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(54) **SHAFT, DEVICE AND METHOD FOR MATERIAL MIXTURE PROCESSING**

(57) A shaft (3, 4) for processing material mixture comprises a plurality of processing members (8, 9, 10) attached to the shaft and protruding from the outer surface of the shaft. The shaft (3, 4) comprises along the longitudinal direction of the shaft three adjacent shaft portions: a first shaft portion (18), a second shaft portion (19) and a third shaft portion (20). At least one processing member (8, 9, 10) is attached to each shaft portion (18,

19, 20). The processing members (8, 9, 10) attached to one shaft portion (18, 19, 20) differ in each case from the processing members attached to the other shaft portions by the shape and/or the attachment angle of the processing member with respect to the longitudinal direction (22) of the shaft (3, 4). A device (1) may comprise one or two of such shafts (3, 4).

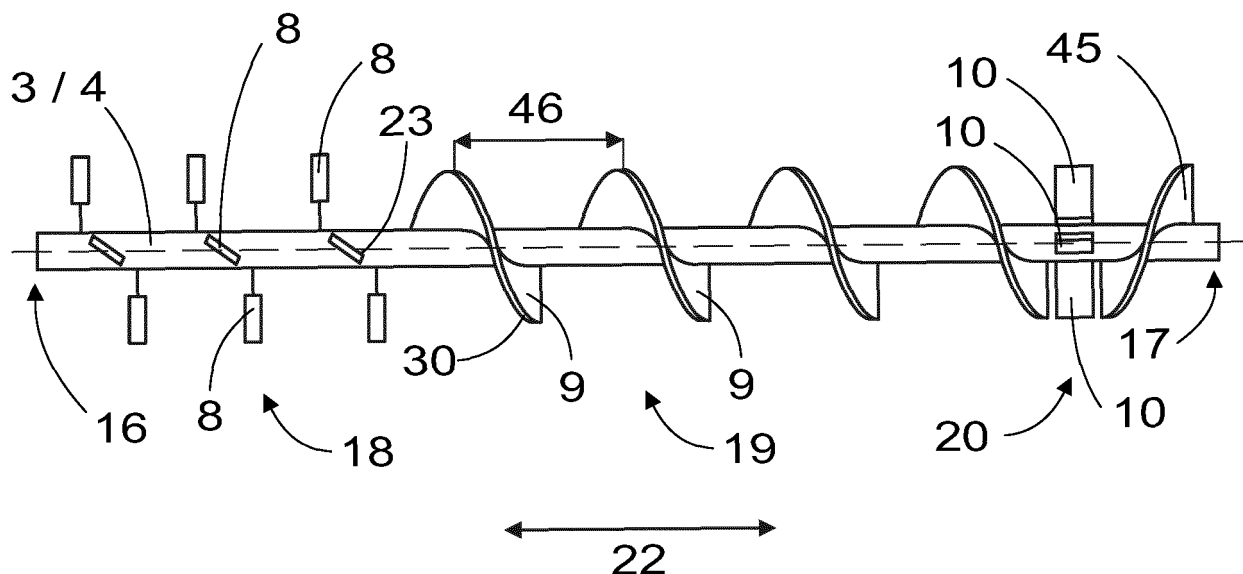


FIG. 3

Description

BACKGROUND

[0001] The disclosure relates to processing material mixtures, and more particularly to a shaft, a device and a method for material mixture processing.

[0002] Industrial side streams, or industrial by-products, often comprise different kinds of material mixtures. These material mixtures are typically non-uniform mixtures and may comprise dry and moist components. Such material mixtures are often difficult to recycle due to their heterogenous nature. Green liquor dregs, which is an example of such an industrial side stream material mixture, refers to moist "black ashes" created in the soda recovery boiler while burning dissolved wood material. It is considered to be one of the most challenging production side streams to recycle. While the composition of dregs is similar to ash, it is much more difficult to recycle because of its moist consistency and the heavy metals it typically contains.

BRIEF DESCRIPTION OF THE DISCLOSURE

[0003] An object of the present disclosure is to provide a new shaft, device and method for material mixture processing.

[0004] The object of the disclosure is achieved by a method, shaft and device which are characterized by what is stated in the independent claims. Some embodiments of the disclosure are disclosed in the dependent claims.

[0005] The disclosure is based on the idea of providing a combination of tools for mechanically processing the material mixture.

[0006] An advantage of the method, shaft and device of the disclosure is that material mixture can be processed into a homogenized, pressed product in an energy efficient and environmentally friendly, emission-free manner. The process enabled by the shaft, device and method is also continuous, contrary to sample type processing, which is beneficial, as it means that storing of the material mixture and/or the output material can be avoided in industrial processes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] In the following the solution will be described in greater detail by means of embodiments with reference to the accompanying drawings, in which

Figure 1 illustrates schematically a device for processing material mixture according to an embodiment seen in perspective;

Figure 2 illustrates schematically a device for processing material mixture according to an embodiment seen from above;

Figure 3 illustrates schematically a shaft for processing material mixture seen from a side;

Figure 4 illustrates schematically a dividing wall according to an embodiment seen from the second processing space portion towards the first processing space portion;

Figure 5 illustrates schematically a first shaft and a second shaft shown with some first processing members from the direction of a first end;

Figures 6a and 6b illustrate schematically a helical portion seen from a side and from an end, respectively; and

Figure 7 illustrates a method for processing material mixture..

[0008] The drawings are provided to illustrate the solution and some features and embodiments of the solution. The drawings are not shown to scale. Where there are two or more similar features shown in the drawings, only some of them may be marked with reference signs for the sake of clarity.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0009] Figure 1 illustrates schematically a device 1 for processing material mixture according to an embodiment seen in perspective; and Figure 2 illustrates schematically a device 1 for processing material mixture according to an embodiment seen from above. Figures 1 and 2 may or may not illustrate a same or similar embodiment. Figure 3 illustrates schematically a shaft 3, 4 for processing material mixture seen from a side. The device 1 of Figure 1 and/or 2 may comprise one, two or more of such shafts 3, 4.

[0010] A material mixture, in the context of this description and accompanying claims and drawings, refers to a material comprising a physical combination of two or more different substances the identities of which are retained in the mixed form. In other words, the substances of the material mixture are not chemically combined. Preferably, the material mixture comprises a non-uniform material mixture, which may also be called a heterogenous material mixture, and more preferably a non-uniform moisture containing material mixture. The aspects and embodiments disclosed may be particularly effective when processing non-uniform material mixtures, and especially when processing non-uniform, moisture containing material mixtures.

[0011] In the context of this disclosure, the material mixture being moisture containing, in other words the material mixture containing moisture, refers to the material mixture or a component thereof containing moisture. In other words, the material mixture does not need to comprise liquid as a separate component but there may be

moisture incorporated or bound in the structure of the material mixture or a component thereof. A moisture containing material mixture may, for instance, have a clayey, or clay-like, and/or gelatinous composition, and/or the moisture may be bound in a material in a different manner, such as in moist wood.

[0012] According to an embodiment, the material mixture may comprise an industrial side stream or an industrial by-product material mixture. According to a further embodiment, the material mixture may comprise at least one or more of the following: calcium-based material, green liquor dregs, desulphurisation gypsum, industrial side stream gypsym, lime mud, fly ash, aluminium-based material, magnesium-based material, and any combinations thereof. Such material mixtures are hard or impossible to process using conventional methods to turn the heterogenous material mixture to a homogenous output material. Known problems are for instance screw conveyors getting stuck, the water and the dry matter getting separated in extractors/centrifuges and the larger parts of hard dry matter not mixing in star sieves and the like. The shaft(s) 3, 4, 14 and device 1 disclosed in this description and accompanying drawings and claims, on the other hand, are found to process such heterogenous material mixtures into homogenous output material effectively, and even to cause powder-like dry components to be absorbed and mixed to moist components, such as green liquor dregs and the like.

[0013] A shaft 3, 4 for processing material mixture, such as a shaft 3, 4 according to Figure 3, comprises a first shaft end 16 and a second shaft end 17. The shaft 3, 4 further comprises a plurality of processing members 8, 9, 10, 15 attached to the shaft 3, 4 and protruding from the outer surface of the shaft. According to an embodiment, the shaft 3, 4 of the type of shown in Figure 3, especially concerning attachment angles and orientation of helical portions may be a shaft provided on the right when seen from the first shaft end 16 towards the second shaft end 17.

[0014] The shaft 3, 4 may comprise along the longitudinal direction 22 of the shaft three adjacent shaft portions: a first shaft portion 18, a second shaft portion 19 and a third shaft portion 20. The shaft portions 18, 19, 20 being adjacent along the longitudinal direction 22 refers to the length of the shaft 3, 4 being divided into the shaft portions. The shaft portions 18, 19, 20 may follow one another directly, in other words without any connecting portion, or other portion(s) may be provided between them. Preferably, the first shaft portion 18 is provided closest to or at the first shaft end 16, the third shaft portion 20 is provided closest to or at the second shaft end 17 and the second shaft portion 19 is provided between the first shaft portion 18 and the third shaft portion 20. Depending on the embodiment, the cross section of the shaft portions 18, 19, 20 may vary or the shaft portions 18, 19, 20 may form a uniform shaft of continuous size and shape.

[0015] According to an embodiment, the third shaft por-

tion 20 is shorter than the first shaft portion 18 and the second shaft portion 19. According to an embodiment, the length of the second shaft portion 19 may be in the range of 0.6 to 3 times the length of the first shaft portion 18 in the longitudinal direction 22 of the shaft. According to an embodiment, the length of the third shaft portion 20 may be in the range of 0.05 to 0.4 times the length of the second shaft portion 19 in the longitudinal direction 22 of the shaft. A ratio between the lengths of the first shaft portion 18, the second shaft portion 19 and the third shaft portion 20, especially the ratio between the lengths of the first shaft portion 18 and the second shaft portion 19, may depend on the material mixture processed with the shaft 3, 4, 14 and/or the device 1. In embodiments, where the first processing members 8 and/or the second processing members 9 are attached to the shaft 3, 4 in a removable manner, this ratio may even be adjustable.

[0016] At least one processing member 8, 9, 10, 15 is attached to each shaft portion 18, 19, 20. The processing members attached to one shaft portion differ in each case from the processing members attached to the other shaft portions by the shape and/or the attachment angle 23 of the processing member 8, 9, 10, 15 with respect to the longitudinal direction of the shaft.

[0017] According to an embodiment, the first shaft portion 18 is provided with a plurality of first processing members 8, and each first processing member 8 comprises a plate-like plane portion protruding outwards from the outer surface of the shaft 3, 4. The plane portion may be provided at an attachment angle 23 with respect to the longitudinal direction 22 of the shaft.

[0018] According to an embodiment, the attachment angle 23 of at least some of the first processing members 8 is in the range of 10 - 80 degrees, preferably in the range of 30 - 60 degrees and most preferably in the range of 40 - 50 degrees. The selection of the attachment angle 23 affects the mixing properties of the first processing members 8 and the speed at which the first processing members 8 move the material mixture forward, and an optimal attachment angle 23 may depend on the content and texture of the material mixture. An attachment angle 23 that is too small or too large does not effectively move the mixture material forward. An attachment angle 23 closer to 45 degrees effectively mixes the material mixture, but does not cut the material mixture, which is beneficial in many processes.

[0019] According to an embodiment, the attachment angles of the first processing members 8 provided on the shaft 3, 4 provided on the left when seen from the first shaft end 16 towards the second shaft end 17 are slanted towards left, in other words extending from right to left when seen from the first shaft end 16 towards the second shaft end 17, and the attachment angles of the first processing members 8 provided on the shaft 3, 4 provided on the right when seen from the first shaft end 16 towards the second shaft end 17 are slanted towards right, such as in the embodiment of Figure 3. Thereby, when the shafts 3, 4 are rotated towards one another,

the material mixture is moved forward and towards the longitudinal middle line of the processing space 24.

[0020] According to an embodiment, all the first processing members 8 may have the same attachment angle 23 or an approximately same attachment angle 23 not varying more than 10 degrees from the attachment angles 23 of the other first processing members 8.

[0021] According to an embodiment, the first processing members 8 may be provided in one or several rows extending in the longitudinal direction 22 of the shaft 3, 4. According to an embodiment, all the first processing members in such a row may have the same attachment angle 23. According to another embodiment, the attachment angle 23 of at least some of the first processing members 8 may depend on the distance of the first processing member 8 from the first shaft end 16. In other words, one or more of the first processing members 8 provided closest to the first shaft end 16 may have a different attachment angle 23 than one or more of the first processing members 8 provided further away from the first shaft end 16. In such embodiments, the mixing characteristics of the first shaft portion 18 may be affected by the selection of the attachment angles 23 of the first processing members 8.

[0022] According to an embodiment, at least some of the first processing members 8, or all of the first processing members 8, may be fixedly attached to the first shaft 3. According to an embodiment, the first processing members 8 may be fixedly attached to the first shaft by welding.

[0023] According to another embodiment, at least some of the first processing members 8, or all of the first processing members 8, may be attached to the first shaft 3 in a removable and/or adjustable manner. First processing members 8 attached in a removable manner may be removed from the first shaft 3 and, depending on the embodiment, reattached to the first shaft 3 with the same attachment angle 23 and/or with a different attachment angle 23 than before the removal. The attachment angle 23 of first processing members 8 attached to the first shaft 3 in an adjustable manner may be adjusted after first attachment. Adjustable first processing members 8 may also be removable or their attachment angle 23 may be changed in some other manner, for instance using a specific tool or by loosening the first processing member 8 in question to adjust the attachment angle 23 and then tightening the first processing member 8 to the new attachment angle 23. According to an embodiment, one or more of the first processing members 8 may be attached to the first shaft 3 in a removable and adjustable manner by bolts.

[0024] According to an embodiment, the second shaft portion 19 may be provided with at least one second processing member 9. Each second processing member 9 may comprise a helical segment or cut helix shaped helical portion protruding outwards from the outer surface of the shaft 3, 4 and extending helically with respect to the longitudinal direction 22 of the shaft 3, 4. According

to an embodiment, a helix angle 28 of the helical portion is in the range of 20 to 60 degrees. The helix angle 28 is a known characteristic of a helical shape. In the context of this description and accompanying drawings and claims the helical angle 28, thus, is an angle between the longitudinal direction 22 of the shaft 3, 4, 14 and the outer perimeter 30 of the helical portion, at the point where the outer perimeter 30 crosses the longitudinal direction 22 of the shaft 3, 4, 14 seen in a direction perpendicular to the longitudinal direction 22. The helix angle 28, pitch 46, length 29 and cut part 47 of a helical portion are illustrated in Figures 6a and 6b.

[0025] In the context of this description and accompanying claims and drawings, a helical segment or a cut helix shaped helical portion refer to shapes that do not form one continuous screw-like helical blade extending in a spiralling manner from one end of a shaft or shaft portion to a second end of the shaft or the shaft portion. Instead, such a helical segment or a cut helix shaped helical portion only extends along a portion of the shaft or shaft portion that is shorter than the whole lengths of the shaft or the shaft portion, and two or more of such helical segments or cut helix shaped helical portions may thus be provided in each case spaced from one another along the longitudinal direction 22 of the shaft 3, 4, 14.

[0026] According to an embodiment, the length 29 of at least one helical portion is in the range of 70 to 450 degrees about the shaft, preferably in the range of 80 to 340 degrees and most preferably in the range of 170 to 280 degrees. A length 29 of a helical portion refers to the length of an individual helical portion measured in degrees along the outer perimeter 30 of the helical portion around the axis of the shaft 3, 4. In other words, a helical portion an outer perimeter of which extends once around the shaft such that both ends of the outer perimeter are provided on a line parallel to the axis of the shaft, is 360 degrees. According to an embodiment, the pitch 46 of at least one helical portion is at least 100 mm, preferably at least 250 mm and most preferably in the range of 300 mm to 600 mm. A pitch is a known characteristic of a helical shape and refers to the length one whole round of the helical shape extends along the longitudinal axis of the shaft 3, 4. It should be noted that the pitch 46 is, thus, the length of one whole round of the helical shape also in the embodiments, in which the helical shape, such as the helical second processing member 9 or the helical fourth processing member is shorter than a whole round.

[0027] According to an embodiment, a cut part 47 of the helical portion is in the range of 20 to 180 degrees, preferably in the range of 30 to 150 degrees and most preferably in the range of 35 to 115 degrees. According to an embodiment, such as the embodiment of the Figures 3, 6a and 6b, the length 29 of the helical portion is 270 degrees +/- 10 degrees and the cut part 47 of the helical portion is 90 degree +/- 10 degrees.

[0028] According to an embodiment, the helical portions of the shaft 3, 4 provided on the left when seen from the first shaft end 16 towards the second shaft end 17

are provided in a left-hand orientation, in other words the outer perimeter 30 of the helical portion extending from right to left at an angle of the helix angle 28 when seen from the first shaft end 16 towards the second shaft end 17, and the helical portions of the shaft 3, 4 provided on the right are provided in a right-hand orientation, such as in the shaft of Figure 3. Thereby, when the shafts 3, 4 are rotated towards one another, the material mixture is moved forward and towards the longitudinal middle line of the processing space 24.

[0029] According to an embodiment, the third shaft portion 20 is provided with at least one third processing member 20, and each third processing member 20 comprises a plate-like plane portion protruding outwards from the outer surface of the shaft 3, 4. The plane portion may be provided at an attachment angle in range of -10 degrees to 10 degrees with respect to the longitudinal direction 22 of the shaft 3, 4. In other words the plate-like portion of the third processing member 20 may be provided in a direction substantially parallel to the longitudinal direction 22 of the shaft 3, 4. According to an embodiment, the third processing member protrudes from the outer surface of the shaft 3, 4 in a radial direction or a direction deviating not more than 10 degrees from the radial direction. According to an embodiment, the shaft 3, 4 may comprise two or more of third processing members 20.

[0030] According to an embodiment, such as the embodiment of Figure 3, the first shaft 3 and/or the second shaft 4 may further comprise at least one fifth processing member 45 provided at the second shaft end 17. According to an embodiment, the first shaft 3 and the second shaft 4 each comprise exactly one fifth processing member 45. The fifth processing member 45 may comprise a helical portion similar to that of the second processing member 9. According to an embodiment, the helical portion of the fifth processing member 45 may comprise a length 29 of the helical portion of 180 degrees. In other words, the helical portion of the fifth processing member 45 may comprise a half turn or a half of one whole helical shape. Preferably, the orientation of the helical portion of the fifth processing member 45 is opposite to that of the second processing members 9 provided on the same shaft. In other words, in a shaft 3, 4 where the helical portions of the second processing members 9 are provided in a right-hand orientation, the helical portion of the fifth processing member 45 is preferably provided in a left-hand orientation, and vice versa. Thereby, the fifth processing member(s) 45 of the first shaft 3 and/or the second shaft 4 may prevent the material mixture from building up at the second end 6 of the housing 2.

[0031] According to an embodiment, the shaft 3, 4 further comprises a fourth shaft portion 21, and the fourth shaft portion 21 is provided with at least one fourth processing member 15. The fourth processing member 15 may comprise a helical portion protruding outwards from the outer surface of the shaft 3, 4, 14 and extend helically with respect to the longitudinal direction 22 of the shaft 3, 4, 14. According to an embodiment, the fourth

shaft portion 21 may be provided with two or more fourth processing members 15. According to an embodiment, each fourth processing member may comprise, similarly to second processing members 9, a helical segment or cut helix shaped helical portion protruding outwards from the outer surface of the shaft 3, 4, 14. The characteristics of the fourth processing members 15, such as the helix angle, the length of the helical portion, cut part of the helical portion, and the pitch of the helical portion, may be similar to the second processing members 9 or they may differ from the characteristics of the second processing members. According to an embodiment, the helical portion of the fourth processing member 15 forms a continuous feed screw. According to an embodiment, the length of the fourth shaft portion may be at least 1 meter long in the longitudinal direction of the shaft.

[0032] According to an embodiment, the characteristics of the second processing members 9 and/or fourth processing members 15, such as the helix angle, the length of the helical portion and the pitch of the helical portion, may in each case remain the same or vary over the length of the second shaft portion 19 and the fourth shaft portion 21, respectively. In some embodiments, for instance in case of specific type of material mixtures, varying characteristics of the second processing members 9 and/or fourth processing members 15 may improve the processing of the material mixture and the quality of the output material.

[0033] According to an embodiment, at least the first shaft portion 18, the second shaft portion 19 and the third shaft portion 20 form a uniform and continuous shaft structure.

[0034] According to an embodiment, the shaft 3, 4, 14 has a round, elliptical, square or rectangular cross section.

[0035] A device 1 for material mixture processing may comprise a housing 2 and a processing space 24 defined inside the housing 2. The device may further comprise at least one shaft, a first shaft 3, according to any one of the embodiments disclosed in this description or a combination thereof. The first shaft 3 may extend inside the housing 2 from a first end 5 of the housing to a second end 6 of the housing. Preferably, the first shaft 3 may be coupled to the housing 2 in a rotatable manner at both the first end 5 and the second end 6. According to an embodiment, the first shaft 3 is rotatably supported at both the first end 5 and the second end 6 of the housing 2. According to a further embodiment, the first shaft 3 is rotatably supported at both the first end 5 and the second end 6 of the housing 2 by a bearing 40. Such bearings 40 are widely known in the art and are not described here in more detail.

[0036] According to an embodiment, the housing 2 may comprise at least the first end 5, the second end 6, two sides 41, a top 42 and a bottom 43. This part of the housing 2 may be called a main part. The sides 41, the top 42 and the bottom 43 of the main part of the housing may in each case be formed of one or more structural

parts. For instance, according to an embodiment, the cross-sectional area of the housing 2 and/or the shape of the cross section of the housing 2 may vary along the length of the housing 2.

[0037] According to an embodiment, the housing 2 may comprise at least one protruding part protruding from the second end 6 and/or one of the sides 41 of the main part. Such a protruding part may similarly comprise two sides 41, a top 42 and a bottom 43, and it may form a third end 44 for housing 2 at the distal end of the protruding part. At least a portion of the top 42 and/or the bottom 43 of the main part may in each case form a continuous structure, for instance an L-shaped structure, with the top 42 and/or the bottom 43 of the protruding part, or the top 42 and/or the bottom 43 of the protruding part may be formed as structural parts separate from the top 42 and the bottom 43 of the main part.

[0038] The device 1 further comprises an inlet opening 7 for receiving material mixture provided at the first end 5 of the housing 2, and an outlet opening 12 for discharging the processed material mixture from the device 1. According to an embodiment, a feed hopper 31 is provided above the inlet opening 7. Different types of feed hoppers for feeding material to different types of equipment are widely known in the art. Preferably, the feed hopper 31 is configured to suit feeding material mixture to the device 1 by an excavator, a bucket loader or similar.

[0039] According to an embodiment, the device 1 further comprises rotating equipment 32 for rotating the first shaft 3. According to an embodiment, the rotating equipment 32 comprises at least one rotary actuator driven by electric energy or fluid power. Such rotary actuators are known in the art and are therefore not described in more detail. An advantage of such embodiments is that they may be used with no or minimal local emissions.

[0040] According to an embodiment, the device 1 may further comprise a second shaft 4. The second shaft 4 may comprise a shaft according to an embodiment disclosed in this description or a combination thereof. According to an embodiment, the first shaft 3 and the second shaft 4 may be similar to one another. According to another embodiment, the first shaft 3 and the second shaft 4 may be otherwise similar but formed as mirror images of one another.

[0041] The second shaft 4 may extend inside the housing 2 from a first end 5 of the housing to a second end 6 of the housing. Preferably, the second shaft 4 may be coupled to the housing 2 in a rotatable manner at both the first end 5 and the second end 6. According to an embodiment, the second shaft 4 is rotatably supported at both the first end 5 and the second end 6 of the housing 2. According to a further embodiment, the second shaft 4 is rotatably supported at both the first end 5 and the second end 6 of the housing 2 by a bearing 40. Such bearings 40 are widely known in the art and are not described here in more detail. According to an embodiment, the first shaft 3 and the second shaft 4 are both coupled to the housing 2 in a manner similar to each other.

[0042] According to an embodiment, the first shaft 3 and second shaft 4 may be provided parallel to one another. According to an embodiment, the first shaft 3 and the second shaft 4 may be configured to rotate in a synchronized manner but in opposite directions such that the shafts rotate towards each other. This is illustrated schematically in Figure 5 with some first processing members 8 shown. The first shaft 3 and the second shaft 4 may be coupled to each other by a gear transmission or another mechanical or pressure medium based manner such that rotation speeds of the first shaft 3 and the second shaft 4 are same, but the direction of rotation is opposite. According to an embodiment, the rotation speed of the first shaft 3 and/or the second shaft 4 may be controlled by a frequency converter, preferably one frequency converter.

[0043] According to an embodiment, the processing members 8, 9, 10, 15 are provided in such a manner that they extend, during rotation, in each case to a shared area 38 between the shafts 3, 4 but are not brought into contact with each other. In other words, the first processing members 8 provided on the first shaft 3 may extend to a shared area 38 with the first processing members 8 provided on the second shaft 4, the second processing members 9 provided on the first shaft 3 may extend to a shared area 38 with the second processing members 9 provided on the second shaft 4, and so on. This may apply for the first processing members 8, the second processing members 9, the third processing members 10 and/or the fourth processing members 15. The shared area in each case may be of same size or a different size for processing member types 8, 9, 10 and 15 and/or for individual pairs of processing members provided on adjacent shafts 3, 4. This increases the effectiveness of chopping, mixing and homogenizing the material mixture.

[0044] According to an embodiment, the device 1 further comprises a first dividing wall 33 dividing the processing space 24 into a first processing space portion 25 and a second processing portion 26. Figure 4 illustrates schematically a dividing wall according to an embodiment seen from the second processing space portion towards the first processing space portion. According to an embodiment, the first dividing wall 33 comprises at least one first opening 34 connecting the first processing space portion 25 to the second processing space portion 26.

[0045] According to an embodiment, the first shaft portion 18 is provided inside the first processing space portion 25 and the second shaft portion 19 and the third shaft portion 20 are provided inside the second processing space portion 26. According to an embodiment, the first processing space portion 25 and the second processing space portion 26 may be provided within the main part of the housing 2.

[0046] According to an embodiment, the cross-sectional area of the second processing space portion 26 is smaller than the cross-sectional area of the first process-

ing space portion 25. Thereby, the smaller cross-sectional area of the second processing space portion 26 limits the amount of the material mixture fed from the first processing space portion 25 to the second processing space portion 26. This may increase the time the material mixture is kept and processed in the first processing space portion 25, whereby the material mixture is further processed when entering the second processing space portion 26. In other words, the degree to which the material mixture is processed in the first processing space portion 25 may be defined by the ratio of the cross-sectional areas of the first processing space portion 25 and the second processing space portion 26.

[0047] The characteristics of the second processing members 9, such as the helix angle 28 and pitch 46, on the other hand, affect the consistency of the feed of the mixture material further in the process. Thereby, the second processing members 9 and the third processing members 10 may provide a continuous and consistent feed of the mixture material further in the process and in the device towards the second shaft end 17 and the outlet opening 12. According to an embodiment, a first end wall 39 is provided at the second shaft end 17. This first end wall 39 together with the rest of the housing 2 surrounding the second processing space portion 26 and the characteristics of the second processing members 9 and the third processing members 10 create a pressure inside the second processing space portion 26, when mixture material is introduced therein, enhancing the feed of the mixture material further in the process and in the device 1, such as to a third processing space portion 27.

[0048] According to an embodiment, the bottom 43 of the housing 2 in the area of the first processing space portion 25 and the second processing space portion 26 conforms to the rotating path of the distal ends of at least some of the first, second and/or third processing members 8, 9, 10 attached to the first shaft 3 and/or the second shaft 4. According to an embodiment, the bottom 43 of the housing 2 in the area of the first processing space portion 25 and the second processing space portion 26 may thus comprise a gutter or a double gutter shaped form, depending whether one or two shafts 3, 4 are provided within the housing 2. This may optimize the moving of the processed material mixture forward within the housing 2.

[0049] According to an embodiment, the device 1 further comprises a fourth shaft portion 21 according to an embodiment disclosed in this description or a combination thereof. According to an embodiment, the fourth shaft portion 21 is formed as a third shaft 14 separate from the first shaft 3 and the second shaft 4. The third shaft 14 may be similar to or vary within embodiments of the first shaft 3 and second shaft 4. For instance, the third shaft 14 may comprise has a round, elliptical, square or rectangular cross section. However, the third shaft 14 is preferably provided with fourth processing members 15 instead of first processing members 8, second processing members 9, third processing members 10 and/or fifth

processing members 45.

[0050] According to an embodiment, the third shaft 14, such as the torque and the rotating speed of the third shaft 14, is controlled separately from the first shaft 3 and the second shaft 4. This enables an improved control of the process and the output material. According to an embodiment, a dedicated frequency converter (not shown) is used for controlling the third shaft 14. In other words, according to an embodiment, in the device 1, two frequency converters may be used to control the device 1: a first frequency converter to control the first shaft 3 and/or the second shaft 4 and a second frequency converter to control the third shaft 14.

[0051] According to an embodiment, the third shaft 14 may be provided at an angle 35 in the range of 45 to 100 degrees with respect to the first shaft 3. An advantage of such embodiments is that a compact device 1 may be provided, which enables fitting it more easily to existing production plants and the like. According to an embodiment, a device 1 according to an embodiment disclosed in this description or a combination thereof may be provided with moving equipment, such as a carriage, to form a portable device.

[0052] According to an embodiment, the housing 2 may comprise a third processing space portion 27 defined within the processing space 24 inside the housing 2. The third shaft 14 may be provided within this third processing space portion 27. According to an embodiment, the third processing space portion 27 is provided adjacent to or angled to the second processing space portion 26. According to an embodiment, at least one second opening (not shown) is provided connecting the second processing space portion 26 and the third processing space portion 27.

[0053] The third shaft 14 may extend inside the housing 2, preferably inside a third processing space portion 27. According to an embodiment, the third shaft 14 is coupled to the housing 2 in a rotatable manner at least at one end of the third shaft 14, namely the end directed towards the second opening. According to an embodiment, the third shaft 14 is rotatably supported at the end of the third shaft 14 directed towards the second opening by a bearing (not shown).

[0054] According to an embodiment, the bottom 43 of the housing 2 in the area of the third processing space portion 27 conforms to the rotating path of the distal ends of at least some of the fourth processing members 15 attached to the third shaft 14. According to an embodiment, the bottom 43 of the housing 2 in the area of the third processing space portion 27 may thus comprise a gutter shaped form.

[0055] According to an embodiment, the third processing space portion 27 may be formed as an angled portion 13 surrounding the third shaft 14. In such embodiments, the third processing space portion 27 may be provided in the protruding part of the housing 2.

[0056] According to an embodiment, the axis of the third shaft 14 is provided at a lower level than the axis of

the first shaft 3. In such embodiments, the second opening may be provided in the housing 2 at the bottom 43 of the second processing space portion 26, for instance at the bottom 43 the second end 6 of the housing 2. According to an embodiment, the second opening may be provided at least in the area of the fourth processing members 15, in other words in the area of the bottom 43 of the housing 2 above which the fourth processing members 15 are provided, when material mixture is processed in the device 1.

[0057] According to an embodiment, the at least one second opening may be provided in a second dividing wall (not shown) connecting the second processing space portion 26 and the third processing space portion 27. According to another embodiment, particularly an embodiment where the third shaft 14 is provided at a lower level than the axis of the first shaft 3, the second opening may be provided at the bottom of the housing 2 at the second end 6 of the housing 2.

[0058] According to an embodiment, the outlet opening 12 consists of one or more openings, and wherein the total area of said openings is smaller than 90 percent, preferably smaller than 70 percent, more preferably smaller than 60 percent and most preferable smaller than 50 percent, of the area of the cross section of the processing space 24 at the outlet opening 12. According to an embodiment, an end plate (not shown) is provided at the outlet opening 12, wherein the end plate is formed to cover at least 50 percent of the cross section of the processing space 24 at the outlet opening 12. This may comprise for instance the plate being configured to conform to the shape of the cross section of the processing space 24 at the outlet opening 12 except for a portion covering less than 50 percent of the area or the plate comprising a perforated plate, wherein the perforations for the outlet opening.

[0059] According to an embodiment, one or more rollers (not shown) are provided at the outlet opening 12, more particularly inside the housing 2, outside the housing 2 or adjacent to an end plate of the housing 2 provided at the outlet opening 12, and configured to flatten the output material into a plate-like form.

[0060] The controlling of the third shaft 14 and the cross-sectional area of the outlet opening(s) 12 together provide a pressure within the third processing space portion 27. This pressure applied to the mixture material introduced in the third processing space portion 27 enables more homogeneous output material to be produced by the device 1. This is particularly beneficial, when the material mixture contains moist, as the moist further enhances the process under pressure.

[0061] According to an embodiment, the device 1 further comprises a control unit 37 for controlling the operation of the shaft(s) 3, 4, 14 to control the processing of the material mixture in the device 1. According to an embodiment, the control may comprise at least controlling the rotation speeds of the shaft(s) 3, 4, 14 and the pressure applied to the material mixture inside the processing

space 24. According to an embodiment, the control unit 37 may be connected to the device 1 by a wired connection. According to another embodiment, the control unit may be connected to the device by a wireless connection.

According to an embodiment, the control unit 37 may be provided attached to or in the vicinity of the device 1. According to a further embodiment, the control unit 37 may be provided remotely from the device 1.

[0062] Figure 7 illustrates a method for processing material mixture. A method for material mixture processing, such as the method of Figure 7, may comprise receiving 72 material mixture to a device 1 according to an embodiment disclosed in this description or a combination thereof through the inlet opening 7. The method may further comprise rotating 74 one or more of the first shaft 3, the second shaft 4 and/or the third shaft 14 to process the material mixture by the processing members 8, 9, 10, 15 into a homogenous output material, and discharging 76 the homogenous output material through the outlet opening.

[0063] According to an embodiment, the device 1 may further comprise a conveying member (not shown) configurable to convey output material from the outlet opening 12 back to the inlet opening 7. Depending on the embodiment, the conveying member may be configured to convey all of the output material or a portion thereof back to the inlet opening 7. Depending on the embodiment, the conveying member may be configured to convey output material from the outlet opening 12 to the inlet opening 12 continuously or when controlled to do so. Alternatively, two or more of devices 1 described in this description may be provided one after another process-wise, and the conveying member may be configurable to convey material from one device 1 to an adjacent device 1. The material mixture may be circulated in such a device 1 or devices 1 for instance for one, two, three or four cycles, each cycle starting from the inlet opening 7 and ending at the outlet opening 12. According to an embodiment, one or more additive materials, such as ashes and/or lime kiln ESP dust, may be added to the material mixture during one or more of such cycles. Such a conveying member may comprise for instance a feed screw, a conveyor belt or any other conveying means known in the art.

[0064] According to an embodiment, characteristics of output material may be measured at or after the outlet opening 12 and/or at or after the second opening by one or more sensors, meters, or other types of detecting devices. According to an embodiment, the measured characteristics, may be used for providing a feedback loop for controlling the frequency converter(s). According to another embodiment, the measured characteristics, may be used, instead of or in addition to providing a feedback loop for controlling the frequency converter(s), for controlling the conveying member to convey or not to convey all or a part of the output material back to the device 1 for a further cycle.

[0065] According to an embodiment, the method may

further comprise chopping, mixing and/or pushing forward the material mixture by the first processing members 8 inside the first processing space portion 25, homogenizing and pushing forward the material mixture as a consistent and continuous flow by the second processing member(s) 9 inside the second processing space portion 26, feeding the material mixture as a consistent and continuous flow by the third processing member(s) 10 from the second processing space portion 26 to the third processing space portion 27, and applying pressure to the material mixture inside the third processing space portion 27 and feeding the material mixture to be discharged through the outlet opening 12 by fourth processing members 15.

[0066] According to an embodiment, the device 1 described in this description and accompanying drawings and claims is configured to process at least 8 cubic meters or 8 tons of material mixture in an hour.

[0067] It is clear for a person skilled in the art that as the technology advances, the disclosure is not only limited to the embodiments disclosed in this description and accompanying drawings. Instead, the disclosure may vary within the scope defined in the accompanying claims.

Claims

1. A shaft for processing material mixture, the shaft comprising:

a first shaft end and a second shaft end; and a plurality of processing members attached to the shaft and protruding from the outer surface of the shaft,

wherein the shaft comprises along the longitudinal direction of the shaft three adjacent shaft portions: a first shaft portion, a second shaft portion and a third shaft portion, wherein there is at least one processing member attached to each shaft portion, and wherein the processing members attached to one shaft portion differ in each case from the processing members attached to the other shaft portions by the shape and/or the attachment angle of the processing member with respect to the longitudinal direction of the shaft, **characterized in that**

the third shaft portion is provided with at least one third processing member, wherein each third processing member comprises a plate-like plane portion protruding outwards from the outer surface of the shaft, which plane portion is provided at an attachment angle in the range of -10 degrees to 10 degrees with respect to the longitudinal direction of the shaft, and that the first shaft portion is provided closest to or at the first shaft end, the third shaft portion is provided closest to or at the second shaft end and

the second shaft portion is provided between the first shaft portion and the third shaft portion.

2. A shaft according to claim 1, wherein the first shaft portion is provided with a plurality of first processing members, and wherein each first processing member comprises a plate-like plane portion protruding outwards from the outer surface of the shaft, which plane portion is provided at an attachment angle with respect to the longitudinal direction of the shaft, and wherein the attachment angle of at least some of the first processing members is in the range of 10 - 80 degrees.
3. A shaft according to claim 1 or 2, wherein the second shaft portion is provided with at least one second processing member, and wherein each second processing member comprises a helical segment or cut helix shaped helical portion protruding outwards from the outer surface of the shaft and extending helically with respect to the longitudinal direction of the shaft.
4. A shaft according to claim 3, wherein the length of at least one helical portion is in the range of 70 to 450 degrees about the shaft.
5. A shaft according to any one of claims 1 - 4, wherein the shaft further comprises a fourth shaft portion, and wherein the fourth shaft portion is provided with at least one fourth processing member, which fourth processing member comprises a helical portion protruding outwards from the outer surface of the shaft and extending helically with respect to the longitudinal direction of the shaft.
6. A shaft according to any one of claims 1 - 5, wherein at least the first shaft portion, the second shaft portion and the third shaft portion form a uniform and continuous shaft structure.
7. A device for material mixture processing, the device comprising:
 - a housing;
 - a processing space defined inside the housing;
 - at least one shaft, a first shaft, according to any one of claims 1 - 6 extending inside the housing from a first end of the housing to a second end of the housing and coupled to the housing in a rotatable manner at both the first end and the second end;
 - an inlet opening for receiving material mixture provided at the first end of the housing; and
 - an outlet opening for discharging the processed material mixture from the device.
8. A device according to claim 7, wherein the device

further comprises rotating equipment for rotating the first shaft, and wherein the rotating equipment comprises at least one rotary actuator driven by electric energy or fluid power.

9. A device according to claim 7 or 8, wherein the device further comprises a second shaft according to any one of claims 1 - 6, wherein the first shaft and second shaft are provided parallel to one another and configured to rotate in a synchronized manner but in opposite directions such that the shafts rotate towards each other, and wherein the processing members are provided in such a manner that they extend, during rotation, to a shared area between the shafts but are not brought into contact with each other.

10. A device according to any one of claims 7 - 9, wherein the device further comprises a first dividing wall dividing the processing space into a first processing space portion and a second processing portion, wherein the first dividing wall comprises at least one first opening connecting the first processing space portion to the second processing space portion.

11. A device according to any one of claims 7 - 10, wherein

the device further comprises a fourth shaft portion according to claim 5,
the fourth shaft portion is formed as a third shaft separate from the first shaft and the second shaft, the third shaft is provided in a third processing space portion, and wherein
at least one second opening is provided connecting the second processing space portion to the third processing space portion.

12. A device according to claim 11, wherein

the third shaft is provided at an angle in the range of 45 to 100 degrees with respect to the first shaft, and wherein
the housing comprises an angled portion surrounding the third shaft and defining the third processing space portion.

13. A device according to claim 11 or 12, wherein the axis of the third shaft is provided at a lower level than the axis of the first shaft.

14. A device according to any one of claims 7 - 13, wherein the outlet opening consists of one or more openings, and wherein the total area of said openings is smaller than 50 percent of the area of the cross section of the processing space at the outlet opening.

15. A device according to any one of claims 7 - 14, wherein the device further comprises a control unit for con-

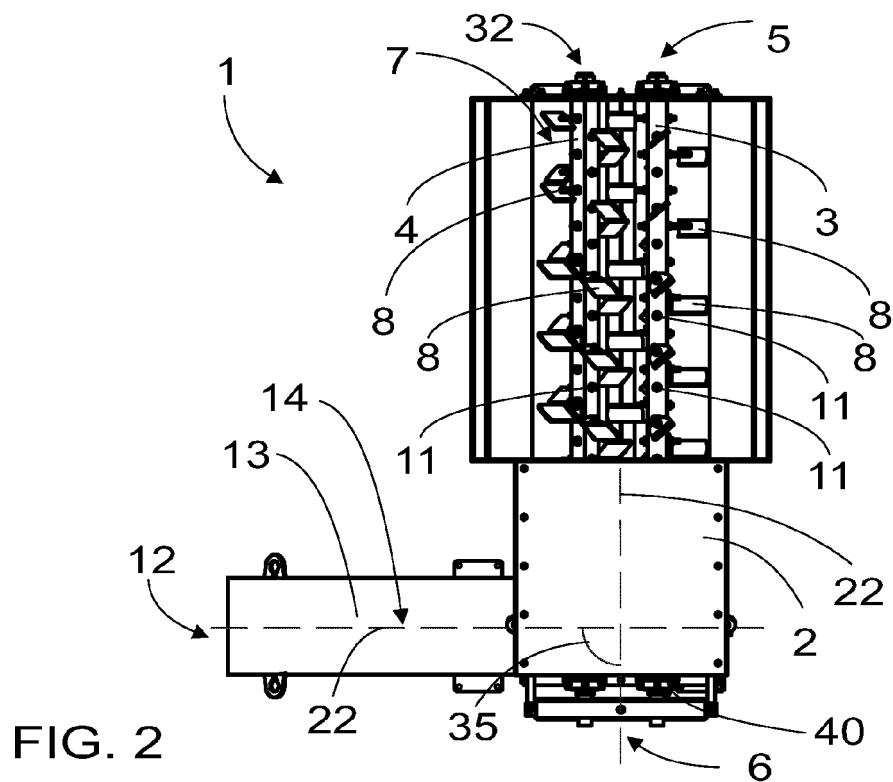
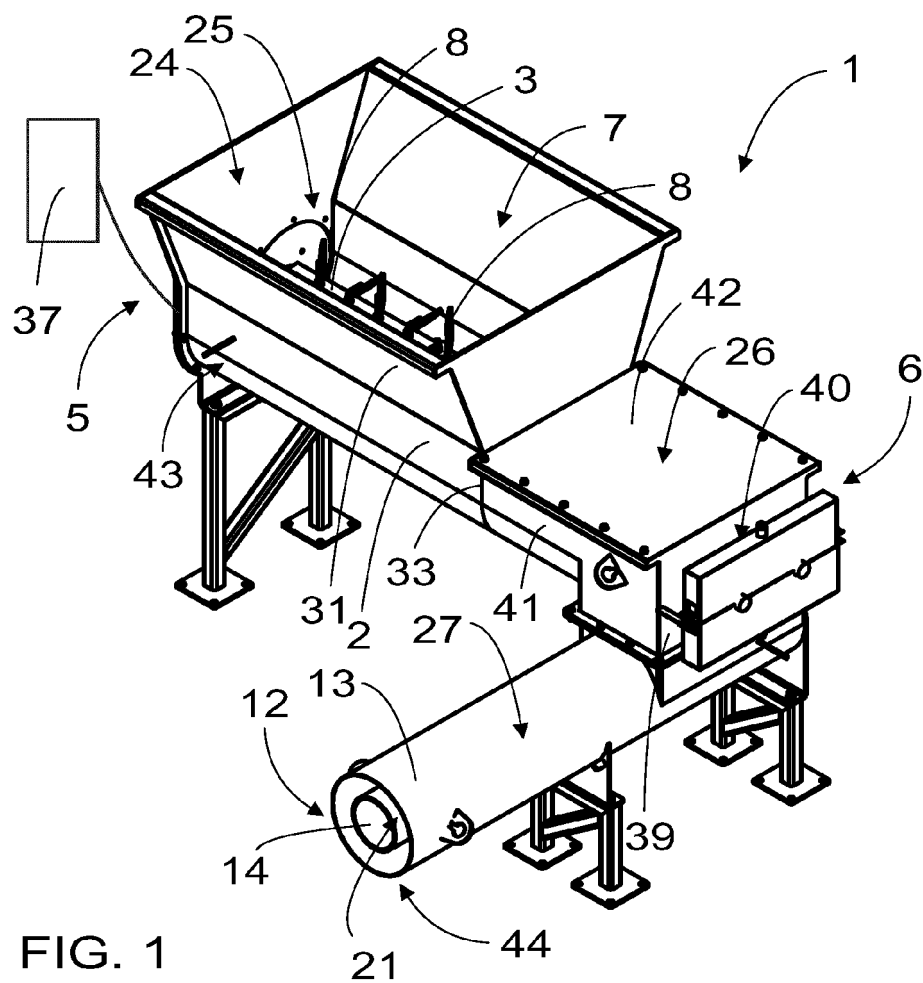
trolling the operation of the shaft(s) to control the processing of the material mixture in the device, the control comprising at least controlling the rotation speeds of the shaft(s) and the pressure applied to the material mixture inside the processing space.

16. A method for material mixture processing, the method comprising

receiving material mixture to a device according to any one of claims 7 - 15 through the inlet opening,
rotating one or more of the first shaft, the second shaft and/or the third shaft to process the material mixture by the processing members into a homogenous output material, and
discharging the homogenous output material through the outlet opening.

17. A method according to claim 16, wherein the method comprises

chopping, mixing and pushing forward the material mixture by the first processing members inside the first processing space portion,
homogenizing and pushing forward the material mixture by the second processing member(s) inside the second processing space portion,
feeding the material mixture by the third processing member(s) from the second processing space portion to the third processing space portion, and
applying pressure to the material mixture inside the third processing space portion and feeding the material mixture to be discharged through the outlet opening by fourth processing members.



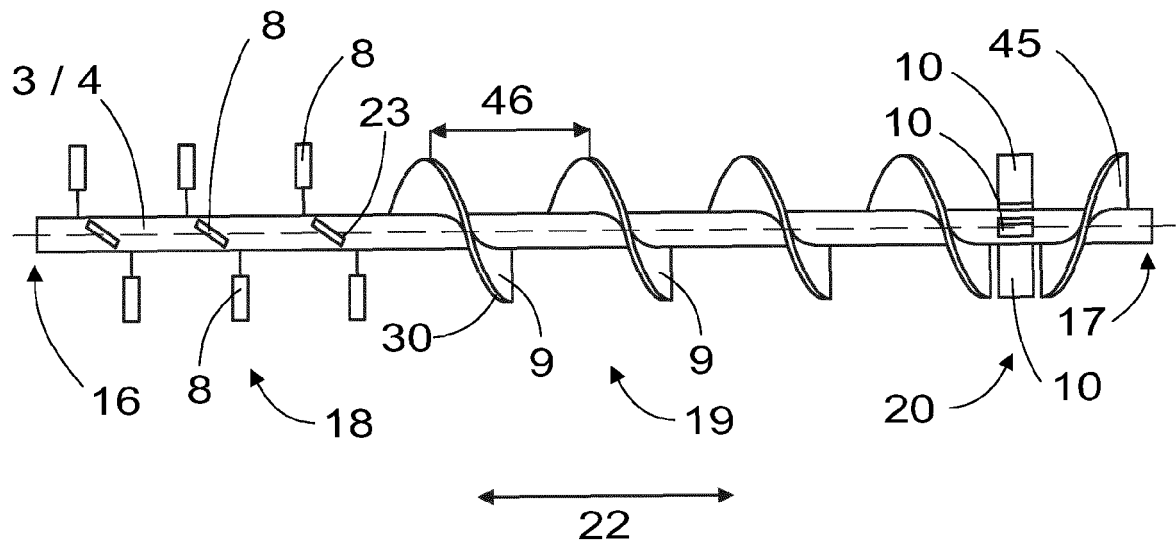


FIG. 3

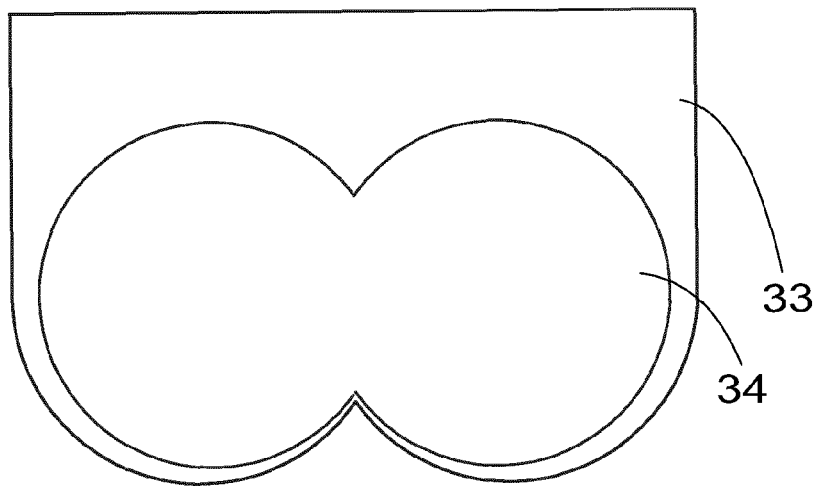


FIG. 4

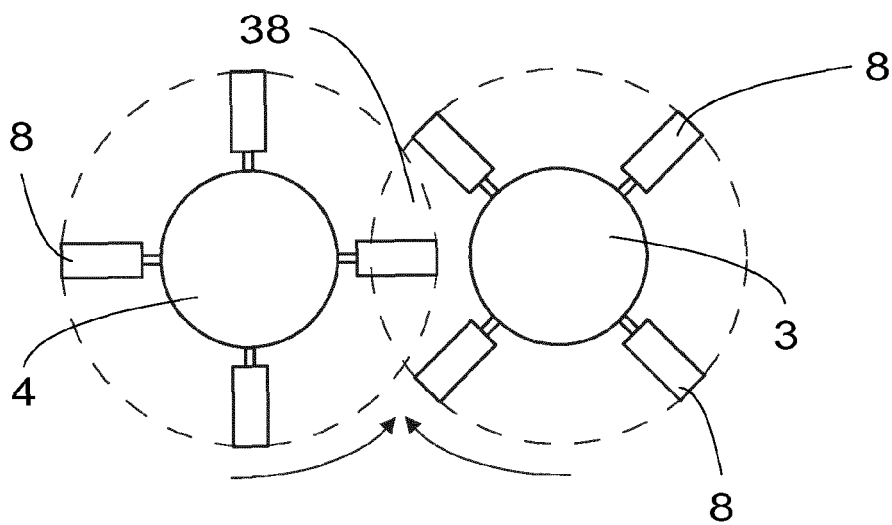


FIG. 5

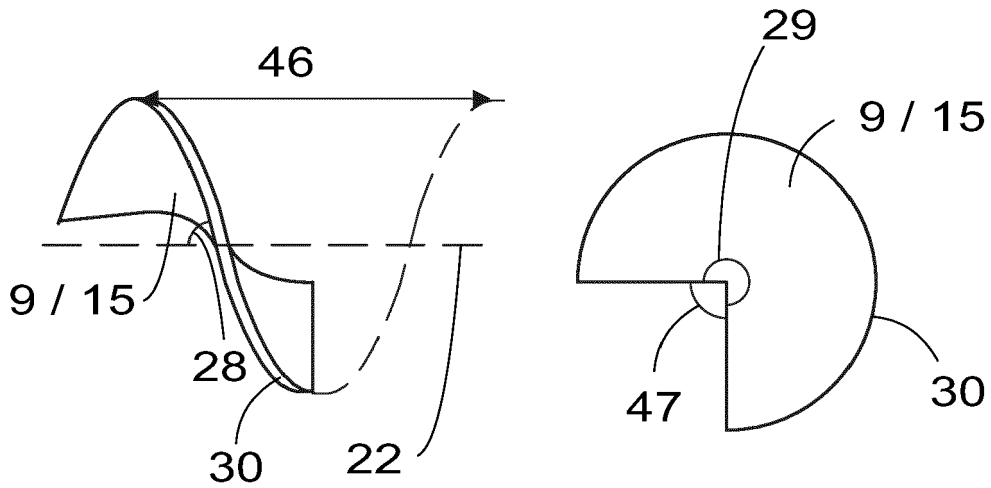


FIG. 6a

FIG. 6b

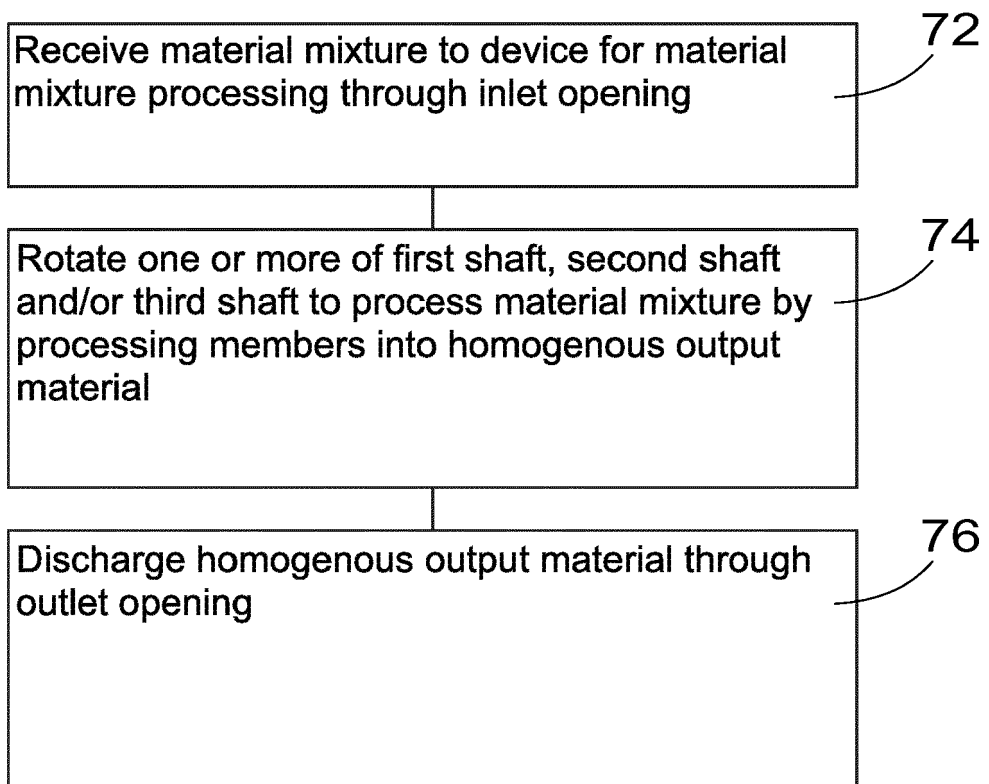


FIG. 7



EUROPEAN SEARCH REPORT

Application Number

EP 22 20 8967

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