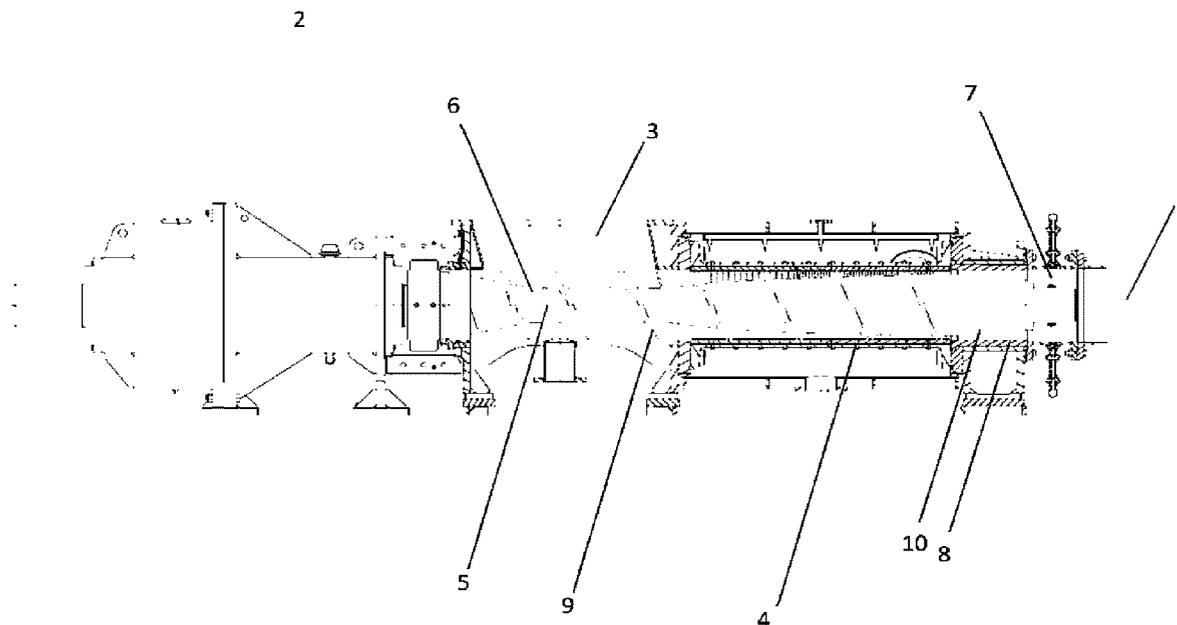




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(54) **Titre : DISPOSITIF ET PROCÉDE DE MACÉRATION D'UN MATÉRIAU A TRANSPORTER**
 (54) **Title: DEVICE AND METHOD FOR MACERATING A MATERIAL TO BE CONVEYED**



(57) **Abrégé/Abstract:**

The invention relates to a method for macerating a material to be conveyed, where the material to be conveyed is fed through a compression screw (2), macerated, and compressed into a gas-tight and liquid-tight plug. The invention is characterised in that the degree of maceration of the material to be conveyed is controlled by relative positioning of the screw (6) to the plug pipe (8). The invention relates to a device to perform the method and enables optimum control of maceration of the fibrous pulp.

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Abstract:

The invention relates to a method for macerating a material to be conveyed, where the material to be conveyed is fed through a compression screw (2), macerated, and compressed into a gas-tight and liquid-tight plug. The invention is characterised in that the degree of maceration of the material to be conveyed is controlled by relative positioning of the screw (6) to the plug pipe (8). The invention relates to a device to perform the method and enables optimum control of maceration of the fibrous pulp.

DEVICE AND METHOD FOR MACERATING A MATERIAL TO BE CONVEYED

The invention relates to a method for macerating a material to be conveyed, e.g. wood chips, where the material to be conveyed is fed through a compression screw conveyor according to the invention, the compression screw conveyor receives the material to be conveyed in an inlet area, and a screw rotating round an axis of rotation inside a housing conveys the material to be conveyed to a discharge area and macerates it at the same time, the material to be conveyed being compressed between a plug pipe and the screw to form a gas-tight and liquid-tight plug and the plug forming a seal between the discharge area and the compression screw conveyor.

10 According to an embodiment of the invention, there is provided a compression screw conveyor to control maceration of a material to be conveyed comprising an inlet area to receive the material to be conveyed, a screw rotatable round an axis of rotation in a housing and an outlet area, where the screw is mounted rotatably inside a plug pipe in the discharge area, wherein the screw has a flight, at least partially, the screw being formed as an area
15 without a flight, at least partially, in the area of the plug pipe, and the screw and the plug pipe being suitable for being moved and positioned in relation to one another, where a calibrating area is formed between plug pipe and screw, the calibrating area comprising either an area of the plug pipe with a decreasing inner diameter and an area of the screw without a flight and with a constant outer diameter or an area of the screw without a flight and with a
20 decreasing outer diameter, or the calibrating area comprises an area of the plug pipe with a constant or increasing inner diameter and an area of the screw without a flight and with an increasing outer diameter.

Compression screw conveyors are used to dewater a material to be conveyed by compressing it, but also to macerate a material to be conveyed. In this case, maceration
25 means softening or defiberizing the material to be conveyed, where the combination of conveying and compressing in the compression screw conveyor results in delamination of the cell walls and mechanical defiberizing of the material to be conveyed, i.e. reducing the material to be conveyed to its fibre components and at the same creating a correspondingly larger specific surface area of the material to be conveyed. The
30 compression screw conveyor also permits a pressure seal between the compression screw conveyor and a device connected to the discharge area, for example a reactor,

because the material to be conveyed is formed into a gas-tight and liquid-tight plug between the inlet area and the discharge area. This is necessary because the device connected, e.g. the reactor, is filled with a gaseous or liquid fluid containing reactants and must be sealed off against the environment. The device connected to the discharge

5 area of the compression screw conveyor can be designed as a pressure vessel, for example, as an atmospheric or pressurized reactor, as a digester, or otherwise. Reactant means, in particular, chemicals in a liquid fluid (e.g. a solvent, an aqueous solution, ethanol or similar mixtures), where the term "chemical" can be a catalyst, for example, an acid (e.g. H_2SO_4 or acetic acid), a lye (e.g. NaOH), or similar mixtures. Typical uses are

10 found in the pulp and paper sector and also generally in processing of fibrous pulps, e.g. wood pulps, and there, for example, in the production of fibreboard, MDF, and so on. Hence, in addition to treating the material to be conveyed in a digester, an important field of application is impregnation of the material to be conveyed, where the compression

screw conveyor allows air and liquid to be expelled from the material to be conveyed and the material to be macerated, where the macerated material to be conveyed is carried out of the compression screw conveyor and into a reactor containing the reactants needed for impregnation. Hence, in addition to treating the material to be conveyed in a digester, an important field of application is impregnation of the material to be conveyed, where the compression screw conveyor allows air and liquid to be expelled from the material to be conveyed and the material to be macerated, where the macerated material to be conveyed is carried out of the compression screw conveyor and into a reactor containing the reactants needed for impregnation. Another use is available in the production of bio-fuels, where bioethanol, for example, can be produced from biomass comprising cereal crops, maize or sugar beets.

Compression screw conveyors typically consist of a housing with a screw inside that is mounted rotatably round an axis of rotation, where the screw has a flight, at least partially, and where the material to be conveyed is compressed increasingly in the tapering area between the housing and the screw. At the discharge area of the compression screw conveyor, the screw has no flight, at least partially, in order to form the plug. The housing can have openings in the area of the screw in order to allow dewatering and/or aeration by compression of the material to be conveyed. Conventional screw conveyors can be built with a cylindrical housing together with a screw with a cylindrical outer contour, where other housing shapes, e.g. with a conical outer contour, are also possible.

EP 2 817 449 B1 describes a system for handling a wood-free plant material, where compression screw conveyors for feeding chips to digesters are used and the compression screw conveyor comprises a plug pipe with a constant inner diameter at the end of the compression screw conveyor. The aim of EP 2 817 449 B1 is, among other things, to disclose a compression screw conveyor arrangement with an optimized pressure seal. This is achieved by the interaction of a compression screw conveyor and a force-feeding screw.

DE 1 101 126 B describes a process and a device for impregnating raw materials containing pulp, where the material is compressed progressively in order to expel air and liquid and the material is brought into direct contact with the impregnating liquid when it expands. It is also noted that the material reduced to its fibre components

advantageously presents a larger surface area for subsequent application of the impregnating material.

EP 3 333 311 B1 describes a process and a device for impregnating biomass.

5 Improved maceration, among other things, is to be achieved by the pre-compressed biomass from the compression screw conveyor being fed through a force-feed screw because it was noted that pre-compression of the high-volume biomass containing hollow spaces results in increased compression of the plug. It was also noted that it is advantageous to specify the filling level of the reactor unit according to the speed at which the biomass is conveyed in order to enable homogeneous impregnation of
10 the biomass.

EP 0 493 422 B1 refers to a plug screw feeder for use during maceration of wood chips, comprising a screw with variable speed and a force-feed screw with variable speed, where the speeds of the screw and the force-feed screw are used to obtain the desired extent of fibre displacement.

15 US 2007/164143 A1 discloses a plug screw feeder for maceration, where the maceration effect can be increased or adjusted by using tubular inserts.

US5320034A discloses a device and a method for improved maceration of wood chips.

The aim of the invention is an improved means of macerating a material to be
20 conveyed, especially a pulp. Another aim is to enable a better and more even effect by the reactants on the macerated pulp. An additional aim is to enable optimum dewatering while effecting the required maceration or to compensate for the effects of inhomogeneous material to be conveyed, which is fed unevenly to the compression screw conveyor, for example, or has widely scattered material
25 properties. Another aim is to continue being able to adjust the maceration if the screw or plug pipe are worn and to minimize the power consumption of the compression screw conveyor while maintaining the maceration requirement.

According to the invention, this is achieved by the degree of maceration of the material to be conveyed being controlled by relative positioning of the screw to the
30 plug pipe. The plug pipe is disposed in the discharge area of the compression screw conveyor in the housing and has an annular structure, at least partially, and/or a

truncated cone structure, at least partially. The screw extends into the plug pipe, where the screw is mounted to rotate round an axis of rotation and has an area with no flight inside the plug pipe to form the plug. The plug pipe is normally replaceable so it can be changed easily if worn and because different geometries can be formed by changing the plug pipe. The area between the plug pipe and the screw can be influenced by positioning of the screw in relation to the plug pipe. Thus, the area between plug pipe and screw, and especially the gap at the end of the screw towards the plug pipe can either be narrowed or widened. Maceration of the material to be conveyed is increased due to narrowing of the area or the gap and decreased by widening of the area or the gap.

A favourable embodiment of the invention is characterised in that the screw is moved in axial direction along the axis of rotation inside the housing in order to control the degree of maceration. Here, the housing and plug pipe are stationary, and the screw is moved in axial direction, causing further narrowing or widening of the area between the plug pipe and the screw, and in particular, of the gap at the end of the screw towards the plug pipe. The screw can be moved if the screw bearing unit has a movable design, where the bearing unit supports the screw shaft and is arranged opposite the discharge area. Here, the screw is driven by a stationary drive, where a coupling that can absorb the axial movement of the screw is provided between the bearing unit of the screw and the drive.

Another favourable embodiment of the invention is characterised in that the plug pipe is pushed in axial direction along the axis of rotation inside the housing in order to control the degree of maceration. Here, the housing and screw are stationary, and the plug pipe is moved in axial direction, causing narrowing or widening of the area between the plug pipe and the screw, and in particular, of the gap at the end of the screw towards the plug pipe.

An advantageous embodiment of the invention is characterised in that the material to be conveyed is brought from the discharge area into a reactor, the material to be conveyed reacts with a reactant inside the reactor, and the reaction result in the reactor is influenced by controlling the degree of maceration of the material to be conveyed. Controlling the degree of maceration of the material to be conveyed means controlling disintegration of the material to be conveyed, and thus controlling disintegration of the material to be conveyed into its fibre components as well as

implying control of the specific surface area of the shredded material to be conveyed, which is extremely relevant in chemical but also absorptive and adsorptive processes. Optimum effect by the reactants on the material to be conveyed and thus an optimum reaction result are only possible if maceration in the reactor is controlled.

5 Here, the term reaction result covers, among other things and in relation to the material to be conveyed in each case, the extent of impregnation, the penetration with reactants, the product quality, and the yield.

An advantageous embodiment of the invention is characterised in that the material to be conveyed is compressed between the inlet area and the discharge area between
10 the housing and the screw with a flight, at least partially, where the plug is formed in the discharge area between the plug pipe and an area of the screw with no flight. In the area of the plug pipe, the screw can partially have an area with a flight, where the area of the screw with no flight follows this area of the screw with a flight in conveying direction.

15 Another favourable embodiment of the invention is characterised in that the plug passes through a ring area in the discharge area, where the ring area is formed by an area of the plug pipe with a constant inner diameter and an area of the screw with no flight and with a constant outer diameter. The plug forms in this ring area in particular, where maceration of the material to be conveyed is not yet controlled. The
20 plug passes advantageously through the ring area first of all to form the sealing plug and then through a calibrating area to adjust the maceration.

A similarly advantageous embodiment of the invention is characterised in that the plug passes through a calibrating area after the ring area in the discharge area, the calibrating area being formed either by an area of the plug pipe with an inner
25 diameter decreasing in conveying direction and an area of the screw with no flight and with a constant or decreasing outer diameter, or the calibrating area being formed by an area of the plug pipe with a constant or increasing inner diameter in conveying direction and an area of the screw with no flight and with an increasing
30 outer diameter. To the extent that the calibrating area is formed by an area of the plug pipe with a constant inner diameter in conveying direction and an area of the screw with no flight and with an increasing outer diameter, an area with a diameter that is larger than the constant inner diameter of the plug pipe adjoins the plug pipe. Here, the area of the screw with no flight and with the increasing outer diameter can

be positioned inside the plug pipe or in the area with the diameter that is larger than the constant inner diameter of the plug pipe, where positioning between these positions is, of course, also possible. Due to relative positioning of the plug pipe and the screw, specific spacing is set between the plug pipe and the screw in the calibrating area and, in particular, a specific gap is set at the end of the screw as far as the plug pipe. The calibrating area can either be narrowed or widened by relative positioning of the plug pipe and screw. An area of the plug pipe with a decreasing inner diameter can be achieved with a conically shaped plug pipe, where the intended tip of the cone points to the discharge area. Then the area of the screw with no flight is formed conically with a constant diameter or with a decreasing outer diameter, the intended tip of the cone again pointing to the discharge area. The space between the cone surfaces lying inside one another and hence also maceration is controlled directly by the relative movement of the cone surfaces. An area of the plug pipe with an increasing inner diameter can be obtained with a conically shaped plug pipe, the intended tip of the cone pointing towards the inlet area. The area of the screw with no flight is then formed conically with an increasing outer diameter, the intended tip of the cone again pointing to the inlet area. In this way, maceration of the material to be conveyed can be increased either by the calibrating area narrowing or it can be reduced by the calibrating area widening due to axial movement of the screw.

According to another embodiment of the invention, there is provided a compression screw conveyor to control maceration of a material to be conveyed, e.g. wood chips, comprising an inlet area (3) to receive the material to be conveyed, a screw (6) rotatable round an axis of rotation (5) in a housing (4) and an outlet area (7), where the screw (6) is mounted rotatably inside a plug pipe (8) in the discharge area (7), characterised in that the screw (6) has a flight (9), at least partially, the screw (6) being formed as an area (10) without a flight, at least partially, in the area of the plug pipe (8), and the screw (6) and the plug pipe (8) being suitable for being moved and positioned in relation to one another, where a calibrating area (12) is formed between plug pipe (8) and screw (6), the calibrating area (12) comprising either an area (13) of the plug pipe with a decreasing inner diameter and an area of the screw without a flight and with a constant outer diameter or an area (14) of the screw without a flight and with a decreasing outer diameter, or the calibrating area (12) comprises an area of the plug pipe with a constant or increasing inner diameter and an area of the screw without a flight and with an increasing outer diameter (16).

An advantageous design of the compression screw conveyor is characterised in that the screw can be moved in axial direction along the axis of rotation and in relation to the housing or in that the plug pipe can be moved in axial direction along the axis of rotation and in relation to the housing and the screw.

- 5 In addition, a ring area is formed advantageously between the plug pipe and the screw, the ring area comprising an area of the plug pipe with a constant inner diameter and an area of the screw with no flight and with a constant outer diameter.

The embodiment of the compression screw conveyor according to the invention is characterised in that a calibrating area is formed between the plug pipe and the screw,
10 where the calibrating area either comprises an area of the plug pipe with an

inner diameter decreasing in conveying direction and an area of the screw with no flight and with a constant or decreasing outer diameter, or the calibrating area comprises an area of the plug pipe with a constant or increasing inner diameter in conveying direction and an area of the screw with no flight and with an increasing outer diameter. To the extent that the calibrating area is formed by an area of the plug pipe with a constant inner diameter in conveying direction and an area of the screw with no flight and with an increasing outer diameter, an area with a diameter that is larger than the constant inner diameter of the plug pipe adjoins the plug pipe. The decreasing or increasing area of the screw or plug pipe can be formed by the plug pipe or screw having a conical shape. According to these embodiments, axial positioning of the screw in relation to the plug pipe allows the calibrating area to be reduced or increased in size.

The invention will now be described using the examples in the drawings.

Figure 1 shows a compression screw conveyor for maceration according to the state of the art.

Figure 2 shows an embodiment of the compression screw conveyor according to the invention with a first, relative positioning of the screw to the plug pipe.

Figure 3 shows an embodiment of the compression screw conveyor according to the invention with a second, relative positioning of the screw to the plug pipe.

Figure 4 shows another embodiment of the compression screw conveyor according to the invention.

Figure 1 shows a compression screw conveyor for maceration according to the state of the art. Here, the material to be conveyed is fed through the inlet area 3 to the compression screw conveyor 2 and to a reactor 1 not shown here, where the compression screw conveyor 2 has a housing 4, a screw 6 that can be rotated round an axis of rotation 5 and has a flight 9, at least partially, a discharge area 7, and a plug pipe 8. In the area of the plug pipe 8, the screw 6 has an area 10 with no flight.

Figures 2 and 3 show an embodiment of the compression screw conveyor according to the invention, Fig. 2 showing a first relative positioning of the screw to the plug pipe and Fig. 3 a second relative positioning of the screw to the plug pipe. Here, a screw 6 that can be rotated round an axis of rotation 5 and has a flight 9, at least

partially, is mounted in a housing 4. In the discharge area 7, the screw 6 has an area 10 with no flight inside the plug pipe 8, the plug pipe 8 and the area 10 of the screw with no flight forming a ring area 11 and the ring area 11 being followed by a calibrating area 12 in conveying direction of the material to be conveyed. In addition, the area of the screw with no flight is designed conically with an increasing outer diameter 16, the intended tip of the cone pointing towards the inlet area and the plug pipe 8 having a constant inner diameter in conveying direction. The calibrating area is formed by the area of the plug pipe with a constant inner diameter and the area 16 of the screw with no flight and with an increasing outer diameter, an area 15 with a diameter that is larger than the constant inner diameter of the plug pipe adjoining the plug pipe. In Figure 2, the area 16 of the screw with no flight and with the increasing outer diameter is positioned in the area 15 with the diameter that is larger than the constant inner diameter of the plug pipe, and in Figure 3, the area 16 of the screw with no flight and with the increasing outer diameter is positioned in the plug pipe 8. Advantageously, maceration of the material to be conveyed can be increased in this way either by the calibrating area 12 narrowing or it can be reduced by the calibrating area 12 widening due to axial movement of the screw 6. Figure 2 shows the compression screw conveyor 2 with relative positioning of the screw 6 further in conveying direction of the material to be conveyed, i.e. closer to the discharge area 7. And conversely, Fig. 3 shows the compression screw conveyor 2 with relative positioning of the screw 6 in the opposite direction to the conveying direction of the material to be conveyed, i.e. closer to the inlet area 3. Hence, the calibration area 12 in Fig. 3 is smaller than in Fig. 2, whereby positioning of the screw 6 in Fig. 3 results in the material to be conveyed being macerated more and positioning of the screw 6 in Fig. 2 results in the material to be conveyed being macerated less.

Figure 4 shows another embodiment of the compression screw conveyor according to the invention, the screw 6 being mounted rotatably in a housing 4 and the screw 6 having a flight 9, at least partially. In the discharge area 7, the screw 6 has an area 10 with no flight inside the plug pipe 8, the plug pipe 8 and the area 10 of the screw with no flight forming a ring area 11 and the ring area 11 being followed by a calibrating area 12 in conveying direction of the material to be conveyed. In addition, the area 14 of the screw with no flight is designed conically with an outer diameter decreasing in conveying direction, the intended tip of the cone pointing towards the discharge area 7 and the plug pipe 8 having an area 13 with a decreasing inner

diameter. Here, arrow A illustrates the option of relative positioning of the screw 6 to the plug pipe 8 and arrow B the option of relative positioning of the plug pipe 8 to the screw 6.

5 Thus, the present invention offers numerous advantages: an effective means of controlling maceration of a pulp and also better and more even effect by the reactants on the macerated pulp. Similarly, optimized dewatering performance is possible at the same time as controllable maceration. It is also possible to select a mode of operation in which a requested degree of maceration can be set, but which requires minimal power consumption by the compression screw conveyor. In this way, wear on the compression screw conveyor, plug pipe, etc. can be kept to a minimum and, conversely, a required degree of maceration can still be set when there has been wear on the compression screw conveyor, plug pipe, etc., thus making longer use possible because the worn components can be replaced at a later stage. Similarly, the impact of inhomogeneous material to be conveyed because it is fed unevenly to the compression screw conveyor, for example, has inherently scattering material properties, or a changing composition, can be compensated and the requested degree of maceration can be set in each case. In addition, the solution according to the invention allows the compression screw conveyor to be started up quickly with low power consumption, where the degree of maceration can be controlled or set quickly.

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15
20

Reference numerals

- 1 Reactor
- 2 Compression screw conveyor
- 25 3 Inlet area
- 4 Housing
- 5 Axis of rotation
- 6 Screw
- 7 Discharge area
- 30 8 Plug pipe
- 9 Flight
- 10 Area of the screw with no flight
- 11 Ring area

12 Calibrating area

13 Area of the plug pipe with a decreasing inner diameter

14 Area of the screw with no flight and a decreasing outer diameter

15 Area with a diameter that is larger than the constant inner diameter of the plug
pipe

5

16 Area of the screw with no flight and an increasing outer diameter

What is claimed is:

1. A compression screw conveyor to control maceration of a material to be conveyed comprising an inlet area to receive the material to be conveyed, a screw rotatable round an axis of rotation in a housing and an outlet area, where the screw is mounted rotatably
5 inside a plug pipe in the discharge area, wherein the screw has a flight, at least partially, the screw being formed as an area without a flight, at least partially, in the area of the plug pipe, and the screw and the plug pipe being suitable for being moved and positioned in relation to one another, where a calibrating area is formed between plug pipe and screw, the calibrating area comprising either an area of the plug pipe with a decreasing inner
10 diameter and an area of the screw without a flight and with a constant outer diameter or an area of the screw without a flight and with a decreasing outer diameter, or the calibrating area comprises an area of the plug pipe with a constant or increasing inner diameter and an area of the screw without a flight and with an increasing outer diameter.
2. The compression screw according to claim 1, wherein the material to be conveyed
15 is wood chips.
3. The compression screw according to claim 1 or 2, wherein the screw is movable in axial direction along an axis of rotation and in relation to the housing.
4. The compression screw according to claim 1 or 2, wherein the plug pipe is movable in axial direction along the axis of rotation and in relation to the housing and the screw.
- 20 5. The compression screw according to claim 1 or 2, wherein a ring area is formed between plug pipe and screw, the ring area comprising an area of the plug pipe with a constant inner diameter and an area of the screw without a flight and with a constant outer diameter.
6. The compression screw according to claim 1 or 2, wherein a reduction or an
25 increase in size of the calibrating area is achievable.
7. A method for macerating a material to be conveyed where the material to be conveyed is fed through a compression screw conveyor according to any one of claims 1 to 6, the compression screw conveyor receives the material to be conveyed in the inlet area, and the screw rotating round the axis of rotation inside the housing conveys the
30 material to be conveyed to the discharge area and macerates the material to be conveyed

at the same time, the material to be conveyed being compressed between the plug pipe and the screw to form a gas-tight and liquid-tight plug, the plug forming a seal between the discharge area and the compression screw conveyor, wherein the degree of maceration of the material to be conveyed is controlled by relative positioning of the screw to the plug pipe.

5 8. The method according to claim 7, wherein the material to be conveyed is wood chips.

9. The method according to claim 7 or 8, wherein the screw is moved in axial direction along the axis of rotation inside the housing to control the degree of maceration.

10 10. The method according to claim 7 or 8, wherein the plug pipe is moved in axial direction along the axis of rotation inside the housing to control the degree of maceration.

11. The method according to claim 7 or 8, wherein the material to be conveyed is brought from the discharge area into a reactor, the material to be conveyed reacts with a reactant inside the reactor, and the reaction result in the reactor is influenced by controlling the degree of maceration of the material to be conveyed.

12. The method according to claim 7 or 8, wherein the material to be conveyed is compressed between the inlet area and the discharge area between the housing and the screw with a flight, at least partially, where the plug is formed in the discharge area between the plug pipe and a part of the screw with no flight.

20 13. The method according to claim 12, wherein the plug passes first of all through a ring area and then through a calibrating area.

14. The method according to claim 12, wherein the plug passes through a ring area in the discharge area, the ring area being formed by an area of the plug pipe with a constant inner diameter and by an area of the screw without a flight and with a constant outer diameter.

25 15 The method according to claim 12, wherein the plug passes through a calibrating area after the ring area in the discharge area, the calibrating area being formed either by an area of the plug pipe with a decreasing inner diameter and an area of the screw with no flight and with a constant outer diameter or an area of the screw with no flight and a

decreasing outer diameter, or the calibrating area being formed by an area of the plug pipe with a constant or increasing inner diameter and an area of the screw with no flight and with an increasing outer diameter.

16. The method according to claim 13, wherein maceration is increasable either by the
5 calibrating area narrowing or reduced by the calibrating area widening due to axial movement of the screw.

Fig.1

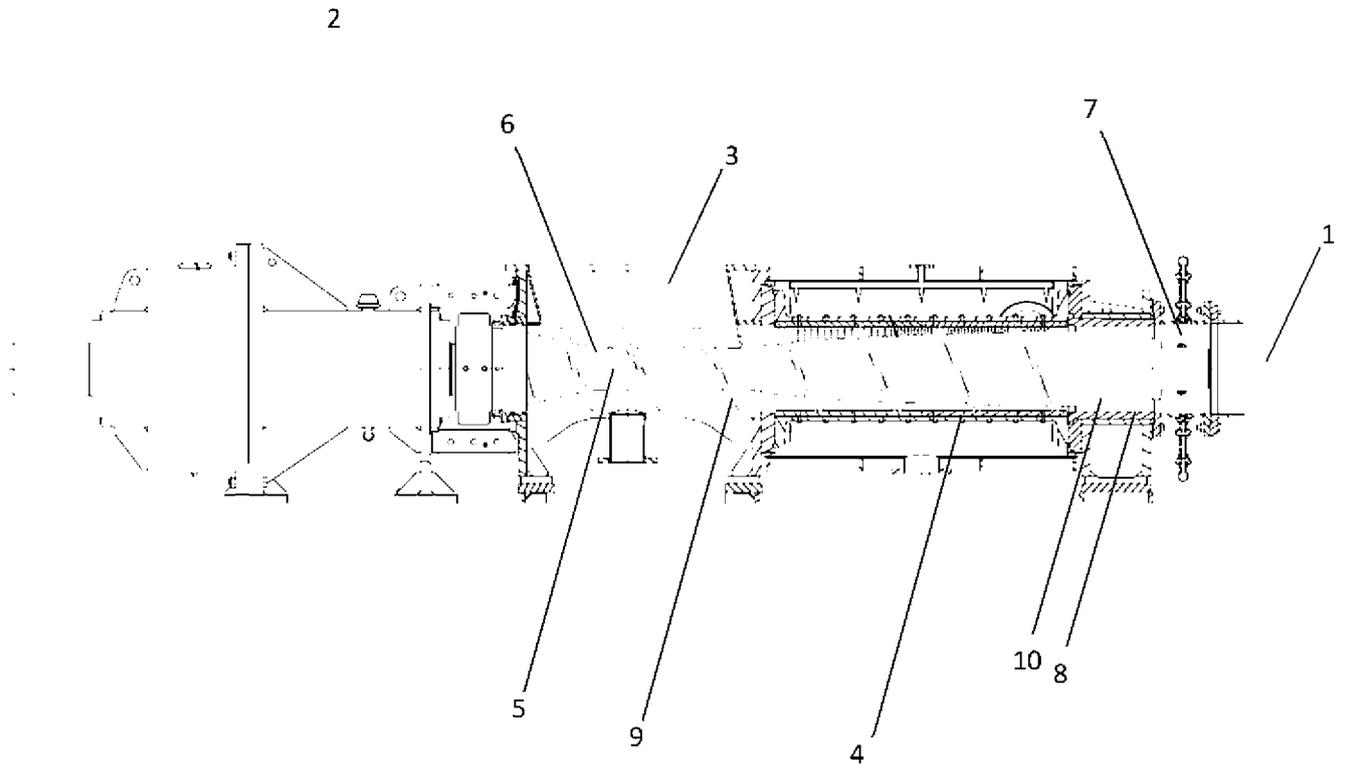


Fig.2

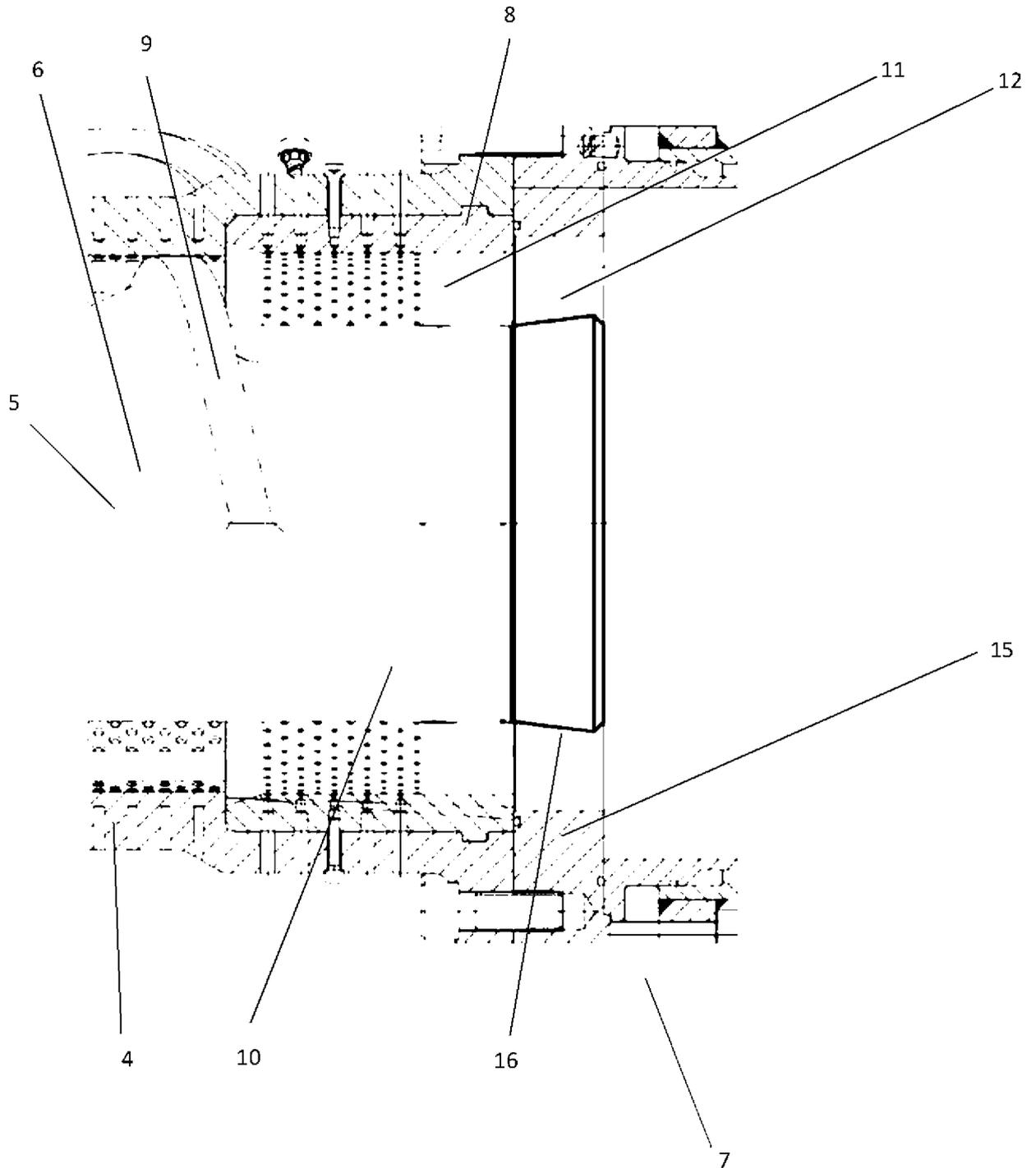


Fig.3

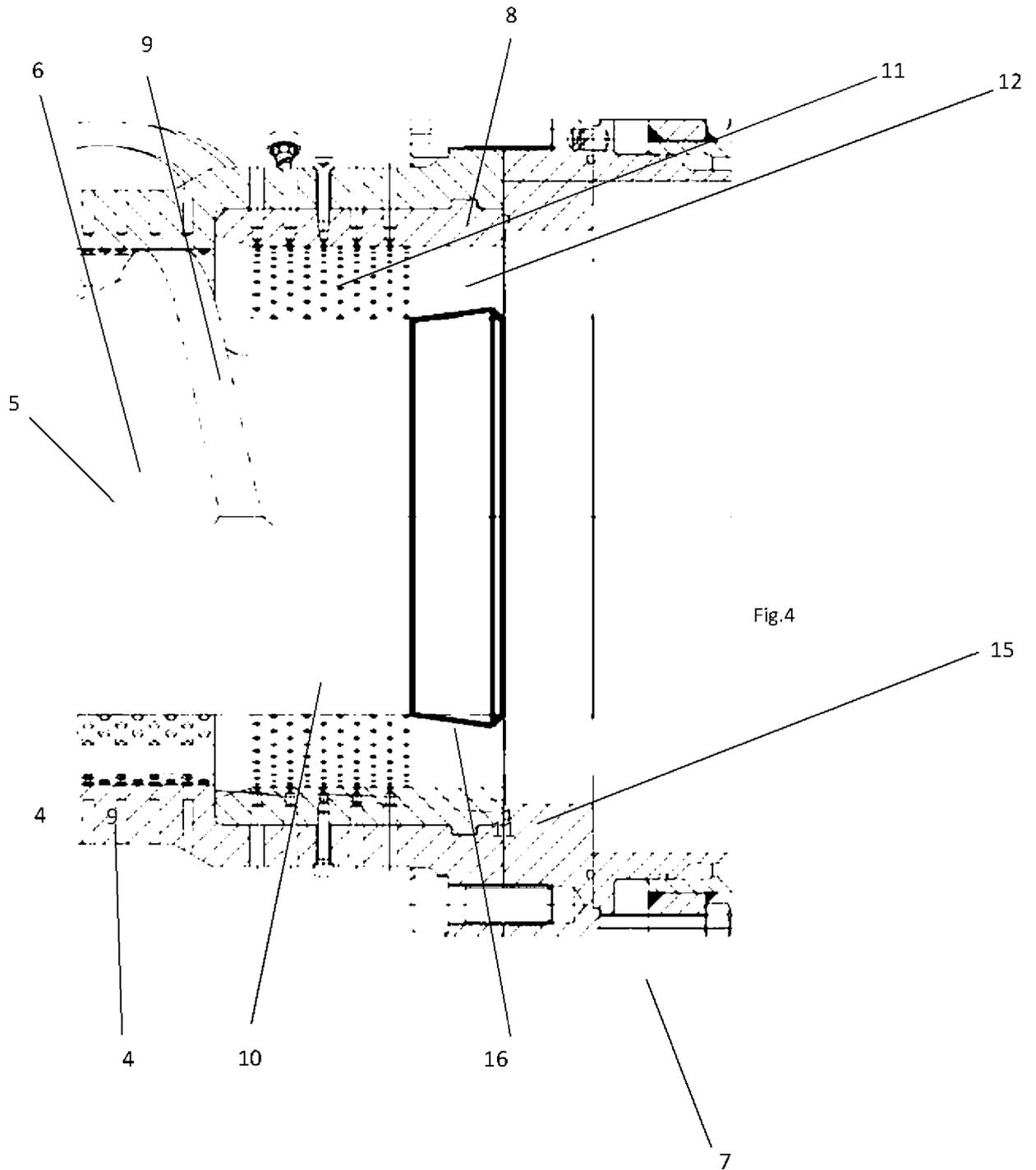
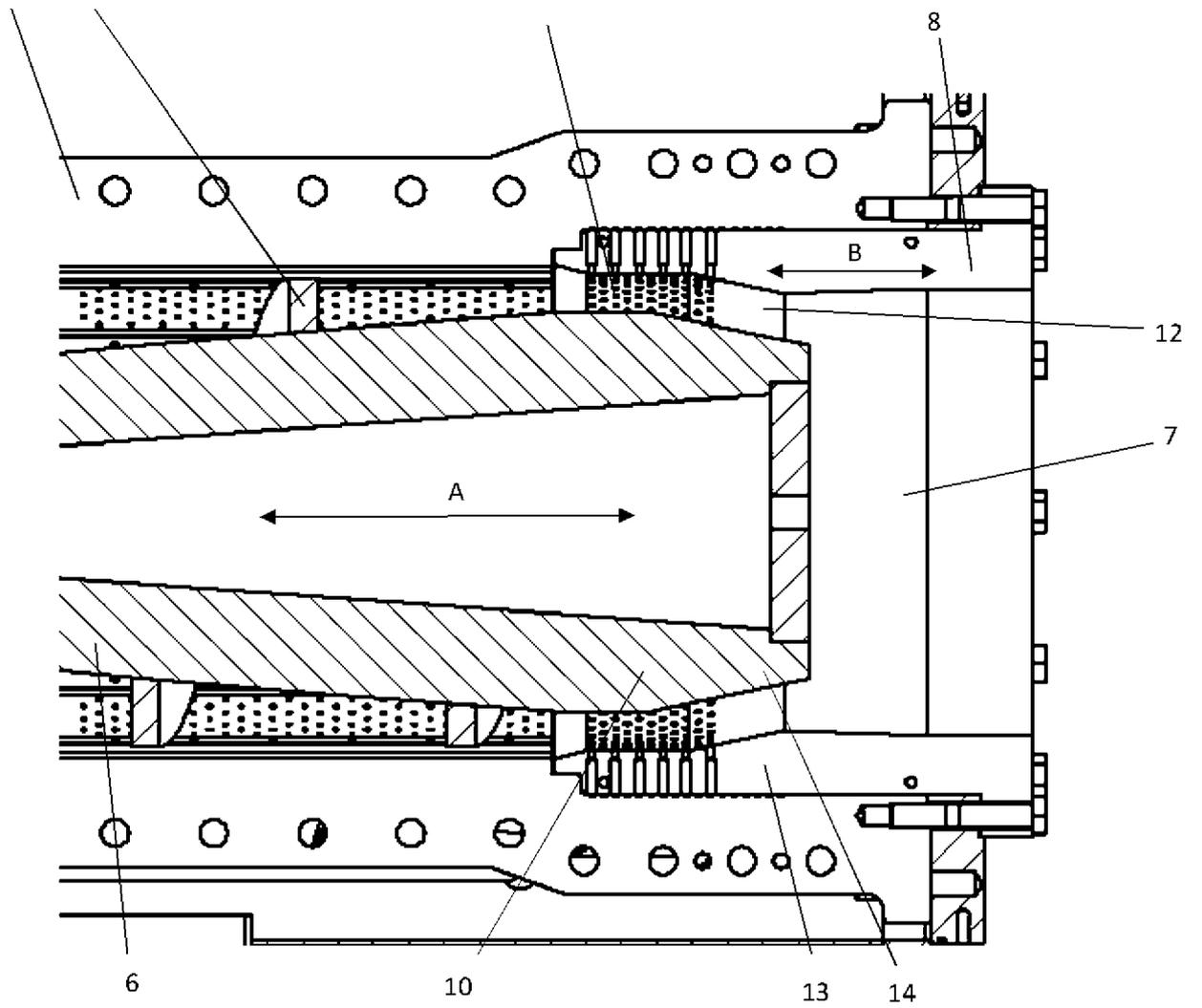


Fig.4



2

