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(54) **HEADBOX AND METHOD FOR APPLYING COATING COMPOSITIONS ONTO A MOVING WET PULP SUBSTRATE USING SAID HEADBOX**

STOFFAUFLAUF UND VERFAHREN ZUM AUFTRAGEN VON
BESCHICHTUNGSZUSAMMENSETZUNGEN AUF EIN BEWEGENDES NASSPULPESUBSTRAT
UNTER VERWENDUNG DIESES STOFFAUFLAUFS

CAISSE DE TÊTE ET PROCÉDÉ D'APPLICATION DE COMPOSITIONS DE REVÊTEMENT SUR UN
SUBSTRAT DE PÂTE HUMIDE MOBILE À L'AIDE DE LADITE CAISSE DE TÊTE

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• **JASPERS, Willy**
6241 GK Bunde (NL)

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(74) Representative: **Schmitz, Joseph**
Isler & Pedrazzini AG
Giesshübelstrasse 45
Postfach 1772
8027 Zürich (CH)

(73) Proprietor: **Sappi Papier Holding GmbH**
8101 Gratkorn (AT)

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(72) Inventors:
• **BOERSMA, Tjerk**
3590 Diepenbeek (BE)

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to the field of paper machines, in general, and in particular to a headbox, such as a secondary headbox, for applying a coating composition onto a moving wet pulp substrate in a paper machine, as well as a method of applying a coating composition onto a moving wet pulp substrate in a paper machine equipped with such a headbox, a paper machine comprising such a headbox as well as the use of such a headbox in a method of applying a horizontal stream of a coating composition onto a horizontally moving wet pulp substrate in a paper machine.

10 PRIOR ART

[0002] Paper machines use a moving woven mesh, also known as wire, to create a continuous paper web by filtering out the fibres held in a wet paper stock and producing a continuously moving wet mat of fibre.

15 **[0003]** In the paper machine, the wet paper stock is dispensed onto the wire mesh from a so-called headbox. The headbox essentially holds the wet paper stock and must, on one hand, keep the fibers from clumping together by generating turbulence in its interior, and on the other hand, uniformly distribute the wet paper stock across the width of the wire. Fulfilling both requirements ensures the formation of a homogenous mat of wet pulp on the wire.

20 **[0004]** It is known in the art of papermaking to add a second headbox downstream of the primary headbox to apply a different pulp blend or other coatings on top of a base pulp layer provided by the primary headbox. Such a traditional secondary headbox is normally located at a point where the base sheet is drained, i.e. at some point after the wet end section, and are a common configuration when manufacturing on linerboard.

25 **[0005]** However, in recent years, the use of novel materials as coating compositions, to be applied via a secondary headbox, has been hindered due to the special rheological properties that said materials impose on coating compositions. While secondary headbox designs are plentiful, the existing designs are mostly suitable and optimized for the application of coating compositions having low viscosity at low shear and thus, it is not possible to apply the novel materials in a way such that a homogenous layer, in width and thickness, is reliably formed, if said material exhibits high viscosity at low shear.

30 **[0006]** The formation of such a homogenous layer will in any case depend on multiple factors, such as matching of the speed at which the coating composition contacts the moving wet pulp layer from the primary headbox to the speed of the moving wet pulp layer, as well as adjusting the angle at which the coating composition contacts the moving wet pulp layer from the primary headbox, all the while warranting that the flow rate, width, thickness, rheology and consistency of the coating composition exiting the secondary head box is on-target.

35 **[0007]** There exists therefore a need to provide a headbox design that is capable of providing a homogenous stream of a coating composition, in both width and thickness, when the coating composition has is highly viscous. An example of a headbox is known from US5104011.

SUMMARY OF THE INVENTION

40 **[0008]** The present invention provides for a headbox design that is capable of providing a stream, such as for example a curtain, of a coating composition onto a moving wet pulp substrate in a paper machine that results in the formation of a coating layer on the wet pulp substrate that is homogenous in thickness and width. The headbox design of the present invention is particularly suited for coating compositions having a particular rheology profile, such as for example coating compositions comprising microfibrillated cellulose. It has further been found that the design of the headbox provides excellent rigidity, or less bending propensity, which leads to a more homogenous coating on the moving wet pulp substrate.

45 **[0009]** It is therefore a first object of the present invention to provide a headbox for a paper machine, in particular a secondary headbox for applying a stream, or jet, of a coating composition onto a moving wet pulp substrate in a paper machine, comprising a stock chamber, a stilling chamber and a slice chamber

- a valve assembly for controlling the flow of coating composition from the stock chamber into the stilling chamber and for controlling the flow of coating composition from the stilling chamber to the slice chamber

50 wherein the valve assembly comprises a rotatable valve body and a valve case body , said rotatable valve body being located within the valve case body ,
 wherein said rotatable valve body is rotatable into a closed state and into one or more opened states,
 55 wherein said rotatable valve body comprises a first and second sealing element and said valve case body comprises a first and second sealing surface ,
 wherein in a closed state,

- a) the first sealing element is in sealing contact with a first sealing surface on the valve case body, thereby forming a first seal which seals the stock chamber from the stilling chamber, and
- b) the second sealing element is in sealing contact with a second sealing surface on the valve case body forming a second seal, which seals the stilling chamber from the slice chamber,

5 wherein in an open state,

- a) the first sealing element is at a first distance d_1 from the first sealing surface on the valve case body forming a first clearance of size s_1 and thereby fluidly connecting the stock chamber to the stilling chamber and
- 10 b) the second sealing element is at a second distance d_2 from the second sealing surface on the valve case body forming a second clearance of size s_2 and thereby fluidly connecting the stilling chamber to the slice chamber, and

15 wherein when the rotatable valve body is rotated from an open state to the closed state, the first and second sealing elements are simultaneously moved along a circular path into sealing contact with a first and second sealing surface wherein when the rotatable valve body is rotated from an closed state to the open state, the first and second sealing elements are simultaneously moved away along a circular path from a first and second sealing surface, and wherein

in any open state, the first clearance is larger than the second clearance.

20 **[0010]** It is a second object of the present invention to provide a paper machine comprising a primary headbox for forming a wet pulp substrate and secondary headbox according to first object of the present invention for applying a stream, or jet, of a coating composition onto a moving wet pulp substrate.

25 **[0011]** It is a third object of the present invention to provide a method of applying a stream, or jet, of a coating composition onto a moving wet pulp substrate in a paper machine, wherein the stream of a coating composition exits the slice chamber of a headbox according the first object of the present invention to provide, in its open state, and wherein the ratio of the speeds between said stream of a coating composition V_1 and said moving wet pulp substrate V_2 is between 0.9 and 1.1.

30 **[0012]** It is a fourth object of the present invention to provide a use of a headbox according the first object of the present invention in a method of applying a horizontal stream, or jet, of a coating composition onto a horizontally moving wet pulp substrate in a paper machine, preferably in a method according the third object of the present invention, wherein the horizontal stream of a coating composition exits the slice chamber of the headbox according the first object of the present invention, in its open state, at a horizontal speed (V_1) and wherein the ratio of the horizontal speeds of said horizontal stream of a coating composition and horizontally moving wet pulp substrate (V_2) is between 0.9 and 1.1.

35 **[0013]** It is a fifth object of the present invention to provide a coated paper comprising one or more substrate and one or more coating layer, said coating layer preferably comprising microfibrillated cellulose, wherein said coated paper has a Bendtsen porosity of less than 15 ml/min and/or a water and oil absorption according to Cobb Unger of less than 5 s, wherein said paper coated paper is preferably obtained via the method according to the third object of the present invention.

40 BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Preferred embodiments of the invention are described in the following with reference to the drawings, which are for the purpose of illustrating the present preferred embodiments of the invention and not for the purpose of limiting the same. In the drawings,

45 Fig. 1 shows a cross-section view of the headbox (1) for a paper machine according to the present invention, comprising a stock chamber (2), which comprises a coating solution during operation, connected to a downstream stilling chamber (3) and a further downstream a slice chamber (4). A double valve assembly for controlling the flow of coating composition from the stock chamber (2) into the stilling chamber (3) and for controlling the flow of coating composition from the stilling chamber (3) to the slice chamber (4) comprises a rotatable valve body (5) and a valve case body (6), said rotatable valve body (5) being located within the valve case body (6), wherein said rotatable valve body (5) is rotatable around an axis A, and is shown in a closed state, where a first sealing element (7) is in sealing contact with a first sealing surface (9) on the valve case body (6), thereby forming a first seal which seals the stock chamber (2) from the stilling chamber (3), and a second sealing element (8) is in sealing contact with a second sealing surface (10) on the valve case body (6) forming a second seal, which seals the stilling chamber (3) from the slice chamber (4). When the rotatable valve body (5) is rotated around axis A, from a closed state (shown) to the open state (shown in Fig. 2), the first and second sealing elements (7, 8) are simultaneously moved away along a circular path C from a first and second sealing surface (9, 10). The solid black cross-shaped elements in the drawing show gaskets.

Fig. 2 shows a cross-section view of the headbox (1) for a paper machine according to the present invention, comprising a stock chamber (2), which comprises a coating solution during operation, connected to a downstream stilling chamber (3) and a further downstream a slice chamber (4). A double valve assembly for controlling the flow of coating composition from the stock chamber (2) into the stilling chamber (3) and for controlling the flow of coating composition from the stilling chamber (3) to the slice chamber (4) comprises a rotatable valve body (5) and a valve case body (6), said rotatable valve body (5) being located within the valve case body (6), and wherein said rotatable valve body (5) is rotatable around an axis A, and is shown in an open state, where a first sealing element (7) is at a distance from a first sealing surface (9) on the valve case body (6) forming a first clearance and thereby fluidly connecting the stock chamber (2) to the stilling chamber (3) and a second sealing element (8) is at a second distance from the second sealing surface (10) on the valve case body (6) forming a second clearance and thereby fluidly connecting the stilling chamber (3) to the slice chamber (4), and where the first clearance is larger than the second clearance, and is in particular two times larger than the second clearance. In the cross-section view, the size of the first and second clearances is indicated by the first distance d_1 and second distance d_2 , respectively. When the rotatable valve body (5) is rotated around axis A, from an open state (shown, $\alpha=17^\circ$) to the closed state (shown in Fig. 1, $\alpha=0^\circ$), the first and second sealing elements (7, 8) are simultaneously moved along a circular path C into sealing contact with a first and second sealing surface (9, 10). The solid black cross-shaped elements in the drawing show gaskets.

Fig. 3 shows an open view of the headbox (1) for a paper machine according to the present invention, comprising a stock chamber (2), which comprises a coating solution during operation, connected to a downstream stilling chamber (3) and a further downstream a slice chamber (4). A double valve assembly for controlling the flow of coating composition from the stock chamber (2) into the stilling chamber (3) and for controlling the flow of coating composition from the stilling chamber (3) to the slice chamber (4) comprises a rotatable valve body (5) with an axle (5a) and a valve case body (6), said rotatable valve body (5) being located within the valve case body (6), wherein said rotatable valve body (5) is rotatable around an axis A, and is shown in a closed state, where a first sealing element (7), in the form of an edge of the rotatable valve body (5) and extending along the longitudinal axis of the rotatable valve body (5), is in sealing contact with a first sealing surface (9) on the valve case body (6), thereby forming a first seal which seals the stock chamber (2) from the stilling chamber (3), and a second sealing element (8) in the form of an edge of the rotatable valve body (5) and extending along the longitudinal axis of the rotatable valve body (5), is in sealing contact with a second sealing surface (10) on the valve case body (6) forming a second seal, which seals the stilling chamber (3) from the slice chamber (4). When the rotatable valve body (5) is rotated around axis A, from a closed state (shown) to the open state (not shown), the first and second sealing elements (7, 8) are simultaneously moved away along a circular path C (not shown) from a first and second sealing surface (9, 10).

DESCRIPTION OF PREFERRED EMBODIMENTS

[0015] In a first object of the present invention provides for a headbox (1) for a paper machine, in particular a secondary headbox for applying a stream of, preferably a jet of, a coating composition onto a moving wet pulp substrate in a paper machine, comprising

- a stock chamber (2)
- a stilling chamber (3)
- a slice chamber (4)
- a valve assembly for controlling the flow of coating composition from the stock chamber (2) into the stilling chamber (3) and for controlling the flow of coating composition from the stilling chamber (3) to the slice chamber (4)

wherein the valve assembly comprises a rotatable valve body (5) and a valve case body (6), said rotatable valve body (5) being located within the valve case body (6), wherein said rotatable valve body (5) is rotatable into a closed state and into one or more opened states, wherein said rotatable valve body (5) comprises a first and second sealing element (7, 8) and said valve case body (6) comprises a first and second sealing surface (9, 10), wherein in a closed state,

- a) the first sealing element (7) is in sealing contact with a first sealing surface (9) on the valve case body (6), thereby forming a first seal which seals the stock chamber (2) from the stilling chamber (3), and/or
- b) the second sealing element (8) is in sealing contact with a second sealing surface (10) on the valve case body

(6) forming a second seal, which seals the stilling chamber (3) from the slice chamber (4),

wherein in an open state,

- 5 a) the first sealing element (7) is at a first distance d_1 from the first sealing surface (9) on the valve case body (6) forming a first clearance and thereby fluidly connecting the stock chamber (2) to the stilling chamber (3) and
 b) the second sealing element (8) is at a second distance d_2 from the second sealing surface (10) on the valve case body (6) forming a second clearance and thereby fluidly connecting the stilling chamber (3) to the slice chamber (4), and

10 wherein when the rotatable valve body (5) is rotated from an open state to the closed state, the first and second sealing elements (7, 8) are simultaneously moved along a circular path into sealing contact with a first and second sealing surface (9, 10)

15 wherein when the rotatable valve body is rotated from an closed state to the open state, the first and second sealing elements (7, 8) are simultaneously moved away along a circular path C from a first and second sealing surface (9, 10), and wherein, in an open state, the first clearance is larger than the second clearance.

20 **[0016]** In the headbox according to the present invention, the ratio (d_1/d_2) between distance d_1 and distance d_2 is more than 1, preferably is between 1 and 3 and/or the distance d_2 is between 0.4 and 20 mm, preferably between 0.4 and 10 mm, more preferably between 0.8 and 3 mm. 1. In a more preferred embodiment, in any open state, (d_1/d_2) between distance d_1 and distance d_2 is constant, and is preferably about 2.

25 **[0017]** The headbox (1) according to the present invention is preferably a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, which wet pulp substrate is formed by dispensing a stock made of water, paper pulp and suitable additives from a primary headbox onto the moving wire mesh of the paper machine in the wet end of the paper machine.

30 **[0018]** The headbox (1) according to the present invention is preferably equipped with one or more pressure sensors, which one or more pressure sensors may be disposed in the stock chamber (2), stilling chamber (3) or slice chamber (4), or in each one, or in at least two of them. By monitoring the pressure within the headbox, it is possible to control the pressure within the headbox, and thereby control the speed V_1 of the jet of coating composition. Thus, in a preferred embodiment, the one or more pressure sensors are connected to a jet speed control unit, which control unit is capable receiving a pressure sensor signal and of adjusting the pressure in the headbox (1), depending on the pressure signal received, via a pressure control unit fluidly connected to the headbox (1), to ensure the speed V_1 of the jet of coating composition is controlled such as to not deviate from a set value and/or such as to achieve the ratio of the speeds of said jet of a coating composition V_1 and moving wet pulp substrate V_2 is between 0.9 and 1.1.

35 **[0019]** The stock from which the wet pulp substrate is formed may comprise one or more pulps, preferably wood pulps, which may further be chemical wood pulps such as for example sulphite pulp or kraft pulp. The chemical wood pulps may further be bleached chemical wood pulps.

[0020] Generally, a mixture of pulps, in particular a mixture of chemical softwood pulp and chemical hardwood pulp, is used in the stock from which the wet pulp substrate is formed.

40 **[0021]** Consequently, the wet pulp substrate formed from said stock comprises the one or more pulps given above.

[0022] Because a primary headbox essentially holds the stock from which wet pulp substrate is formed, in some designs, turbulence is generated its interior with a mixing device, usually a submerged fan or perforated rollers spinning within the stock.

45 **[0023]** In contrast, the headbox (1) according to the present invention, which is preferably a secondary headbox, does not comprise a mixing device in one embodiment, in particular in the stock chamber (2) and the stilling chamber (3). The needed shear for stable operation of the headbox is provided by inner surfaces of the headbox (1), which deviate the stock in the headbox (1) as it passes through the headbox (1), in particular in the stilling chamber (3).

50 **[0024]** The headbox (1) according to the present invention is preferably a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, which stream of a coating composition is preferably in the form of a curtain of a coating composition. The curtain form is mainly due to the outline of the second clearance that is formed when the second sealing element (8) on the rotatable valve body (5) moves away from the second sealing surface (10) on the valve case body (6), once the rotatable valve body (5) is rotated into an open position. Thus, the thickness of the stream, or curtain, can be controlled via the height of the second clearance achieved by the opened rotatable valve body (5). Likewise, the width of the stream, or curtain, can be controlled via the width of the second clearance achieved by the opened rotatable valve body (5).

55 **[0025]** The headbox (1) according to the present invention is preferably a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, which moving wet pulp substrate moves at a speed V_2 .

[0026] The headbox (1) according to the present invention is preferably a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, which headbox (1) comprises a stock chamber (2) for providing a coating composition to the downstream stilling chamber (3). During operation of the headbox (1), the stock chamber (2) thus holds a coating composition. In a preferred embodiment of the headbox (1) according to the present invention, the headbox (1), and in particular the stock chamber (2), is preferably pressurized, and more preferably is configured to be controllable with respect to the pressure within the stock chamber (2). In one embodiment, the stock chamber (2) is equipped with a plurality of inlets, which inlets are each fluidly connected to a plurality of conveyor pipes, that are suitable for conveying a preferably pressurized coating composition into the stock chamber (2). In general, the coating composition can be held in a preferably pressurized, holding tank from which the plurality of conveyor pipe lead to the plurality of inlets of the stock chamber (2). In one embodiment, the stock chamber (2) is equipped with a plurality of inlets, which are distributed along the width of the headbox, i.e. in a direction parallel to the rotation axis of rotatable valve body (5).

[0027] In one embodiment, a lower part of the stock chamber (2) is tapered towards the first seal in the headbox (1), which seals the stock chamber (2) from the downstream stilling chamber (3), in the closed state. In a further embodiment, the lower part of the stock chamber (2) is tapered towards the first seal in the headbox (1), which seals the stock chamber (2) from the downstream stilling chamber (3), in the closed state, wherein one surface of the stock chamber (2), in the lower part, is a substantially planar surface formed by the rotatable valve body (5) and the opposed surface to that surface is a convex surface of the valve case body (6). The tapered form of the stock chamber (2) ensures that a coating composition passing through, from stock chamber (2) to stilling chamber (3), is accelerated and thus experiences more shear.

[0028] The headbox (1) according to the present invention is preferably a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, which headbox (1) comprises a stilling chamber (3) for providing a coating composition to the downstream slice chamber (4). During operation of the headbox (1), the stilling chamber (3) thus holds a coating composition.

[0029] In a preferred embodiment of the headbox (1) according to the present invention, the headbox (1), and in particular the stilling chamber (3), is preferably pressurized, and more preferably is configured to be controllable with respect to the pressure within the stilling chamber (3). The stilling chamber (3) is fluidly connected to the stock chamber (2), in an open state, and thus the pressure of the stock chamber (2) is established in the stilling chamber (3) once the rotatable valve body (5) is rotated into an open state. The stilling chamber (3) may comprise one or more surfaces that are configured to either induce or avoid turbulence when a coating composition flows through the stilling chamber (3), i.e. between the first sealing surface (9) and the second sealing surface (10).

[0030] In one embodiment, the stilling chamber (3) comprises a concave surface positioned in between the first sealing surface (9) and the second sealing surface (10). By forcing the coating composition along a given path, the coating composition is sheared, such as to achieve a thinning of the coating composition to allow a homogenous flow of coating composition across the headbox (1).

[0031] In one embodiment, in the headbox (1) according to the present invention, either when moving into an open or closed state, the first and second sealing elements (7, 8) are simultaneously moved along the same circular path C.

[0032] The headbox (1) according to the present invention is preferably a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, which headbox (1) comprises a slice chamber (4) for providing a stream of a coating composition ejected via the clearance formed by the second sealing element (8) and the second sealing surface (10), in a opened state of the rotatable valve body (5).

[0033] Thus, the thickness of the stream can be controlled via the height of the second clearance achieved by the opened rotatable valve body (5). Likewise, the width of the stream can be controlled via the width of the second clearance achieved by the opened rotatable valve body (5).

[0034] The headbox (1) according to the present invention is preferably a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, which headbox (1) comprises a valve assembly, which comprises a rotatable valve body (5) and a valve case body (6), where the rotatable valve body (5) is located within the valve case body (6) in a rotatable manner. The valve assembly controls the flow of coating composition from the stock chamber (2) into the stilling chamber (3) and for controlling the flow of coating composition from the stilling chamber (3) to the slice chamber (4).

[0035] The rotatable valve body (5) and the valve case body (6) may be formed of any suitable material, and are preferably formed of metal such as for example brass, bronze, copper or steel. In a preferred embodiment, the rotatable valve body (5) and the valve case body (6) are formed of stainless steel and alloys thereof.

[0036] The rotatable valve body (5) is rotatable with respect to the valve case body (6), into a closed state, and into one or more opened states. In its opened state, a coating composition can flow through the headbox (1). The rotatable valve body (5) can be adjusted by rotation to be in a more open state or a less open state, which in turn adjusts the size of the resulting clearance at the first and second seal, and ultimately regulating the pressure, speed and flow rate of the coating composition exiting the second clearance. When the rotatable valve body (5) is rotated from an closed state to the open state, the first and second sealing elements (7, 8) are simultaneously moved away along a circular path from a first and second sealing surface (9, 10), and since the rotatable valve body (5) has predefined geometry and/or cross-sectional

shape, together with the valve case body (6), the size ratio between first and second clearance is determined by the degree of opening and the geometry and/or cross-sectional shape of the rotatable valve body (5) and valve case body (6). In the headbox (1) according to the present invention, the rotatable valve body (5) and the valve case body (6) have a geometry and/or cross-sectional shape such that in any open state, the first clearance is larger than the second clearance. In a more preferred embodiment, the rotatable valve body (5) and the valve case body (6) have a geometry and/or cross-sectional shape such that in any open state, the first clearance is larger than the second clearance and the size of the first clearance and size of the second clearance have a constant ratio, which ratio is preferably about 2, and which may be between 1 and 3. Because the first clearance is larger, the stilling chamber (3) can be provided with sufficient coating composition from the stock chamber (2) and warrant the pressure that is provided from the pressure in the stock chamber (2).

[0037] In one embodiment of the headbox according to claim 1, wherein the first clearance is larger than the second clearance by a factor of more than 1, preferably by a factor of more than 1 and up to 3. By reducing the size of the clearance, it is possible to provide a progressive increase of speed and/or shear imparted onto the coating composition, as it passes through the headbox (1), which leads to a more stable stream of coating composition being discharged from the headbox (1).

[0038] The coating composition, upon being forced through the first larger clearance, is accelerated and exposed to a first amount of shear, and when forced through the second clearance, is further accelerated and exposed to a second amount of shear. In coating compositions that are shear-thinning, the consecutive acceleration and/or shearing leads to a decrease in viscosity which enables the coating composition to be coated homogeneously onto the moving wet pulp substrate.

[0039] It is understood that the clearances, which on one side may be delimited in width, which is generally constant, by the sidewalls of the headbox (1) which may for example be formed by lateral walls of the valve case body (6) or by separate wall plates affixed to the valve case body (6), and which may be delimited in height by the respective sealing elements of the rotatable valve body (5) and sealing surfaces (9, 10) of the valve case body (6), in the open state, have a rectangular shape, where the larger sides correspond to the width and the smaller sides correspond to the height.

[0040] In one embodiment, the rotatable valve body (5), in an open state, leads to a height of the second clearance of from 0.3 to 5 mm, preferably of from 0.8 mm to 3 mm, which translates into essentially the same height, or stated alternatively, thickness, of the stream of a coating composition exiting the slice chamber (4).

[0041] The rotatable valve body (5) comprises a first and second sealing element (7, 8) and said valve case body (6) comprises a first and second sealing surface (9, 10), wherein in a closed state, the first sealing element (7) is in sealing contact with a first sealing surface (9) on the valve case body (6), thereby forming a first seal which seals the stock chamber (2) from the stilling chamber (3), and the second sealing element (8) is in sealing contact with a second sealing surface (10) on the valve case body (6) forming a second seal, which seals the stilling chamber (3) from the slice chamber (4), wherein in an open state, the first sealing element (7) is spaced from the first sealing surface (9) on the valve case body (6), preferably by a first distance d_1 , thereby forming a first clearance having a first size s_1 , and thereby fluidly connecting the stock chamber (2) to the stilling chamber (3) and the second sealing element (8) is spaced from the second sealing surface (10) on the valve case body (6), preferably by a second distance d_2 , thereby forming a second clearance having a second size s_2 and thereby fluidly connecting the stilling chamber (3) to the slice chamber (4).

[0042] The headbox (1) according to the present invention is preferably a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, and is rotatable as a whole such as to modify the direction of the stream of the coating composition exiting the slice chamber (4) and/or wherein the headbox (1) is moveable as a whole in one or more directions, preferably at least in a direction perpendicular to the plane of the moving wet pulp substrate, such as to modify the direction of the stream of the coating composition contacting the moving wet pulp substrate in a paper machine, which moving wet pulp substrate is preferably moving in a horizontal direction. The direction, or angle, at which the stream of a coating composition contacts the moving wet pulp substrate in the paper machine will depend on the position and angle of the headbox (1) relative to the plane the moving wet pulp substrate. For instance, when the headbox (1) is moved away in at least in a direction perpendicular to the plane of the moving wet pulp substrate, the stream will be deviated from its original direction towards the direction of gravity, the longer it is allowed to fall. On the other hand, the initial angle will make that deviation more or less pronounced if headbox (1) is rotated such that the direction of the stream of the coating composition exiting the slice chamber (4) is closer or further from the direction of gravity. In one embodiment, the headbox (1) according to the present invention is rotatable as a whole and/or moveable as a whole, via linear or rotary actuators coupled to the headbox (1) as a whole, where preferably linear actuators are configured such as to move the headbox (1) as a whole and/or rotary actuators are configured such as to rotate the headbox (1) as a whole.

[0043] In one embodiment, the headbox (1) according to the present invention is rotatable as a whole by an angle of -15 to 15° with respect to the plane of the moving wet pulp substrate in the paper machine. Thus, the headbox (1) according to the present invention is in general rotatable towards, or away from, the plane of the moving wet pulp substrate

[0044] In one embodiment, the headbox (1) according to the present invention is moveable as a whole to a distance of from 10 to about 80 mm, at least in a direction perpendicular to the plane of the moving wet pulp substrate. It is noted that the headbox (1) according to the present invention may also moveable along the direction of movement of the moving wet pulp

substrate in the paper machine. This allows the headbox (1) to be positioned above a section of the moving wet pulp substrate in the paper machine that is either upstream or downstream, or stated alternatively, closer or farther from a primary headbox (1), in the direction of movement of the moving wet pulp substrate in the paper machine.

[0045] In one embodiment the headbox (1) according to the present invention is positioned in the wet end section of the paper machine, and is in particular positioned in the wet end section where the moving wet pulp substrate has a solids content of less than 20% by weight, or of about 4 to 20%, preferably of about 4 to 8% by weight.

[0046] In one embodiment, the headbox (1) according to the present invention the rotatable valve body (5) has an elongated shape, and may be formed as shaft, which rotatable valve body is rotatable around a longitudinal axis (A) of the rotatable valve body (5). In preferred embodiment, the distance in radial direction, from the longitudinal axis (A) of the rotatable valve body (5) to the first sealing element (7) is equal to the distance in radial direction, from the longitudinal axis (A) of the rotatable valve body (5), to the second sealing element (8). In one embodiment, the rotatable valve body (5) may have a length, along its longitudinal axis, of about from 1 m to about 8 m, preferably a width of about from about 2 m to about 7 m. Thus, in an embodiment of the headbox according to the present invention, the rotatable valve body (5), being preferably a shaft, is rotatable along a longitudinal axis (A) of the shaft, wherein the first and second sealing elements (7, 8) are located at the same radial distance from the longitudinal axis (A) of the shaft.

[0047] In one embodiment, the headbox (1) according to the present invention, the rotatable valve body (5) comprises an axle extending along a longitudinal axis (A) of the rotatable valve body (5), which axle is coupled to a controllable rotary driving means, such as to rotate the rotatable valve body (5) in one or the other direction. In one embodiment, the axle extending along a longitudinal axis (A) of the rotatable valve body (5) and the rotatable valve body (5) are made integrally from one piece of material, such as steel, for example by machining from one blank. Suitable technologies include milling, turning or combinations of both. The rotatable valve body (5) is preferably made from one piece of a massive material, i.e. the rotatable valve body (5) is not hollow.

[0048] In one embodiment, the headbox (1) according to the present invention, the rotatable valve body (5) comprises one or more rods connected via an articulation to a periphery of the rotatable valve body (5), which rod(s) may for example be coupled to a controllable linear driving means, such as to rotate the rotatable valve body (5) in one or the other direction. In one embodiment, the axle extending along a longitudinal axis (A) of the rotatable valve body (5) and the rotatable valve body (5) are made integrally from one piece of material, such as steel, for example by machining from one blank. Suitable technologies include milling, turning or combinations of both.

[0049] In one embodiment, the headbox (1) according to the present invention, the first and/or second sealing elements (7, 8) are formed by sealing ribs, in particular sealing ribs extending, in a preferably rectilinear manner, in parallel to a longitudinal axis (A) of the rotatable valve body (5), said ribs preferably having a rounded, square or pointed tip. In one embodiment, the headbox (1) according to the present invention, the first and second sealing elements (7, 8) are formed by rectilinear edges extending in parallel to a longitudinal axis (A) of the rotatable valve body (5), preferably having a square tip. In one embodiment, the first and second sealing elements (7, 8) are formed by rectilinear edges extending in parallel to a longitudinal axis (A) of the rotatable valve body (5), preferably having a square tip, and are connected to each other via a planar surface spanning between the first and second sealing elements (7, 8). In an alternative embodiment, the first and second sealing elements (7, 8) are formed by rectilinear edges extending in parallel to a longitudinal axis (A) of the rotatable valve body (5), preferably having a square tip, and are connected to each other via a non-planar surface, which may be concave or convex, spanning between the first and second sealing elements (7, 8). It is understood that the sealing elements may be formed integrally on the rotatable valve body (5), and may be obtained from machining a blank into a rotatable valve body (5) with sealing elements. Alternatively, the sealing elements may be formed separately from the rotatable valve body (5) and fixed to the rotatable valve body (5).

[0050] In one embodiment, the headbox (1) according to the present invention, in a closed state, the rotatable valve body (5) in the headbox (1) is at a rotation angle α of 0° , i.e. when both seals are formed by contact between the sealing elements and the sealing surfaces (9, 10), and in an opened state, the rotatable valve body (5) in the headbox (1) is at a rotation angle α of up to 40° , e.g. between 1° and 40° .

[0051] In one embodiment, in the headbox (1) according to the present invention, the rotatable valve body (5) has a cross-sectional shape, in a direction perpendicular to its longitudinal axis, that is in partially circular, wherein the circular section of the cross-sectional shape of the rotatable valve body (5) is slidingly in sealing contact with valve case body (6). In one embodiment, the circular section of the cross-sectional shape of the rotatable valve body (5) is slidingly in sealing contact with a circular recess in the valve case body (6), or alternatively is slidingly in sealing contact with a circular recess in the valve case body (6) comprising additionally one or two gaskets. The partially circular section of the rotatable valve body (5) ensures that the rotatable valve body (5) may be rotated into either open or closed state of the headbox (1) while keeping in sealing contact with gaskets that are located on the valve case body (6). In one embodiment, the one or two gaskets are held in one or more recesses, respectively, that are formed in the valve case body (6).

[0052] In one embodiment, in the headbox (1) according to the present invention, the first sealing surface (9) is a convex surface of the valve case body (6), said convex surface having preferably a circular shape. When the first sealing surface (9) is a convex surface of the valve case body (6), the flow of a coating composition flowing through the clearance, from the

stock chamber (2) to the stilling chamber (3) that is formed in an open state of the headbox (1), is directed by the convex surface of the valve case body (6).

5 [0053] In one embodiment, in the headbox (1) according to the present invention, the second sealing surface (10) is a planar surface of the valve case body (6). When the second sealing surface (10) is a planar surface of the valve case body (6), the flow of a coating composition flowing through the clearance, from the stilling chamber (3) to the slice chamber (4) that is formed in an open state of the headbox (1) is directed by the planar surface of the valve case body (6), thereby providing a stable and unidirectional stream, or jet, of coating composition. In one embodiment, the planar surface of the valve case body (6) extends in opposing directions, with respect to the second seal, i.e. both in an upstream direction and an downstream direction with respect to the flow of a coating composition,

10 [0054] In one embodiment, in the headbox (1) according to the present invention, the stilling chamber (3) comprises a concave surface on the valve case body (6), in between the first sealing surface (9) and the second sealing surface (10). In one embodiment, the convex surface of the first sealing surface (9) on the valve case body (6) transitions into the concave surface on the valve case body (6) of the stilling chamber (3). Thereby, in an open state, the flow of a coating composition in the headbox (1) across the first clearance is diverted consecutively in two different directions, first by the convex surface of the first sealing surface (9) on the valve case body (6) and secondly by the concave surface on the valve case body (6) of the stilling chamber (3). In one embodiment, the concave surface on the valve case body (6) of the stilling chamber (3) is configured such that it directs the flow of a coating composition towards the second clearance and/or in a direction that lies in the plan of the planar surface of the valve case body (6). In that case, the concave surface on the valve case body (6) of the stilling chamber (3) transitions into the planar surface of the valve case body (6).

20 [0055] In one embodiment, in the headbox (1) according to the present invention, in an open state, the slice chamber (4), at the second sealing element (8) and second sealing surface (10), forms a clearance in the form of a horizontal rectangular slit, for ejecting the stream, or curtain, of a coating composition from the stilling chamber (3) into the slice chamber (4), where the height of the clearance, and consequently, of the horizontal slit is of from 0.3 to 5 mm, preferably of from 0.8 mm to 3 mm. In one embodiment, the width of the horizontal rectangular slit is about from 1 m to about 8 m, preferably about from about 2 m to about 7 m.

25 [0056] In one embodiment, in the headbox (1) according to the present invention, the slice chamber (4) comprises, at its downstream end, a bottom lip (11) for guiding the stream of a coating composition exiting the slice chamber (4) through the second clearance. In one embodiment, the bottom lip (11) has a variable length, since when the rotatable valve body (5) is rotated into an open position, the second sealing element (8) moves away from the second sealing surface (10) along a circular path thereby also moves the second clearance, where the jet is formed, further downstream of the intended direction of flow of the coating composition. The coating composition, when the headbox (1) is in an open state, leaves the stilling chamber (3) through the second clearance into the slice chamber (4) in the form of a stream, or jet, of a coating composition and subsequently leaves the slice chamber (4) to fall onto the moving wet pulp substrate in a paper machine. A bottom lip extending from the slice chamber (4) allows creating a stable stream or jet of a coating composition. The length of the bottom lip, in a closed state of the headbox (1), is fix, and defined as the distance between the second seal and the downstream end of the bottom lip, and may be, for example 32 mm. The length of the bottom lip, in an open state of the headbox (1), is variable instead of fix, and is inferior to the length of the bottom lip, in a closed state of the headbox (1), and is defined as the distance between the second clearance, in an open state of the headbox (1), and the downstream end of the bottom lip, and may be of from 4 mm to 32 mm, preferably of from 9 to 17 mm.

30 [0057] It is a second object of the present invention to provide a paper machine comprising a primary headbox (1) for forming a wet pulp substrate and secondary headbox (1) according to first object of the present invention for applying a stream of a coating composition onto a moving wet pulp substrate. A paper machine according to the present invention is capable of producing paper having a uniform coating, in thickness and composition, in an economical and simplified way, as the headbox (1) is especially rigid due to its design and can deliver a stable jet of coating composition. In particular, the paper machine according to the present invention is capable of producing paper having a uniform coating of microfibrillated cellulose, which is exceptionally difficult to apply such that the coating is uniform.

35 [0058] It is a third object of the present invention to provide a method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, wherein the stream of a coating composition exits the slice chamber (4) of a headbox (1) according the first object of the present invention to provide, in its open state, and wherein the ratio of the speeds between said stream of a coating composition V_1 and said moving wet pulp substrate V_2 is between 0.9 and 1.1. When the ratio of the speeds is in the aforementioned range, the coating, upon touching down on the moving substrate is neither overstretched nor compressed by the moving substrate, which avoids major shear in the bulk of the coating composition at the time of touching down.

40 [0059] It is noted that method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, the stilling chamber (3) is completely filled with a coating composition during operation of the headbox (1), so that no air cavity, or air cushion is formed.

45 [0060] In the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, the stream of a coating composition can be applied onto a moving wet pulp substrate in

a paper machine according to the second object such that the stream of a coating composition contacting the moving wet pulp substrate contacts the moving wet pulp substrate at an angle of between 3 and 75°, preferably of 15 to 40°. Controlling the angle at which a coating composition can be applied onto a moving wet pulp substrate can be useful when adjusting the degree of shear that is imparted on the coating composition immediately after contacting the moving wet pulp substrate. At smaller angles, the lateral shear is minimized, as the stream of a coating composition gets barely deflected whereas at larger angles, the stream of a coating composition gets deflected significantly in the direction of the moving wet pulp substrate.

[0061] In the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, the length of the falling stream of a coating composition is between 3 mm and 500 mm. The length of the falling stream of a coating composition corresponds to the distance between the point where the stream leaves the bottom lip (11) extending from the slice chamber (4) to the point where the stream of a coating composition contacts the moving wet pulp substrate.

[0062] In the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, the flow rate of the stream of a coating composition is in the range of 50 till 4000 l/min per meter width of the second clearance. In one embodiment, the width of the stream of a coating composition is in the range of about from 1 m to about 8 m, preferably a width of about from about 1,5 m to about 5 m, or from about 2 m to about 7 m.

[0063] In the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, the speed of the stream of a coating composition is in the range of 50 to 700 m/min or may be in the range of 50 to 1200 m/min.

[0064] In the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, the coat weight of microfibrillated cellulose that can be applied to the wet pulp substrate is of from 3 to 20 gr/m² in dry weight (air dry, *lutro*).

[0065] In the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, the coating composition comprises microfibrillated cellulose. Preferably the coating composition is an aqueous suspension of microfibrillated cellulose. When the coating composition comprises microfibrillated cellulose, the microfibrillated cellulose may be comprised in an amount of less than 2.5 weight percent, based on the total weight of the coating composition, more preferably in an amount of from 0.5 to 2.0 weight percent, even more preferably in an amount of 0.8 to 1.0 weight percent.

[0066] In the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, when the coating composition comprises microfibrillated cellulose, the microfibrillated cellulose is preferably microfibrillated cellulose made from hardwood. The microfibrillated cellulose enzymes, shear thinning

[0067] While coating compositions comprising microfibrillated cellulose are a prominent example of coating compositions that can be applied with the headbox (1) according to the present invention, and in the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, other coating compositions that may be applied are coating compositions that, in general, are shear-thinning and/or which have a viscosity of about 5 to 100 mPas when under shear rate of about 1000 to 8000 s⁻¹, when measured according to ISO 3219 on a Physica Anton Paar MCR 300 using spindle CC27 SN4989 and cup CC27 SS43953.

[0068] In the method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to the present invention, and particularly in the wet end section of the paper machine, the moving wet pulp substrate has a solids content of less than 20% by weight, about 4 to 20%, preferably of 4 to 8% by weight, based on the total weight of the moving wet pulp substrate. By complement, the remaining weight is formed by at least 80% by weight of aqueous liquids such as water. It is believed that since the water content in the moving wet pulp substrate is high, an entanglement between the loosened wet pulp substrate fibers and the microfibrillated fibers of the coating composition is thereby enhanced, and therefore results in better adhesion between these layers in the final paper product.

[0069] It is a fourth object of the present invention to provide a use of a headbox (1) according the first object of the present invention in a method of applying a horizontal stream of a coating composition onto a horizontally moving wet pulp substrate in a paper machine, preferably in a method according the third object of the present invention, wherein the horizontal stream of a coating composition exits the slice chamber (4) of the headbox (1) according the first object of the present invention, in its open state, at a horizontal speed (V1) and wherein the ratio of the horizontal speeds of said horizontal stream of a coating composition and horizontally moving wet pulp substrate (V2) is between 0.9 and 1.1.

EXAMPLES

[0070] A coating composition comprising microfibrillated cellulose at about 8 g/l was prepared and provided to a headbox (1) according to the present invention via feeding lines placed along the longitudinal dimension of the headbox (1) (i.e. transverse paper machine direction), and fed to the stock chamber (2) of the headbox (1) at about a pressure of 51 kPa. The headbox (1) was then opened by an angle of 14°, such as to provide a jet having a thickness of 1.4 mm and of a width of

1000 mm, at a flow rate of 840 l/min per meter width of the second clearance of the headbox (1). The angle of the headbox (1) with respect to the plane of the moving wet substrate was about 12° and the headbox (1) was positioned at about 5mm above the moving wet substrate. The velocity of the moving wet substrate and the velocity of the jet exiting the headbox (1) was 10 m/s and 10,08 m/s, respectively.

5 [0071] The moving wet substrate was prepared by discharging a stock having a consistency of about 10 g/l of a chemical wood pulp having refining degree more than 90 °SR. The weight of the coating composition on the moving wet substrate was checked by online measuring of the freshly deposited coating composition and found to be homogenous across the entire width, and to be about 14 gr/m².

10 [0072] In the paper product obtained according to the above, the Bendtsen porosity was dropped lower than 15 ml/min and also Cobb Unger was dropped lower than 5 s. Bendtsen porosity was determined according to ISO 5636-1,3; and Cobb Unger was determined according to SCAN-P 37:77.

LIST OF REFERENCE SIGNS

15 [0073]

	1	headbox	7	first sealing element
	2	stock chamber	8	second sealing element
20	3	stilling chamber	9	first sealing surface
	4	slice chamber	10	second sealing surface
	5	valve body	11	lip
	6	valve case body		

25

Claims

30 1. A headbox (1) for a paper machine, in particular a secondary headbox for applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, comprising

- a stock chamber (2)
- a stilling chamber (3)
- a slice chamber (4)
- 35 - a valve assembly for controlling the flow of coating composition from the stock chamber (2) into the stilling chamber (3) and for controlling the flow of coating composition from the stilling chamber (3) to the slice chamber (4)

40 wherein the valve assembly comprises a rotatable valve body (5) and a valve case body (6), said rotatable valve body (5) being located within the valve case body (6), wherein said rotatable valve body (5) is rotatable into a closed state and into one or more opened states, wherein said rotatable valve body (5) comprises a first and second sealing element (7, 8) and said valve case body (6) comprises a first and second sealing surface (9, 10),

45 wherein in a closed state,

- a) the first sealing element (7) is in sealing contact with a first sealing surface (9) on the valve case body (6), thereby forming a first seal which seals the stock chamber (2) from the stilling chamber (3), and/or
- 50 b) the second sealing element (8) is in sealing contact with a second sealing surface (10) on the valve case body (6) forming a second seal, which seals the stilling chamber (3) from the slice chamber (4),

wherein in an open state,

- 55 a) the first sealing element (7) is at a first distance d_1 from the first sealing surface (9) on the valve case body (6) forming a first clearance and thereby fluidly connecting the stock chamber (2) to the stilling chamber (3) and
- b) the second sealing element (8) is at a second distance d_2 from the second sealing surface (10) on the valve case body (6) forming a second clearance and thereby fluidly connecting the stilling chamber (3) to the slice

chamber (4), and

wherein when the rotatable valve body (5) is rotated from an open state to the closed state, the first and second sealing elements (7, 8) are simultaneously moved along a circular path into sealing contact with a first and second sealing surface (9, 10)

wherein when the rotatable valve body (5) is rotated from an closed state to the open state, the first and second sealing elements (7, 8) are simultaneously moved away along a circular path C from a first and second sealing surface (9, 10),

and wherein

in any open state, the first clearance is larger than the second clearance.

2. The headbox according to claim 1, wherein the first clearance is larger than the second clearance by a factor of more than 1 and up to 3.
3. The headbox according to claim 1 or 2, wherein the headbox (1) is rotatable as a whole such as to modify the direction of the stream of the coating composition exiting the slice chamber (4) and/or wherein the headbox (1) is moveable as a whole in one or more directions, preferably at least in a direction perpendicular to the plane of the moving wet pulp substrate, such as to modify the direction of the stream of the coating composition contacting the moving wet pulp substrate in a paper machine, which moving wet pulp substrate is preferably moving in a horizontal direction.
4. The headbox according to any preceding claim, wherein the rotatable valve body (5) is a shaft and/or wherein the rotatable valve body (5) is rotatable around a longitudinal axis (A) of the rotatable valve body (5).
5. The headbox according to any preceding claim, wherein the rotatable valve body (5) comprises an axle extending along a longitudinal axis (A) of the rotatable valve body (5), which axle is coupled to a controllable rotating driving means, such as to rotate the rotatable valve body (5).
6. The headbox according to any preceding claim, wherein the rotatable valve body (5) comprises one or more rods connected via an articulation to a periphery of the rotatable valve body (5), which rod is coupled to a controllable linear driving means, such as to rotate the rotatable valve body (5).
7. The headbox according to any preceding claim, wherein the first and/or second sealing elements (7, 8) are formed by sealing ribs, in particular sealing ribs extending, in a preferably rectilinear manner, in parallel to a longitudinal axis (A) of the rotatable valve body (5), said ribs preferably having a rounded, square or pointed tip.
8. The headbox according to any preceding claim, wherein in an opened state, the rotatable valve body (5) is at a rotation angle α of up to 40° and/or in a closed state, the rotatable valve body (5) is at a rotation angle α of 0° .
9. The headbox according to any preceding claim, wherein the rotatable valve body (5) has a cross-sectional shape that is partially circular, wherein the circular section of the cross-sectional shape of the rotatable valve body (5) is slidingly in sealing contact with one or two gaskets.
10. The headbox according to any preceding claim, wherein the rotatable valve body (5) is a shaft and wherein the rotatable valve body (5) is rotatable along a longitudinal axis (A) of the shaft, wherein the first and second sealing elements (7, 8) are located at the same radial distance from the longitudinal axis (A) of the shaft.
11. The headbox according to any preceding claim, wherein the first sealing surface (9) is a convex surface of the valve case body (6), said convex surface having preferably a circular shape, and/or the second sealing surface (10) is a planar surface of the valve case body (6).
12. The headbox according to any preceding claim, wherein the stilling chamber (3) comprises a concave surface positioned in between the first sealing surface (9) and the second sealing surface (10).
13. The headbox according to any preceding claim, wherein the clearance formed between the stilling chamber (3) and the slice chamber (4) has the form of a horizontal rectangular slit for ejecting the stream of a coating composition from the slice chamber (4), where the height of the horizontal slit is of from 0.3 to 5 mm, preferably of from 0.8 mm to 3 mm.
14. The headbox according to any preceding claim, wherein the slice chamber (4) comprises, at its downstream end, a

bottom lip (11) for guiding the stream of a coating composition exiting the slice chamber (4), and wherein preferably the bottom lip (11) is a variable length bottom lip (11).

5 15. A paper machine comprising a primary headbox for forming a wet pulp substrate and secondary headbox according to any one of claims 1 to 14 for applying a stream of a coating composition onto a moving wet pulp substrate.

10 16. A method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine, wherein the stream of a coating composition exits the slice chamber (4) of a headbox according to any one claims 1 to 14 in its open state, and wherein the ratio of the speeds of said stream of a coating composition V_1 and moving wet pulp substrate V_2 is between 0.9 and 1.1.

15 17. The method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to claim 16, wherein the stream of a coating composition contacting the moving wet pulp substrate contacts the moving wet pulp substrate at an angle of between 3 and 75°.

20 18. The method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to claim 16 or 17, wherein length of the falling stream of a coating composition is between 3 mm and 500 mm, and/or wherein the flow rate of the stream of a coating composition in the range of 50 till 4000 l/min per meter width of the second clearance.

25 19. The method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to any one claim 16 to 18, wherein the wet pulp substrate has a solids content of less than 20% by weight, or of about 4 to 20%, preferably of about 4 to 8% by weight.

30 20. The method of applying a stream of a coating composition onto a moving wet pulp substrate in a paper machine according to any one claim 16 to 19, wherein the coating composition comprises microfibrillated cellulose, preferably is an aqueous suspension of microfibrillated cellulose, and wherein the coating composition more preferably comprises the microfibrillated cellulose in an amount of less than 2.5 weight percent, based on the total weight of the coating composition, more preferably in an amount of from 0.5 to 2.0 weight percent.

35 21. Use of a headbox according to any one of claims 1 to 14 in a method of applying a horizontal stream of a coating composition onto a horizontally moving wet pulp substrate in a paper machine, preferably in a method according to any one claims 16 to 20, wherein the horizontal stream of a coating composition exits the slice chamber of the headbox according to any one of claims 1 to 14, in its open state, at a horizontal speed (V_1) and wherein the ratio of the horizontal speeds of said horizontal stream of a coating composition and horizontally moving wet pulp substrate (V_2) is between 0.9 and 1.1.

40 Patentansprüche

1. Stoffauflaufkasten (1) für eine Papiermaschine, insbesondere ein Sekundärstoffauflaufkasten zum Aufbringen eines Strahls einer Beschichtungszusammensetzung auf ein sich bewegendes nasses Zellstoffsubstrat in einer Papiermaschine, umfassend

- 45 - eine Vorratsbütte (2)
 - eine Beruhigungskammer (3)
 - eine Austrittsspalkkammer (4)
 - eine Ventilanordnung zum Steuern des Stroms der Beschichtungszusammensetzung von der Vorratsbütte (2) in die Beruhigungskammer (3) und zum Steuern des Stroms der Beschichtungszusammensetzung von der Beruhigungskammer (3) zur Austrittsspalkkammer (4) wobei die Ventilanordnung einen drehbaren Ventilkörper (5) und einen Ventilgehäusekörper (6) umfasst, wobei der drehbare Ventilkörper (5) innerhalb des Ventilgehäusekörpers (6) angeordnet ist,
 wobei der drehbare Ventilkörper (5) in einen geschlossenen Zustand und in einen oder mehrere geöffnete Zustände drehbar ist,
 50 wobei der drehbare Ventilkörper (5) ein erstes und ein zweites Dichtelement (7, 8) und der Ventilgehäusekörper (6) eine erste und eine zweite Dichtfläche (9, 10) umfasst,
 wobei in einem geschlossenen Zustand

- a. das erste Dichtelement (7) in dichtendem Kontakt mit einer ersten Dichtfläche (9) am Ventilgehäusekörper (6) steht und dadurch eine erste Dichtung bildet, die die Vorratsbütte (2) von der Beruhigungskammer (3) abdichtet, und/oder
- b. das zweite Dichtelement (8) in dichtendem Kontakt mit einer zweiten Dichtfläche (10) am Ventilgehäusekörper (6) steht und dadurch eine zweite Dichtung bildet, die die Beruhigungskammer (3) gegenüber der Austrittsspaltkammer (4) abdichtet,

wobei in einem offenen Zustand

- a. das erste Dichtelement (7) sich in einem ersten Abstand d_1 von der ersten Dichtfläche (9) am Ventilgehäusekörper (6) befindet, wodurch ein erster Durchgang gebildet wird und die Vorratsbütte (2) mit der Beruhigungskammer (3) fluidisch verbunden wird, und
- b. das zweite Dichtelement (8) sich in einem zweiten Abstand d_2 von der zweiten Dichtfläche (10) am Ventilgehäusekörper (6) befindet, wodurch ein zweiter Durchgang gebildet wird und die Beruhigungskammer (3) mit der Austrittsspaltkammer (4) fluidisch verbunden wird, und

wobei beim Drehen des drehbaren Ventilkörpers (5) von einem offenen Zustand in den geschlossenen Zustand das erste und das zweite Dichtelement (7, 8) gleichzeitig entlang einer Kreisbahn in dichtenden Kontakt mit einer ersten und einer zweiten Dichtfläche (9, 10) bewegt werden,

wobei beim Drehen des drehbaren Ventilkörpers (5) von einem geschlossenen Zustand in den geöffneten Zustand das erste und das zweite Dichtelement (7, 8) gleichzeitig entlang einer Kreisbahn C von einer ersten und zweiten Dichtfläche (9, 10) wegbewegt werden,

und wobei in jedem offenen Zustand der erste Abstand größer ist als der zweite Abstand.

2. Stoffauflaufkasten nach Anspruch 1, wobei der erste Durchgang um einen Faktor von mehr als 1 und bis zu 3 größer ist als der zweite Durchgang.
3. Stoffauflaufkasten gemäß Anspruch 1 oder 2, wobei der Stoffauflaufkasten (1) als Ganzes drehbar ist, um die Richtung des Stroms der Beschichtungszusammensetzung zu ändern, die die Austrittsspaltkammer (4) verlässt, und/oder wobei der Stoffauflaufkasten (1) als Ganzes in eine oder mehrere Richtungen beweglich ist, vorzugsweise zumindest in eine Richtung senkrecht zur Ebene des sich bewegenden nassen Zellstoffsubstrats, um die Richtung des Stroms der Beschichtungszusammensetzung zu ändern, die mit dem sich bewegenden nassen Zellstoffsubstrat in einer Papiermaschine in Kontakt kommt, wobei sich das sich bewegende nasse Zellstoffsubstrat vorzugsweise in horizontaler Richtung bewegt.
4. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei der drehbare Ventilkörper (5) eine Welle ist und/oder wobei der drehbare Ventilkörper (5) um eine Längsachse (A) des drehbaren Ventilkörpers (5) drehbar ist.
5. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei der drehbare Ventilkörper (5) eine Achse umfasst, die sich entlang einer Längsachse (A) des drehbaren Ventilkörpers (5) erstreckt, wobei die Achse mit einem steuerbaren Drehantriebsmittel gekoppelt ist, um den drehbaren Ventilkörper (5) zu drehen.
6. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei der drehbare Ventilkörper (5) eine oder mehrere Stangen umfasst, die über ein Gelenk mit einem Umfang des drehbaren Ventilkörpers (5) verbunden sind, wobei die Stange mit einem steuerbaren linearen Antriebsmittel gekoppelt ist, um den drehbaren Ventilkörper (5) zu drehen.
7. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei die ersten und/oder zweiten Dichtelemente (7, 8) durch Dichtrippen gebildet sind, insbesondere durch Dichtrippen, die sich vorzugsweise geradlinig parallel zu einer Längsachse (A) des drehbaren Ventilkörpers (5) erstrecken, wobei die Rippen vorzugsweise eine abgerundete, quadratische oder spitze Spitze aufweisen.
8. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei sich der drehbare Ventilkörper (5) im geöffneten Zustand in einem Drehwinkel α von bis zu 40° befindet und/oder sich der drehbare Ventilkörper (5) im geschlossenen Zustand in einem Drehwinkel α von 0° befindet.
9. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei der drehbare Ventilkörper (5) eine teilweise kreisförmige Querschnittsform aufweist, wobei der kreisförmige Abschnitt der Querschnittsform des drehbaren

Ventilkörpers (5) gleitend in dichtendem Kontakt mit einer oder zwei Dichtungen steht.

- 5 10. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei der drehbare Ventilkörper (5) eine Welle ist und wobei der drehbare Ventilkörper (5) entlang einer Längsachse (A) der Welle drehbar ist, wobei sich das erste und das zweite Dichtungselement (7, 8) im gleichen radialen Abstand von der Längsachse (A) der Welle befinden.
- 10 11. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei die erste Dichtfläche (9) eine konvexe Fläche des Ventilgehäusekörpers (6) ist, wobei die konvexe Fläche vorzugsweise eine kreisförmige Form aufweist, und/oder die zweite Dichtfläche (10) eine ebene Fläche des Ventilgehäusekörpers (6) ist.
- 15 12. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei die Beruhigungskammer (3) eine konkave Oberfläche umfasst, die zwischen der ersten Dichtfläche (9) und der zweiten Dichtfläche (10) angeordnet ist.
- 15 13. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei der zwischen der Beruhigungskammer (3) und der Austrittsspaltkammer (4) gebildete Durchgang die Form eines horizontalen rechteckigen Schlitzes zum Ausstoßen des Stroms einer Beschichtungszusammensetzung aus der Austrittsspaltkammer (4) hat, wobei die Höhe des horizontalen Schlitzes 0,3 bis 5 mm, vorzugsweise 0,8 mm bis 3 mm beträgt.
- 20 14. Stoffauflaufkasten nach einem der vorhergehenden Ansprüche, wobei die Austrittsspaltkammer (4) an ihrem stromabwärtigen Ende eine Unterlippe (11) zum Leiten des aus der Austrittsspaltkammer (4) austretenden Stroms einer Beschichtungszusammensetzung aufweist, und wobei die Unterlippe (11) vorzugsweise eine Unterlippe (11) mit variabler Länge ist.
- 25 15. Eine Papiermaschine, die einen Primärstoffauflaufkasten zum Bilden eines nassen Zellstoffsubstrats und einen Sekundärstoffauflaufkasten gemäß einem der Ansprüche 1 bis 14 zum Aufbringen eines Stroms einer Beschichtungszusammensetzung auf ein sich bewegendes nasses Zellstoffsubstrat umfasst.
- 30 16. Verfahren zum Aufbringen eines Stroms einer Beschichtungszusammensetzung auf ein sich bewegendes nasses Zellstoffsubstrat in einer Papiermaschine, wobei der Strom der Beschichtungszusammensetzung die Austrittsspaltkammer (4) eines Stoffauflaufkastens gemäß einem der Ansprüche 1 bis 14 in ihrem offenen Zustand verlässt, und wobei das Verhältnis der Geschwindigkeiten des Stroms der Beschichtungszusammensetzung V_1 und des sich bewegenden nassen Zellstoffsubstrats V_2 zwischen 0,9 und 1,1 liegt.
- 35 17. Verfahren zum Aufbringen eines Stroms einer Beschichtungszusammensetzung auf ein sich bewegendes nasses Zellstoffsubstrat in einer Papiermaschine gemäß Anspruch 16, wobei der Strom einer Beschichtungszusammensetzung, der mit dem sich bewegenden nassen Zellstoffsubstrat in Kontakt kommt, das sich bewegende nasse Zellstoffsubstrat in einem Winkel zwischen 3 und 75° berührt.
- 40 18. Verfahren zum Aufbringen eines Stroms einer Beschichtungszusammensetzung auf ein sich bewegendes nasses Zellstoffsubstrat in einer Papiermaschine gemäß Anspruch 16 oder 17, wobei die Länge des fallenden Stroms einer Beschichtungszusammensetzung zwischen 3 mm und 500 mm liegt und/oder wobei die Strömungsrate des Stroms einer Beschichtungszusammensetzung im Bereich von 50 bis 4000 l/min pro Meter Breite des zweiten Durchgangs liegt.
- 45 19. Verfahren zum Aufbringen eines Stroms einer Beschichtungszusammensetzung auf ein sich bewegendes nasses Zellstoffsubstrat in einer Papiermaschine gemäß einem der Ansprüche 16 bis 18, wobei das nasse Zellstoffsubstrat einen Feststoffgehalt von weniger als 20 Gewichtsprozent oder von etwa 4 bis 20 Gewichtsprozent, vorzugsweise von etwa 4 bis 8 Gewichtsprozent aufweist.
- 50 20. Verfahren zum Aufbringen eines Stroms einer Beschichtungszusammensetzung auf ein sich bewegendes nasses Zellstoffsubstrat in einer Papiermaschine gemäß einem der Ansprüche 16 bis 19, wobei die Beschichtungszusammensetzung mikrofibrillierte Zellulose umfasst, vorzugsweise eine wässrige Suspension von mikrofibrillierter Zellulose ist, und wobei die Beschichtungszusammensetzung die mikrofibrillierte Zellulose noch bevorzugter in einer Menge von weniger als 2,5 Gewichtsprozent, basierend auf dem Gesamtgewicht der Beschichtungszusammensetzung, umfasst, noch bevorzugter in einer Menge von 0,5 bis 2,0 Gewichtsprozent.
- 55 21. Verwendung eines Stoffauflaufkastens nach einem der Ansprüche 1 bis 14 in einem Verfahren zum Aufbringen eines horizontalen Stroms einer Beschichtungszusammensetzung auf ein sich horizontal bewegendes nasses Zellstoff-

substrat in einer Papiermaschine, vorzugsweise in einem Verfahren nach einem der Ansprüche 16 bis 20, wobei der horizontale Strom einer Beschichtungszusammensetzung die Austrittsspaltkammer des Stoffauflaufkastens nach einem der Ansprüche 1 bis 14 in ihrem offenen Zustand mit einer horizontalen Geschwindigkeit (V_1) verlässt und wobei das Verhältnis der horizontalen Geschwindigkeiten des horizontalen Stroms einer Beschichtungszusammensetzung und des sich horizontal bewegenden nassen Zellstoffsubstrats (V_2) zwischen 0,9 und 1,1 liegt

Revendications

1. Une caisse de tête (1) pour une machine à papier, en particulier une caisse de tête secondaire pour appliquer un flux d'une composition de revêtement sur un substrat de pâte humide en mouvement dans une machine à papier, comprenant

- une chambre de stockage (2)
- une chambre de tranquillisation (3)
- une chambre de règle (4)
- un ensemble de vannes pour contrôler le flux de composition de revêtement de la chambre de stockage (2) vers la chambre de tranquillisation (3) et pour contrôler le flux de composition de revêtement de la chambre de tranquillisation (3) vers la chambre de règle (4)

dans laquelle l'ensemble de soupape comprend un corps de soupape rotatif (5) et un corps de boîtier de soupape (6), ledit corps de soupape rotatif (5) étant situé à l'intérieur du corps de boîtier de soupape (6), dans laquelle ledit corps de vanne rotatif (5) peut tourner vers un état fermé et vers un ou plusieurs états ouverts,

dans laquelle ledit corps de vanne rotatif (5) comprend un premier et un deuxième élément d'étanchéité (7, 8) et ledit corps de boîtier de vanne (6) comprend une première et une deuxième surface d'étanchéité (9, 10), dans laquelle dans un état fermé,

a) le premier élément d'étanchéité (7) est en contact étanche avec une première surface d'étanchéité (9) sur le corps du boîtier de soupape (6), formant ainsi un premier joint qui isole la chambre de stockage (2) de la chambre de tranquillisation (3), et/ou

b) le deuxième élément d'étanchéité (8) est en contact étanche avec une deuxième surface d'étanchéité (10) sur le corps du boîtier de soupape (6) formant un deuxième joint, qui isole la chambre de tranquillisation (3) de la chambre de règle (4),

dans laquelle dans un état ouvert,

a) le premier élément d'étanchéité (7) est à une première distance d_1 de la première surface d'étanchéité (9) sur le corps du boîtier de soupape (6) formant un premier jeu et reliant ainsi fluidiquement la chambre de stockage (2) à la chambre de tranquillisation (3) et

b) le deuxième élément d'étanchéité (8) est à une deuxième distance d_2 de la deuxième surface d'étanchéité (10) sur le corps du boîtier de soupape (6), formant un deuxième jeu et reliant ainsi fluidiquement la chambre de tranquillisation (3) à la chambre de règle (4), et

dans laquelle lorsque le corps de vanne rotatif (5) est tourné d'un état ouvert à l'état fermé, les premier et deuxième éléments d'étanchéité (7, 8) sont déplacés simultanément le long d'un trajet circulaire en contact d'étanchéité avec une première et une deuxième surface d'étanchéité (9, 10)

dans lequel lorsque le corps de vanne rotatif (5) est tourné d'un état fermé à l'état ouvert, les premier et deuxième éléments d'étanchéité (7, 8) sont simultanément éloignés le long d'un trajet circulaire C d'une première et d'une deuxième surface d'étanchéité (9, 10),

et dans lequel dans tout état ouvert, le premier jeu est plus grand que le second jeu.

2. La caisse de tête selon la revendication 1, dans laquelle le premier jeu est plus grand que le second jeu d'un facteur supérieur à 1 et jusqu'à 3.

3. La caisse de tête selon la revendication 1 ou 2, dans laquelle la caisse de tête (1) est rotative dans son ensemble de manière à modifier la direction du flux de la composition de revêtement sortant de la chambre de règle (4) et/ou dans laquelle la caisse de tête (1) est mobile dans son ensemble dans une ou plusieurs directions, de préférence au moins

dans une direction perpendiculaire au plan du substrat de pâte humide en mouvement, de manière à modifier la direction du flux de la composition de revêtement en contact avec le substrat de pâte humide en mouvement dans une machine à papier, lequel substrat de pâte humide en mouvement se déplace de préférence dans une direction horizontale.

- 5
4. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle le corps de vanne rotatif (5) est un arbre et/ou dans laquelle le corps de vanne rotatif (5) peut tourner autour d'un axe longitudinal (A) du corps de vanne rotatif (5).
- 10
5. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle le corps de vanne rotatif (5) comprend un axe s'étendant le long d'un axe longitudinal (A) du corps de vanne rotatif (5), lequel axe est couplé à un moyen d'entraînement rotatif contrôlable, de manière à faire tourner le corps de vanne rotatif (5).
- 15
6. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle le corps de vanne rotatif (5) comprend une ou plusieurs tiges reliées par l'intermédiaire d'une articulation à une périphérie du corps de vanne rotatif (5), laquelle tige est couplée à un moyen d'entraînement linéaire contrôlable, de manière à faire tourner le corps de vanne rotatif (5).
- 20
7. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle les premier et/ou deuxième éléments d'étanchéité (7, 8) sont formés par des nervures d'étanchéité, en particulier des nervures d'étanchéité s'étendant, de préférence rectilignement, parallèlement à un axe longitudinal (A) du corps de vanne rotatif (5), lesdites nervures présentant de préférence une extrémité arrondie, carrée ou pointue.
- 25
8. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle, dans un état ouvert, le corps de vanne rotatif (5) est à un angle de rotation α allant jusqu'à 40° et/ou dans un état fermé, le corps de vanne rotatif (5) est à un angle de rotation α de 0°.
- 30
9. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle le corps de soupape rotatif (5) a une forme de section transversale qui est partiellement circulaire, dans laquelle la section circulaire de la forme de section transversale du corps de soupape rotatif (5) est en contact d'étanchéité coulissant avec un ou deux joints.
- 35
10. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle le corps de soupape rotatif (5) est un arbre et dans laquelle le corps de soupape rotatif (5) peut tourner le long d'un axe longitudinal (A) de l'arbre, dans laquelle les premier et deuxième éléments d'étanchéité (7, 8) sont situés à la même distance radiale de l'axe longitudinal (A) de l'arbre.
- 40
11. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle la première surface d'étanchéité (9) est une surface convexe du corps de boîtier de soupape (6), ladite surface convexe ayant de préférence une forme circulaire, et/ou la seconde surface d'étanchéité (10) est une surface plane du corps de boîtier de soupape (6).
- 45
12. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle la chambre de tranquillisation (3) comprend une surface concave positionnée entre la première surface d'étanchéité (9) et la seconde surface d'étanchéité (10).
- 50
13. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle l'espace libre formé entre la chambre de tranquillisation (3) et la chambre de règle (4) a la forme d'une fente rectangulaire horizontale pour éjecter le flux d'une composition de revêtement de la chambre de tranchage (4), où la hauteur de la fente horizontale est de 0,3 à 5 mm, de préférence de 0,8 mm à 3 mm.
- 55
14. La caisse de tête selon l'une quelconque des revendications précédentes, dans laquelle la chambre de règle (4) comprend, à son extrémité en aval, une lèvre inférieure (11) pour guider le flux d'une composition de revêtement sortant de la chambre de règle (4), et dans laquelle de préférence la lèvre inférieure (11) est une lèvre inférieure de longueur variable (11).
15. Une machine à papier comprenant une caisse de tête primaire pour former un substrat de pâte humide et une caisse de tête secondaire selon l'une quelconque des revendications 1 à 14 pour appliquer un flux d'une composition de revêtement sur un substrat de pâte humide en mouvement.

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- 5 16. Un procédé d'application d'un flux d'une composition de revêtement sur un substrat de pâte humide en mouvement dans une machine à papier, dans lequel le flux d'une composition de revêtement sort de la chambre de règle (4) d'une caisse de tête selon l'une quelconque des revendications 1 à 14 dans son état ouvert, et dans lequel le rapport des vitesses dudit flux d'une composition de revêtement V_1 et du substrat de pâte humide en mouvement V_2 est compris entre 0,9 et 1,1.
- 10 17. Le procédé d'application d'un flux d'une composition de revêtement sur un substrat de pâte humide en mouvement dans une machine à papier selon la revendication 16, dans lequel le flux d'une composition de revêtement en contact avec le substrat de pâte humide en mouvement entre en contact avec le substrat de pâte humide en mouvement à un angle compris entre 3 et 75°.
- 15 18. Le procédé d'application d'un flux d'une composition de revêtement sur un substrat de pâte humide en mouvement dans une machine à papier selon la revendication 16 ou 17, dans lequel la longueur du flux tombant d'une composition de revêtement est comprise entre 3 mm et 500 mm, et/ou dans lequel le débit du flux d'une composition de revêtement est dans la plage de 50 à 4000 l/min par mètre de largeur du deuxième espace libre.
- 20 19. Le procédé d'application d'un flux d'une composition de revêtement sur un substrat de pâte humide en mouvement dans une machine à papier selon l'une quelconque des revendications 16 à 18, dans lequel le substrat de pâte humide a une teneur en solides inférieure à 20 % en poids, ou d'environ 4 à 20 %, de préférence d'environ 4 à 8 % en poids.
- 25 20. Le procédé d'application d'un flux d'une composition de revêtement sur un substrat de pâte humide en mouvement dans une machine à papier selon l'une quelconque des revendications 16 à 19, dans lequel la composition de revêtement comprend de la cellulose microfibrillée, de préférence est une suspension aqueuse de cellulose microfibrillée, et dans lequel la composition de revêtement comprend de préférence la cellulose microfibrillée en une quantité inférieure à 2,5 pour cent en poids, sur la base du poids total de la composition de revêtement, de préférence en une quantité de 0,5 à 2,0 pour cent en poids.
- 30 21. Une utilisation d'une caisse de tête selon l'une quelconque des revendications 1 à 14 dans un procédé d'application d'un flux horizontal d'une composition de revêtement sur un substrat de pâte humide se en mouvement horizontal dans une machine à papier, de préférence dans un procédé selon l'une quelconque des revendications 16 à 20, dans lequel le flux horizontal d'une composition de revêtement sort de la chambre de règle de la caisse de tête selon l'une quelconque des revendications 1 à 14, dans son état ouvert, à une vitesse horizontale (V_1) et dans lequel le rapport des vitesses horizontales dudit flux horizontal d'une composition de revêtement et du substrat de pâte humide en mouvement horizontal (V_2) est compris entre 0,9 et 1,1.
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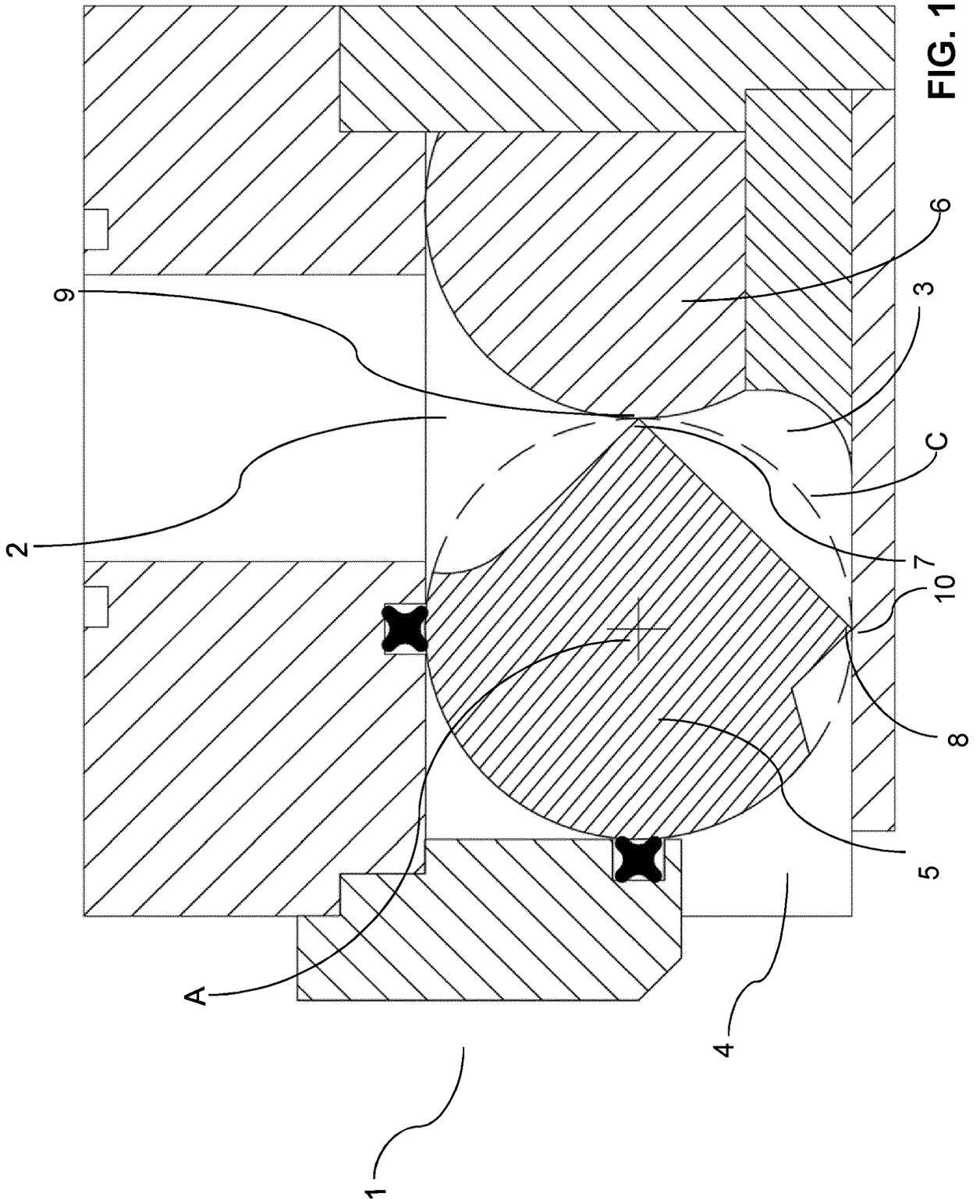
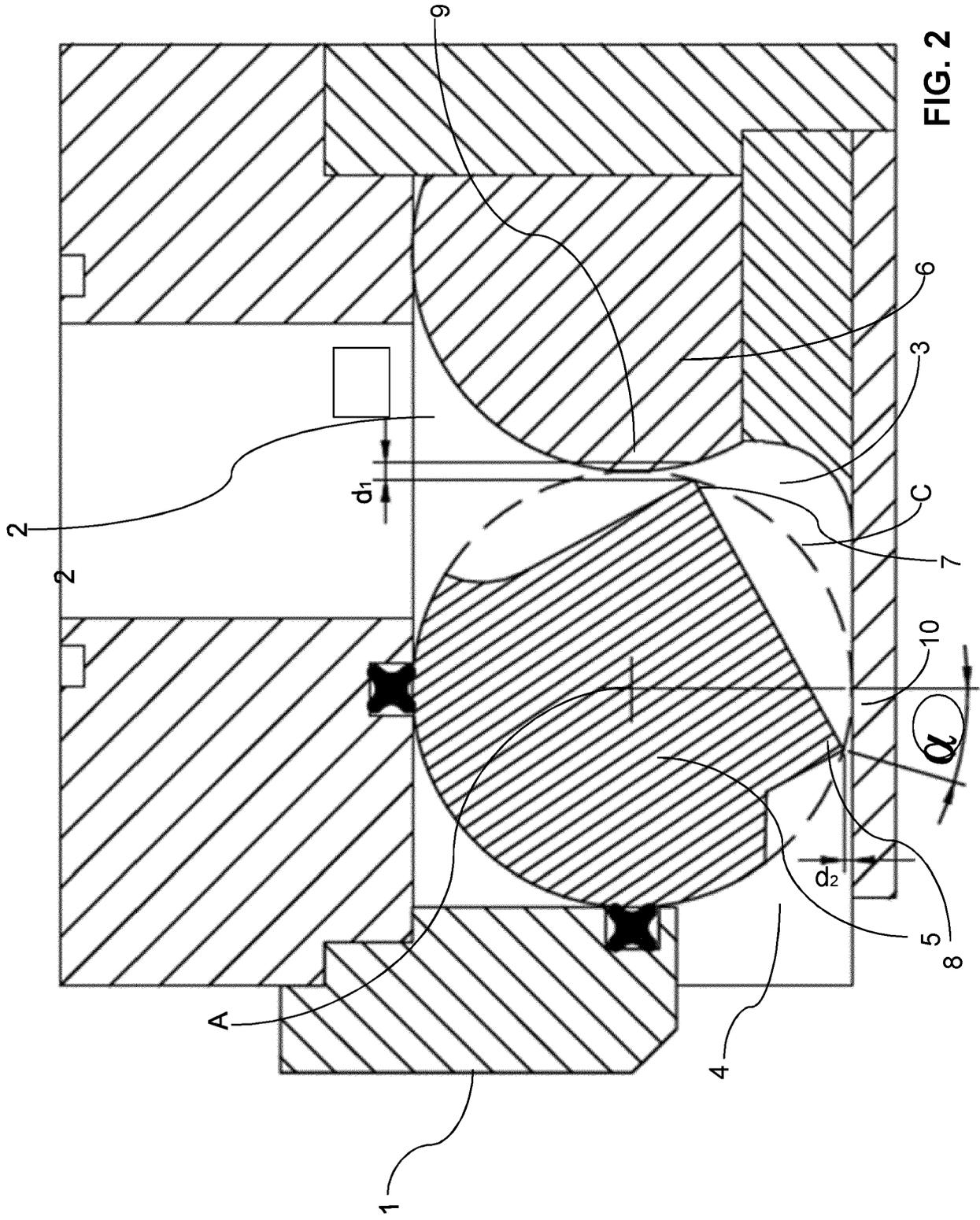


FIG. 1



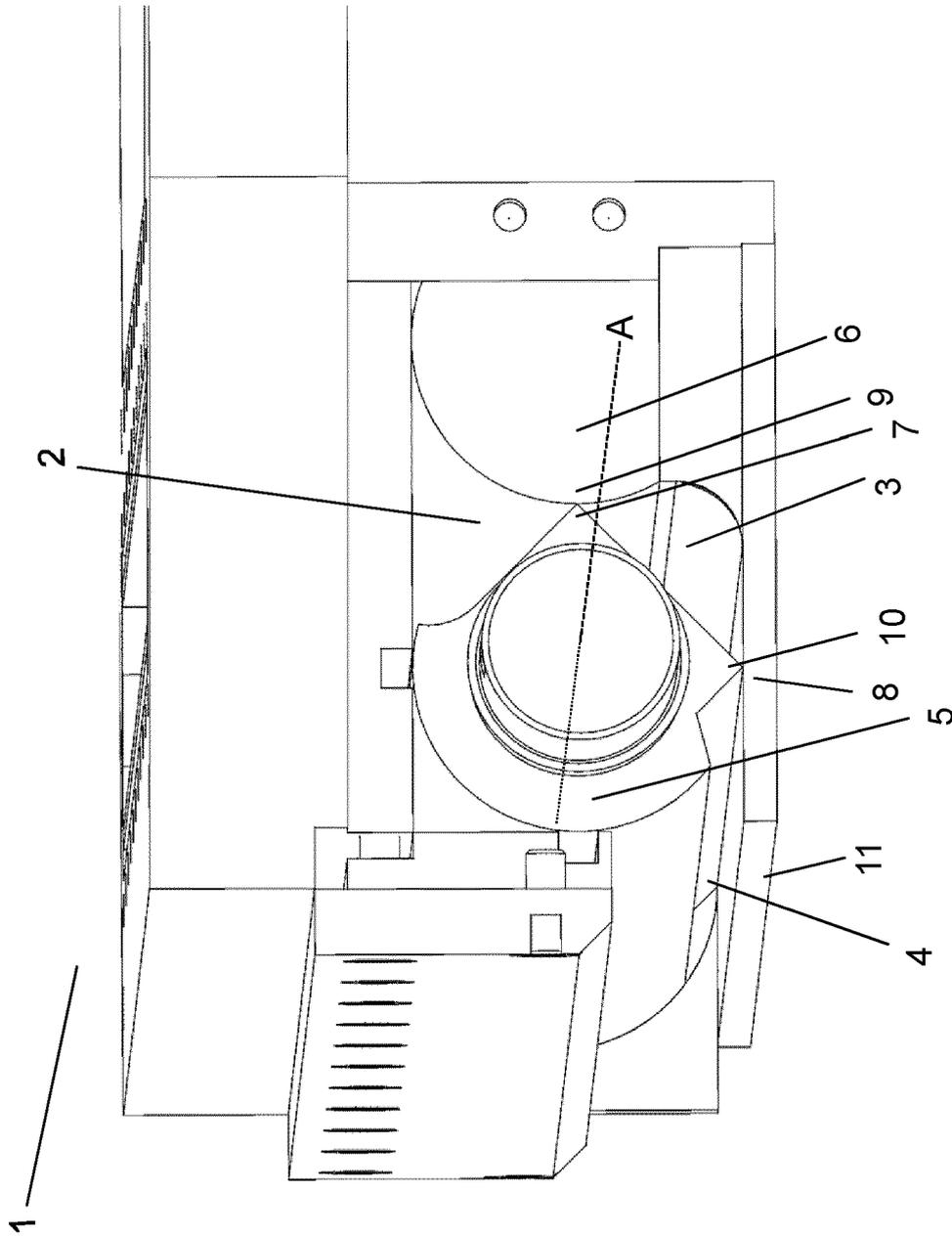


FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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