Title: A METHOD FOR FEEDING HIGH-CONSISTENCY PULP TO A FORMATION SUPPORT AND A HIGH-CONSISTENCY PULP HEADBOX

Abstract: Pulp at a high consistency of about 4 to 20% is fed from a slice onto a formation support that is permeable to water, for the manufacture of a fibre-based product. Before the slice, the pulp is fed in the flow direction into a flow channel tapering on at least part of its length and limited by a surface moving at a velocity different from the pulp flow velocity to fluidize the pulp. The pulp is fed by force into this flow channel by means of a feeding device that supplies kinetic energy to the pulp and is separate from the moving surface, for example a high-consistency pump.
A METHOD FOR FEEDING HIGH-CONSISTENCY PULP TO A
FORMATION SUPPORT AND A HIGH-CONSISTENCY PULP
HEADBOX

The invention relates to a method for feeding high-consistency pulp to
a formation support, in which method fibre pulp at the consistency of
about 4 to 20% is fed from a slice onto a formation support that is per-
meable to water, for manufacturing a fibre-based product. The inven-
tion also relates to a high-consistency pulp headbox, whose inlet part is
connected to a source of fibre pulp at the consistency of about 4 to
20%, and whose outlet end forms a slice or the like for feeding said
pulp onto a formation support that is permeable to water.

In the manufacture of fibre-based products, such as pulp sheets, card-
board or paper, it is advantageous to use pulp whose consistency is as
high as possible, that is, pulp whose fibre solids content is as high as
possible and whose water content is thus low, to reduce the quantity of
circulating water. However, a problem with the feeding of pulp at a high
consistency of 4 to 20% onto the product formation support lies in
obtaining a product of uniform quality, because in pulp at such a high
consistency, the fibres tend to accumulate in a dense fibre network,
and they cannot be evenly distributed on the whole surface area of the
product. The consistency of such pulp is, in fact, already in a range
where a web tends to form when fibres are bound to each other. The
main task in the feeding of such pulp is to keep the pulp, with respect
to its rheological properties, in a "fluid" state similar to water, by pre-
venting the formation of fibre agglomerations and possibly by disinte-
grating any fibre agglomerations already formed. This is important
before the web starts to form onto the formation support, because
defects in the pulp can no longer be amended afterwards.

It is common knowledge to apply various mixing means, such as rotat-
ing perforated rolls, in headboxes for feeding pulp onto a formation
support. These arrangements are intended for disintegrating fibre
flocks in pulp of low consistency, less than 3%, or to increase turbu-
lence in the pulp. In pulp of high consistency, such perforated rolls are
easily clogged.
Patent FI 86444, to which corresponds, *inter alia*, patent EP 348398, discloses a roll fitted in the cross-machine direction to rotate in the pressure chamber of the headbox. The aim is to subject the pulp at a consistency of 6 to 15% to high shearing forces locally between the rotating surface of the roll and another surface. The rotary movement of the roll is also used for feeding pulp in the headbox towards the formation support.

The short-term and local fluidization of pulp at high consistency according to said patent has not been a solution to the problems in the use of pulp at high consistency for the manufacture of a fibre-based product having a large surface area with good formation, that is, a sufficiently uniform web is not achieved. Also, the flow of pulp caused by a roll or a pair of rolls into a slice that opens towards the formation support is not necessarily uniform.

It is an aim of the invention to eliminate the above-mentioned drawbacks. To achieve this aim, the method according to the invention is primarily characterized in that before the slice, the pulp is led into a flow channel tapering on at least part of its length in the flow direction and limited by a surface moving at a velocity that is different from the pulp flow velocity, and that the pulp is fed by force into this flow channel by a feeding device, for example a high-consistency pump, that supplies kinetic energy to the pulp and is separate from the moving surface. By acting in this way, the pulp is subjected to shearing forces along its whole path in the flow channel, and good mixing, turbulence and thereby fluidization of the pulp can be maintained up to the slice, from where the pulp is discharged onto a moving formation support, on which the product starts to form simultaneously when water is removed from the pulp through the formation support.

The surface moving at a speed differing from the pulp rate may be, for example, the peripheral surface of a rotor arranged to rotate in the headbox. The peripheral surface of such a rotor forms one limiting surface of a gap tapering in the flow direction, and a second limiting surface is formed by a stationary wall that is opposite to the peripheral
surface and is curved in the same direction. According to an advantageous embodiment, the turbulence of the pulp is increased by the design of the wall limiting the gap, causing successive constriction points in the pulp flow passage.

The flow channel forming the tapering gap ends in a slice, up to which the pulp is maintained in a turbulent state.

A particular advantage in view of the web formation is obtained, if the direction of flow of the pulp is abruptly turned just before the slice at the end of the flow channel.

The feeding of the pulp into the tapering flow channel, or gap, is effected by force with a feeding device that gives the pulp the kinetic energy required by it, for example a high-consistency pump. This feeding device is a device functionally separate from the rotating rotor. By means of the above-described method, the fibres in the high-consistency pulp are entrained in a continuous movement with respect to each other during the whole flow in the headbox, wherein there is no time for the formation of fibre flocks that might be visible in the product quality, and the fibres do not start to congeal in fixed positions with respect to each other in the headbox.

The high-consistency pulp headbox according to the invention, in turn, is characterized in that the inlet part continues as a flow channel that tapers on at least part of its length, ending in a slice, and that the flow channel is limited by a surface arranged to move at a velocity different from the pulp flow velocity. Such a surface is preferably the peripheral surface of a cylinder arranged to rotate in the headbox.

In the following, the invention will be described in more detail with reference to the appended drawings, in which

Fig. 1 illustrates the general principle of product formation from pulp at a high consistency,
Fig. 2 is a cross-sectional view of a headbox for feeding pulp onto a formation support, and

Figs. 3 to 6 show alternative structures for cylinders in the headbox of Fig. 2.

Figure 1 shows the principle of manufacturing a product in the form of a continuous web W by the method according to the invention. Aqueous fibre suspension, in this case high-consistency pulp, is fed from a pulp container M by a pump P via inlet pipe system 3 into a headbox 1. From the headbox, the pulp is discharged through a slice onto a formation support 2, such as a wire, that runs continuously forward and is permeable to water. The fibre pulp has a consistency of 4 to 20%, in which range the fibre pulp can be called high-consistency pulp. The consistency of the pulp is preferably in the range from 5 to 15%. The fibre pulp carried along with the formation support 2 is gradually dewatered through the formation support 1, wherein its dry matter content is increased, and the fibrous product W starts to form into a cohesive texture in which the fibres are arranged in their fixed positions with respect to each other and are bound to each other. Since the water content of the pulp coming from the headbox onto the formation support is relatively low, less water is removed at this step A of web formation than when using pulp of normal consistency, and the quantity of circulating water is reduced. The circulating water filtered through the wire is illustrated with an arrow in Fig. 1.

After the formation step, the web W that is already cohesive without support, is guided to a pressing step B, in which it is dewatered by mechanical pressing, and finally into a drying step C, in which water is removed by evaporating with heat. The web W formed in this way may be a pulp web, a cardboard web or a paper web. After the drying, there are various finishing possibilities which will not be described in more detail, as they are irrelevant to the invention.

The depiction of Fig. 1 is intended to be illustrative only, and the positions of the various parts and the entries of the formation support 2 and
the other means conveying the web W may vary, depending on the machine and on the product to be manufactured.

Figure 2 shows the structure of the headbox in more detail, in a vertical section taken in the direction of the pulp flow and the running direction of the web to be formed. High-consistency pulp is fed into the headbox 1 through the inlet pipe system 3, from above into an inlet part formed by the initial end of the flow channel 4 that tapers gradually towards the slice 5 of the headbox. The flow channel 4 is formed between a cylinder 6 arranged to rotate in a chamber within the headbox and a curved wall 7 opposite to its peripheral surface. The wall 7 has a larger radius of curvature than the cylinder, and it approaches the cylinder 6 in the direction of flow of the pulp, resulting in a tapering flow channel with a generally curved form. The wall 7 of the flow channel is immobile, even though it may be movable in the direction of radius of the cylinder 6, to adjust the "gap" between the cylinder 6 and the wall 7. The cylinder 6 can also be called "rotor", and the wall 7 immobile with respect to it can also be called "stator". In the flow channel 4, pulp is supplied along the whole length substantially over the machine width, and the terms "narrowing" and "tapering" refer in this context to the reduction of the dimensions in a direction perpendicular to the machine width and the flow direction, that is, in the direction of the radii of curvature of the cylinder and the wall. The headbox in Fig. 2 illustrates the shape of the flow channel over the whole machine width.

In Fig. 2, the flow channel 4 extends in an angle of about 90 degrees with respect to the feeding direction of the inlet flow (inlet direction of the inlet pipe system 3), but this feeding angle may vary within a large range; that is, it may range from 0 to almost 180 degrees. The flow channel 4 may thus also start as a direct extension to the inlet pipes 3, or it may extend in a sharper angle than 90 degrees.

The cylinder 6 does not substantially affect the pulp flow in the flow channel 4 towards the slice 5, but this is obtained by means of an external feeding device. Thanks to this, the rotary movement of the cylinder 6 effectively exerts energy to the pulp flowing towards the slice 5, fluidizing it and preventing the formation of fibre bundles and the
fixation of fibres with respect to each other. To boost the shearing forces exerted on the pulp, the peripheral surface of the cylinder 6 is provided with a three-dimensional surface pattern; that is, it may comprise, for example, knobs. Various alternatives for surface patterning are illustrated in Figures 3 to 6 (Figs. 3 and 5 are elevated views, and Figs. 4 and 6 are perspective views). In the cylinder of Figs. 3 and 4, the three-dimensional pattern is formed by successive ridges or elevations in the peripheral direction, and in the case of Figs. 5 and 6, it is formed by separate elevations in the peripheral direction and the axial direction.

At the terminal end of the flow channel 4, the wall 7 is provided with successive elevations or ridges in the direction of the axis of rotation of the cylinder 6, forming successive constriction or expansion points in the cross-sectional area of the flow. In this area, the average distance of the wall 7 from the cylinder 6 may be constant, and the design of the wall surface may be used to effectively maintain turbulence also at the terminal end of the flow channel. The elevations or ridges may extend in similar configuration over the whole machine width, or they may be discontinuous and staggered. It is also possible that the wall 7 is provided with separate knobs which form a corresponding design to maintain turbulence.

As the cross-sectional area of the flow of the channel 4 is reduced at least in the beginning in the flow direction due to the fact that the wall 7 approaches the cylinder 6 in the direction of its radius, this means that with a constant volume flow rate, the linear flow velocity of the pulp is increased. It is a requirement for turbulence that the peripheral speed of the cylinder 6 based on a rotary movement differs from this linear flow velocity over the whole length of the flow channel. When the cylinder 6 rotates in the direction of the pulp flow (counterclockwise in Fig. 2), its peripheral speed should exceed the greatest linear velocity of the pulp based on the volume flow in channel 4. Turbulence is also generated, if the peripheral speed of the cylinder is slower than the linear velocity of the pulp in the same direction. It is also possible that the cylinder 6 rotates against the pulp flow direction (clockwise in Fig. 2),
wherein it also effectively gives up energy to the pulp flowing through the flow channel 4.

The rotational speed of the cylinder 6 is dependent on the consistency of the pulp in such a way that the higher the consistency of the pulp to be fed, the higher the rotational speed is to be adjusted. It can be shown that at a certain rotational speed, a fluidization point is achieved, at which the pulp at a given consistency starts to act like water. The cylinder 6 or rotor does not have an essential pumping effect, but its function is only to exert shearing forces on the pulp flowing in the channel 4. The actual volume flow is produced by a high-consistency pump P that feeds pulp into the headbox 1, which pump may be a displacement-type pump or a fluidizing pump. The pump feeds pulp into the headbox 1 through inlet pipe system 3 without any buffer tank or the like in between.

At the terminal end of the flow channel 4, there is a sharp turn where the short terminal part 4a of the flow channel following the peripheral surface of the cylinder turns away from the cylinder, forming a short slice channel which ends in the slice 5. In the case shown in Fig. 2, the turn is about 90°; in other words, the terminal part of the channel is directed away from the cylinder in the direction of the radius of the cylinder, but the turn may be sharper or gentler, greater or smaller than 90°. This short terminal part 4a of the flow channel 7 is also curved in the direction opposite to the curvature of the initial part, gradually into the direction of the formation support 2. The pulp is discharged from the slice 5 in a direction opposite to the direction of movement of the periphery of the cylinder 6. By means of the sharp turn at the end of the flow channel 4, a quick change of direction is obtained in the fibre pulp flowing therein. The quick turn causes shearing forces and frictional forces in the flowing pulp and thereby maintains fluidization. If the cylinder 6 rotates against the flow in the channel 4, the pulp will be discharged from the slice 5 in the direction of movement of the periphery of the cylinder 6.

Furthermore, it is possible that there is a gentler or smoother change of direction at the end of the flow channel, or that the direction is not
changed at all. In this case, the direction of the terminal part 4a ending in the slice 5 deviates only a little or not at all from the direction of the flow channel 4. In these cases, the flow channel 4 may be arranged in a mirror-like manner with respect to the rotor 6 in Fig. 1, the position of the slice channel 4a and the running direction of the wire remaining unaltered.

The figure also shows the path of the formation support 2 that is permeable to water, past the headbox 1. The lower surface of the headbox forms a first sliding surface 8 that guides the formation support towards the slice 5 and ends at the lower edge of the slice 5. The upper edge of the slice extends as a second sliding surface 9 in the running direction of the formation support 1, guiding the formation support 2 and the pulp discharged onto it from the slice 5, which pulp immediately begins to form into a web when dewatering starts downwards through the formation support 2. The tension of the formation support can be set suitable by means of the position of the sliding surfaces 8 and 9. After the second sliding surface 9, the web W runs on top of the formation support 1 towards the pressing step, as described above.

The headbox also comprises means sealing the gap between the cylinder 6 and the rest of the headbox outside the flow channel 4, such as doctor blades, which prevent the discharge of the pulp elsewhere. These are indicated with the reference numeral 10 in Fig. 2.

The machine width may vary within a large range. In wide machines, the inlet pipe system 3 can be arranged as a structure to distribute high-consistency pulp evenly in different locations at the initial end of the flow channel 4.

The diameter of the cylinder or rotor is advantageously 300 to 1200 mm. The width of the inlet channel depends, among other things, on the grammage of the product to be manufactured. The length of the slice channel 4a is 15 to 50 mm, and the size of its slice is determined by the grammage of the product to be manufactured.
The invention is suitable, among other things, for feeding fibre pulp into a pulp drying machine, but the invention is not limited solely to machines whose end product is pulp. The invention is also suitable for cardboard manufacturing machines and papermaking machines. It is also possible that the fibre pulp to be fed from the headbox does not form the entire product, but the headbox may also be placed in a two-ply or multi-ply former, in which one or more fibre layers are attached to the layer formed of the high-consistency pulp.
Claims:

1. A method for feeding high-consistency pulp onto a formation support, in which method pulp at a consistency of about 4 to 20% is fed from a slice (5) onto a formation support (2) that is permeable to water, for the manufacture of a fibre-based product, characterized in that before the slice (5), the pulp is led into a flow channel (4) tapering on at least part of its length in the flow direction and limited by a surface moving at a velocity different from the pulp flow velocity to fluidize the pulp, and that the pulp is fed by force into the flow channel (4) by means of a feeding device that supplies kinetic energy to the pulp and is separate from the moving surface, for example a high-consistency pump (P).

2. The method according to claim 1, characterized in that the surface moving at a speed different from the pulp flow velocity consists of the peripheral surface of a rotary cylinder (6).

3. The method according to claim 2, characterized in that the cylinder (6) rotates at the channel (4) in the direction of flow of the pulp.

4. The method according to claim 2, characterized in that the cylinder (6) rotates at the channel (4) against the direction of flow of the pulp.

5. The method according to any of the preceding claims, characterized in that at the end of the flow channel (4), just before the slice (5), the direction of flow of the pulp is sharply turned.

6. The method according to any of the preceding claims, characterized in that the moving surface is provided with a three-dimensional pattern.

7. The method according to any of the preceding claims, characterized in that turbulence is maintained in the pulp by means of the shape of the wall (7) opposite to the moving surface, limiting the flow channel (4).
8. The method according to any of the preceding claims, characterized in that the consistency of the fibre pulp to be fed is 5 to 15%.

9. A high-consistency pulp headbox, whose inlet part is connected to a source (M) of fibre pulp at a consistency of about 4 to 20%, and whose outlet part forms a slice (5) or the like for feeding said pulp onto a formation support (2) that is permeable to water, characterized in that the inlet part continues as a flow channel (4) that tapers on at least part of its length, ending at the slice (5), and that the flow channel (4) is limited by a surface that is arranged to move at a velocity different from the pulp flow velocity, and that the inlet part is connected to the source (M) of fibre pulp by means of a feeding device that supplies kinetic energy to the pulp and is separate from the moving surface, for example a high-consistency pump (P), arranged to feed pulp by force into the flow channel (4).

10. The high-consistency pulp headbox according to claim 9, characterized in that the surface limiting the flow channel (4) is the peripheral surface of a cylinder (6) arranged to rotate in the headbox, and that the flow channel (4) is limited on the other side by a curved wall (7) opposite to the peripheral surface.

11. The high-consistency pulp headbox according to claim 9 or 10, characterized in that the terminal end of the flow channel (4) is provided with a sharp turn where the flow channel turns into a short terminal part (4a) ending in the slice (5).

12. The high-consistency pulp headbox according to any of the preceding claims 9 to 11, characterized in that at least at the terminal end of the flow channel (4), the surface of the solid wall (7) limiting the flow channel forms successive constriction and expansion points in the cross-sectional area of the flow.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. D21F1/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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D. Further documents are listed in the continuation of Box C

X See patent family annex

- Special categories of cited documents
  - "A" document defining the general state of the art which is not considered to be of particular relevance
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  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "p" document published prior to the international filing date but later than the priority date claimed
  - "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  - "X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  - "Y" document of particular relevance the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - "Z" document member of the same patent family

Date of the actual completion of the international search

27 February 2009

Date of mailing of the international search report

10/03/2009

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