I. O., Radchenko L. B. Screw Extrusion of Thermoplastics: II. Simulation of Feeding Zone of the Single Screw Extruder. *Russian Journal of Applied Chemistry*. 2012. Vol. 85(3). P. 505−514. https://doi.org/10.1134/S1070427211030317.

18. Mikulyonok I. O. Equipment for preparing and continuous molding of thermoplastic composites. *Chemical and Petroleum*

Engineering. 2013. Vol. 48(11/12). P. 658–661. https://doi.org/10.1007/s10556-013-9676-x.

19. Rauwendaal C. Polymer extrusion. 5th ed. Munich : Carl Hanser Verlag GmbH & Co. KG, 2014. 950 p. https://doi.org/10.3139/9781569905395.

20. Mikulionok I. O. Classification of Processes and Equipment for Manufacture of Continuous Products from Thermoplastic Materials. *Chemical and Petroleum Engineering*. 2015. Vol. 51(1/2). P. 14–19. https://doi.org/10.1007/s10556-015-9990-6.

21. Vlachopoulos J., Polychronopoulos N. D. Understanding Rheology and Technology of Polymer Extrusion. Dundas (ON, Canada) : Polydynamics Inc, 2019. 337 p. URL: http://www.mie.uth.gr/ekp_yliko/Rheo_Tech_Book_Part_A.pdf (дата звернення 25.12.2023).

22. Mikulionok I. O. Classification of Screw Cooling Devices of Single-Screw Extruders for Polymer Materials Processing (Survey of Designs). *Chemical and Petroleum Engineering*. 2022. Vol. 58(1/2). P. 68–73. https://doi.org/10.1007/s10556-022-01057-5.

23. Tadmor Z., Gogos C. G. Principles of polymer processing. 2nd ed. Hoboken: John Wiley & Sons, 2006. 961 p. URL: http://www3.fi.mdp.edu.ar/procesamiento1/material/Tadmor-Gogos.pdf (дата звернення 04.01.2024).

24. Agassant J.-F., Avenas P., Carreau P. J., Vergnes B., Vincent M. Polymer Processing: Principles and Modeling. 2nd ed. Munich : Carl Hanser Verlag, 2017. 841 p.

25. Savoire R., Lanoisellé J.-L., Vorobiev E. Mechanical Continuous Oil Expression from Oilseeds: A Review. *Food and Bioprocess Technology*. 2013. Vol. 6(1). 16 p. https://doi.org/10.1007/s11947-012-0947-x.

26. Машиностроение. Энциклопедия / ред. совет К. В. Фролов и др. Москва: Машиностроение,2003. Т. IV-17 Машины и оборудование пищевой и перерабатывающей промышленности / под ред. С. В. Мачихина. 736 с.

27. Фармонов Ж. Б., Давлатов Ф. Ф., Кодиров Ш. М., Серкаев К. П., Самадий М. А. Получение масел с применением метода холодного прессования. *Universum: Технические науки*. 2021. № 5(86). 5 с. https://doi.org/10.32743/UniTech.2021.86.5.11689.

28. Chandra S., Kumar M., Dwivedi P., Shinde L.P. Functional and nutritional health benefit of cold-pressed oils: a review. *Journal of Agriculture and Ecology*. 2020. Vol. 9. P. 21–29. http://doi.org/10.53911/JAE.2020.9102.

29. Bhuiya M. M. K., Rasul M., Khan M., Ashwath N., Rahman M. Comparison of oil extraction between screw press and solvent (n-hexane) extraction technique from beauty leaf (Calophyllum inophyllum L.)

feedstock. *Industrial Crops and Products*. 2020. Vol. 144. e112024. https://doi.org/10.1016/j.indcrop.2019.112024.

30. Çakaloğlu B., Özyurt V. H., Ötleş S. Cold press in oil extraction. A review. *Ukrainian Food Journal*. 2018. Vol. 7(4). P. 640–654. https://doi.org/10.24263/2304-974X-2018-7-4-9.

31. Mikulionok I. O. Screw extruder mixing and dispersing units. *Chemical and Petroleum Engineering*. 2013. Vol. 49(1/2). P. 103–109. https://doi.org/10.1007/s10556-013-9711-y.

32. Гукасян А. В. Перспективы развития инновационных пищевых технологий с применением обработки двуокисью углерода. *Научные труды КубГТУ*. 2016. № 14. С. 245–250.

33. Кошевой Е. П., Гукасян А. В., Косачев В. С. «Зеленые» технологии с применением двуокиси углерода в пищевой промышленности. *Вестник ВГУИТ*. 2018. Т. 80, № 2. С. 225–228. http://doi.org/10.20914/2310-1202-2018-2-225-228.

34. Микулёнок И. О., Лукач Ю. Е. Особенности конструктивного исполнения роторных измельчителей для резино- и полимерсодержащих отходов (Обзор). *Экотехнологии и ресурсосбережение*. 2007. № 3. С. 69–72.

35. Mikulionok I. O. Structural Implementation of the Process of Elasto-Deformation Shredding of Rubber-Containing Wastes (Survey of Patents). *Chemical and Petroleum Engineering*. 2016. Vol. 51(9/10). P. 604–608. https://doi.org/10.1007/s10556-016-0093-9.

36. Uitterhaegen E., Evon P. Twin-screw extrusion technology for vegetable oil extraction: A review. *International Journal of Food Engineering*. 2017. Vol. 212. P. 190–200. http://dx.doi.org/10.1016/j.jfoodeng.2017.06.006.

37. Kartika I. A., Pontalier P. Y., Rigal L. Twin-screw extruder for oil processing of sunflower seeds: Thermo-mechanical pressing and solvent extraction in a single step. *Industrial Crops and Products*. 2010. Vol. 32(3). № 3. P.297–304. https://doi.org/10.1016/j.indcrop.2010.05.005.

38. Оборудование для производства биотоплива [рекламн.-информ. проспект]. Киев : ОАО «Большевик», [1999?]. 4 с.

39. Schenkel G. Plastics Extrusion Technology and Theory. The design and operation of screw extruders for plastics. London : Lliffe Books Ltd., 1966. 477 p.

40. Olaoye I. O., Salako Y. A., Owolarafe O. K. Development of Multi Seeds Oil Expeller. *Arid Zone Journal of Engineering, Technology* and *Environment.* 2020. Vol. 16. № 4. P. 699–716. URL: https://www.azojete.com.ng/index.php/azojete/article/download/370/257 (дата звернення 21.12.2023).

Стаття надійшла до редакції 01.02.2024 р.

І. Мікульонок[1]
[1]Національний технічний університет України
«Київський політехнічний інститут імені Ігоря Сікорського»

КЛАСИФІКАЦІЯ ТА АНАЛІЗ КОНСТРУКЦІЙ ШНЕКОВИХ ПРЕСІВ ДЛЯ ОЛІЙНОЇ СИРОВИНИ

Анотація

Метою досліджень було виконання критичного аналізу конструктивно-технологічного оформлення процесу полімерних і гумових відходів за допомогою різальних подрібнювачів.

Розроблено розширену класифікацію різальних подрібнювачів для руйнування різноманітних побутових і промислових полімерних і гумових відходів: об'ємних, погонних, листових і плівкових. Виконано критичний огляд найбільш характерних конструкцій різальних подрібнювачів, запропонованих науковцями, конструкторами й винахідниками провідних країн світу.

Конструкції проаналізовано залежно від принципу перетворення оброблюваних відходів, характеру дії різального інструмента на оброблюваний матеріал в часі, технологічної операції різання, кількості стадій подрібнення, типу руху робочого органа, ступеня універсальності оброблення відходів, форми ротора (роторів), розташування осі ротора (осей роторів) у просторі, форми рухомих різальних елементів роторних подрібнювачів, температури оброблення відходів, а також ступеня мобільності подрібнювача. Виконано критичний аналіз не лише класичних, а й інноваційних конструкцій подрібнювачів, наведених у патентних документах провідних країн світу.

Аналіз сучасного стану і перспектив використання різальних подрібнювачів полімерних і гумових відходів свідчить, що подрібнювачі цього типу залишаються й найближчому майбутньому залишатимуться основним видом обладнання для руйнування полімервмісних відходів з метою їх подальшого перероблення фізичними методами. Основні зусилля при цьому спрямовано на створення універсальних подрібнювачів, здатних переробляти відходи різного типорозміру з різних полімерів та еластомерів, а також максимально позбавлених недоліків традиційних різальних подрібнювачів, передусім високого рівня шуму та відносно низької стійкості різальних елементів.

Ключові слова: олійна сировина, олія, шнекові преси, класифікація, конструкції.