Reel and a method of reeling a fiber web

Abstract: A reel (1) and a method of continuously reeling a fibrous web into a jumbo roll (6) around a reel spool (5), wherein a reel drum (10) with its axis (105) in the y direction is shorter than the nominal bearing distance (51) of the reel spool (5), and that the reel drum (10) in the z direction is in the free clearance (201) of the frames (20), when examined at the rotation axis (101).
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Reel and a method of reeling a fibrous web

The invention relates to a reel for continuously reeling a fibrous web into a jumbo roll around a reel spool.

The invention also relates to a method of continuously reeling the fibrous web around the reel spool.

A reel is a device that reels a material, which is produced as a continuous fibrous web, into the form of a roll, a jumbo roll. In the manufacturing process of the fibrous web, the reeling is generally a first subprocess, wherein a continuous process is discontinued to be continued in sequences. The jumbo roll is formed around the reel spool that works as the core of reeling, i.e., the fibrous web on one jumbo roll has a beginning and an end. An ongoing trend in the field is the continuous increase in jumbo rolls, causing an ongoing need for the development of reels. In practice, the dimensioning of the reel spool defines the maximum size of the jumbo roll. However, since we are talking about a dynamic environment and the fibrous web is a reelable material that is sensitive to various failures, the task carried out by the reel as a maintainer of the efficiency of a paper or cardboard machine is extremely significant. One reason behind the continuous increase in the size of jumbo rolls is the desire to decrease the number of beginnings and ends, which impede or disturb the production and lower the efficiency, in the production of fibrous webs.

Previously, the method described in the Fl-patent 91383 (EP 0483092 B1) transferred the size of jumbo rolls into a new order, since it was possible to build the first part of the jumbo roll in a good manner regarding the properties of the fibrous web that was to be reeled. The importance of the first part becomes emphasized, when the amount of fibrous web to be reeled is increased, since the first part works as the base of the roll structure. One feature that improved the technology here was the progressive centre torque of the jumbo roll that was provided by means of primary and secondary drives, enabling the versatile use of reeling parameters in building the jumbo roll. The prior art before this solution comprises what is called a pope reel, wherein the jumbo roll was built by pressing the jumbo roll against a driving reel drum, whereby the jumbo roll was formed by means of the friction between the reel drum and the jumbo roll.

In its time, the method described in the US-patent 5370327, for the first time, introduced the idea in the field that the jumbo roll would be built on one vertical
plane, so that the jumbo roll would be on top of horizontal rails and at the same vertical height throughout the reeling. FI 91383 also presented this type of solution, but before beginning to reel, the reel spool was moved in a pope-type manner into its initial position. The moving reel drum in the US-patent 5370327 makes it possible to keep the centre of the reel spool on a constant level. One advantage of this solution is changing the adjustment of the nip power from loading on the side of the jumbo roll to loading on the side of a constant mass reel drum.

In addition to the "pioneer" patents of the second generation reels in the field described above, there is an extensive selection of various embodiments, wherein the principles described in these two patents have been further developed. One of them is described in the US-patent 5931406.

In connection with the specification of this invention, the following terms are used to facilitate the description: the machine direction (MD) is called an x direction, the cross direction (CD) is called a y direction, and the elevation is called a z direction. The incoming direction of the fibrous web is called an upstream direction and the outgoing direction of the fibrous web is called a downstream direction. In this connection, the core of reeling is called a reel spool, but it could just as well be called a reeling axis.

The object of the invention is to develop a solution that would enable the build-up of even larger jumbo rolls than before. One object of the invention is also to provide a solution, which, however, as to its reeling principle, is based on the known manner to form jumbo rolls by means of the reel drum.

The object of a certain preferred embodiment of the invention is to provide an especially strong design reel, which is capable of repeating the desired reeling parameter values at an extremely high repetition accuracy, providing a top class jumbo roll, even if, at the beginning, the mass of the reel spool alone and, at the end, the mass of the finished jumbo roll were large in the field compared to a typical mass at the filing date of this application. In other words, the object of the certain preferred embodiment is to provide a new generation reel, which will shift the maximum size of jumbo rolls into a new order of magnitude.

The reel according to the invention is characterized in that the reel drum with its axis in the y direction is shorter than the nominal bearing distance of the reel spool, and that the reel drum is movable in the z direction in the free clearance between the frames, when examined at the rotation axis.
The method according to the invention, in turn, is characterized in that the tightness of the roll formed by the reel according to Claim 1 is affected by means of a press roll by connecting the press roll in a nip contact with the jumbo roll that is to be reeled.

The reel according to the invention can be used to achieve the desired increase in the size of the jumbo roll.

The preferred embodiments of the invention are described in detail by means of the appended drawings, in which:

Fig. 1 shows the cross section of the reel according to a preferred embodiment in the y direction;

Fig. 2 shows the cross section of the reel according to a preferred embodiment in the x direction;

Fig. 3 shows the section of the reel drum and the frame structure of the reel according to a preferred embodiment in the x direction,

Fig. 4 shows an end structure of the reel drum of the reel according to the preferred embodiment;

Figs. 4A, 4B and 4C show embodiments of the arrangement of drives;

Fig. 5 shows a reel according to the preferred embodiment in the z direction;

Figs. 6a-6d and 7a-7d show possible reeling sequences;

Fig. 8 illustrates the effect of the drives on the tightness of the jumbo roll.

Fig. 1 shows a reel 1 comprising, as its main parts, a reel drum 10 and a frame 20. A fibrous web W is reeled, continuously in sequences, around a reel spool 5 that works as the core of reeling, i.e., when the desired amount of fibrous web W has been reeled on a jumbo roll 6, the fibrous web is cut and guided to be reeled around the next empty reel spool 5a. Fig. 1 shows the sequence phase immediately before the changing moment of the jumbo roll, wherein the jumbo roll 6 that is being completed has been transferred to the changing station and off the reel drum 10. At the starting point of reeling, a new reel spool 5a is rotating at an substantially same speed as the propagation speed of the fibrous web W. A nip force F acts between the reel drum 10 and the reel spool 5a. A cutting or turn-up device
40 is ready to cut the fibrous web W that is still moving onto the jumbo roll 6. A press roll 30 that compresses the surface of the jumbo roll 6 takes care of reeling the surface layers of the jumbo roll, which is being completed, and holding it together after pulling out, all the way until the jumbo roll 6 has stopped rotating.

Fig. 2 shows the cross section of the reel 1 according to a preferred embodiment in the x direction. In Fig. 1, the reel spool 5 is supported by the frames 20 at its bearing housings 57. The reel spool is symmetrical with respect to the centre line C, i.e., at each end of the reel spool 5, there are similar structures that are described in detail in connection with Fig. 3. Fig. 2 further shows the structure of the reel drum 10. The reel drum 10 comprises a shell 100, ends 103, axes 105, a web feeding zone 106 and bearings 108. Thus, the reel drum 10 is fitted with bearings 108 to be rotated around the rotation axis 101. The transmission 109 that conveys the rotary movement to the reel drum, and the drive 110 that rotates the reel drum are described in detail hereinafter. Fig. 2 also shows the location of the reel drum 10 between the frames 20.

Fig. 3 shows a more accurate detail of Fig. 2, i.e., the section of the reel drum 10 and the frame structure of the reel 1 according to a preferred embodiment, and the end zone of the reel spool 5 in the x direction.

The reel spool 5 comprises a shell 50, an end 53, an axis 53, a bearing housing 57, inside of which there are bearings 58, and a coupling 59. The sleeve-like bearing housing 57 is pivoted to rotate, by means of the bearings 58, with respect to the rest of the structure of the reel spool 5, i.e., the shell 50, the ends, 53, the axes 55 and the couplings 59 rotate as one assembly that is quite firmly connected together. The force caused by the mass of the reel spool 5 (and the jumbo roll 6) is conveyed to the frames 20 of the reel 1 through the groove 570 that is in the bearing housing 57. The groove 570 ensures that the reel spool 5 remains in a desired location on top of the frames 20.

The nominal bearing distance s1 of the reel spool 5 (the direction is shown by an arrow in Fig. 3) can be determined as a measure, which extends from the middle of the groove 570 of the first end of the reel spool to the middle of the groove 570 of its second end. In this connection, there is no need to define the middle more accurately, since, to be exact, when defining the bearing distance, the properties of the slightly different, and generally two bearings 58 should be taken into account, which bearings are located inside the bearing housing 57. However, the said nominal bearing distance s1 is also the basic size of the distance between the
frames 20, i.e., it is approximately the same as the distance between the middle points of the frames 20, i.e., the distance of the frames 200 (the direction is shown by an arrow in Fig. 3). When two times half the thickness of the frame 20 is subtracted from the distance of the frames 200, this results in an approximate free clearance between the frames, i.e. the "wall to wall" measure between the frames 20. The said measure is not necessarily exactly this, since levelling machining and the like can be carried out in the area, increasing the "wall to wall" measure. In connection with this invention, the thus obtained "wall to wall" measure or distance is called a free clearance 201. Fig. 3 shows one example of the free clearance 201.

Fig. 3 shows that the reel drum 10 with its axis 105 in the y direction is shorter than the nominal bearing distance 51 of the reel spool 5, and that the reel drum 10 is movable in the z direction between the frames 20, as examined at the rotation axis 101. In this embodiment according to the figure, the optional movability in the x direction has also been included in the structure. For the movability, the reel drum 10 is connected to horizontal and vertical guides, of which Fig. 3 shows one horizontal guide 120. In this way, the reel drum 10 is available, when so desired, for producing a nip force F between the jumbo roll 6 and the reel drum 10 in an optional direction on the xz plane, as shown in Fig. 1. Naturally, this optional direction of the nip force requires that the said direction is, at least to a certain degree, towards the jumbo roll 6 or the reel spool 5, for the nip force F to be produced or exist at all.

Fig. 3 also shows, how a drive shaft 1101 is arranged from the drive 110 to convey the rotational force to the reel drum 10, the drive shaft 1101 being arranged to connect to the transmission 109 in the z direction at a distance 1091 from the rotation axis 101 of the reel drum. To provide a disturbance-free and steady rotation speed, it is advantageous to use, as the drive shaft 1101, a constant speed articulated shaft or the like, wherein a momentary angle of the articulation has no effect on the rotation speed or the angular speed of the drive shaft 1101. Accordingly, the drive shaft 1101 in the z direction is at the distance 1091 from the rotation axis 101 of the reel drum, whereby the point of examination comprises the end that is on the side of the reel drum 10 of the drive shaft 1101. This kind of "off-set" is one factor that enables a sufficient strength of the structure of the frame 20 and the thickness of the frame in the z direction 205 next to the rotation axis 101 of the reel drum. The purpose of this is thus to enable the reeling of extremely heavy jumbo rolls 6. The transmission 109 of the reel drum 10 is also in the area of the free
clearance 201. In prior art solutions, the members that correspond to the drive
shaft 1101 are generally directly connected to the rotation axis 101 of the reel
drum 10. This manner, usable as such, however, causes consequences, among
others, regarding the selection of the diameter of the reel drum and the reel spool
and the thickness of the frame in the z direction. If a relatively small diameter reel
drum and/or reel spool is selected for this solution according to the prior art, the
thickness of the frame in the z direction that remains above the drive shaft is de-
termined by the geometry selected for this or other reasons. The solution accord-
ing to the preferred embodiment according to the invention has a considerably
freer geometry.

Fig. 4 shows a structure of the end area of the reel drum 10 of the reel according
to the preferred embodiment. In Fig. 4, the reel drum 10 is thus fitted with bearings
108 (not shown) that are inside the bearing housing 107 to rotate around the rota-
tion axis 101. The reel drum 10 is connected to horizontal (the x direction) guides
120 and vertical (the z direction) guides 121, which enable the movement of the
reel drum on the xz plane. Fig. 4 also shows an embodiment of the transfer
means/power transmission of the reel drum, comprising a first transfer
means/power transmission 130 for arranging a movement and, possibly, a force in
the x direction, and a second transfer means/power transmission 131 for arranging
a movement and a force in the z direction. They can be, for example, hydraulic cylin-
der, servo cylinders, screw jacks or the like. The first transfer means/power
transmission 130 and the second transfer means/power transmission 131 are
preferably capable of measuring out a force extremely accurately, particularly in
the direction of the nip force F. It should also be noticed that the first transfer
means/power transmission 130 and the second transfer means/power transmis-
sion 131 are not necessarily similar, since according to an embodiment, the nip
force F is primarily adjusted in the z direction by means of the second transfer
means/power transmission 131. On the other hand, the oscillation of the jumbo roll
is primarily carried out by means of the first transfer means/power transmission
130 that is in the x direction. In other words, the force or a force component is not
necessarily adjusted in the x direction at all, but the entire force adjustment can be
carried out in the z direction. Accurate position determination equipment have also
preferably been integrated into the first transfer means/power transmission 130
and the second transfer means/power transmission 13 or the associated struc-
tures for determining the exact position of the reel drum 10. In this way, the ge-
ometry of the reel is also known, when the same information is determined on the
jumbo roll. This position determination can be implemented, for example, by
means of a suitable stepper motor, laser position measurement, linear motor, magnetostrictive measurement or the like. According to an embodiment, the bearings 108 of the reel drum and actuating devices 120, 130 in the x direction are placed in the free clearance 201. Furthermore, the actuating devices 121, 131 in the z direction can be placed in the free clearance 201 or outside the same, as in the embodiment shown in Fig. 4.

Fig. 4 also illustrates an embodiment, wherein the drive shaft 1101 that is connected from the drive 110 to the transmission 109 is, in the z direction, at the distance 1091 from the rotation axis 101 of the reel drum. A conventional way of arranging the power transmission of the reel drum is to place a transmission that comprises a gearing including a reduction gear almost in contact with the drive, and to bring the drive shaft from this transmission to the end of the reel drum. In this embodiment according to the invention, the transmission 109 with its possible reduction and increasing gears is at the end of the reel drum in a parallel direction but at the distance 1091. One possible implementation thereof is to place one cogwheel of the gear directly on the axis 105 of the reel drum 10, for example, and the other cogwheel on the second axis, to which the drive shaft 1101 is then connected. The said distance 1091 in such an embodiment can be defined as desired, and a gear pair that meets the requirements can be designed for this case. Another possible implementation comprises the use of a cogged belt and a sprocket pair as the transmission 109. A further possible embodiment is to use an angle transmission so that the play of the reel drum is implemented by means of the intermediate shaft of the angle transmissions. In that case, each end of the drive shaft 1101 can be fitted with bearings in a static bearing housing, when the intermediate shaft in the transmission 109 has been arranged so as to change its length.

In practical applications, the distances 1091 in the z direction may be in the order of 300-900 mm, whereby the said distance would accommodate quite a number of suitable transmission members. One criterion for an applicable numerical value of "at the distance 1091" includes dimensions that can be compared with the radius of the reel drum 10. With values substantially higher than the radius, the structure of the reel 1 may become unnecessarily complex, whereas, when compared with the radius, "at the distance 1091" that has a coefficient of below 0.5 may make it difficult to achieve sufficient power transmission capacity. As a rough generalization, it could be stated that a preferred embodiment would most likely be found at a distance. 1091, which is 0.5-1.5 times the radius of the reel drum.
Fig. 4 also shows a preferred embodiment, wherein the components that participate in the reel drum 10 and moving the reel drum 10 are connected to each other by means of a subframe 150. This enables a logical placement of the devices at a distance from each other that is suitable for the operation; when properly designed, it also stiffens the structures of the reel 1. One particular advantage of this embodiment is its easier maintainability, since almost any component or part of the reel can be quickly and easily replaced, without having to dismantle the structures much. Examples of systems that can be attached to the subframe 150 include the structures of a doctor blade 45 or those of a changing device 40, as shown in Fig. 1.

Fig. 4A shows one alternative embodiment of the arrangement according to Fig. 4, wherein at least one drive 110 is placed in the free clearance 201. The purpose of the solution is to provide a possibility to implement different structural solutions. The basic idea can be implemented in various ways. One such embodiment is based on the solution of a drum motor type, wherein the rotor 110R that comprises the outer shell of the drive 110 is integrated to rotate together with the shell 100 of the reel drum 10. In that case, the axis 105 of the reel drum 10 works as part of the stator 110S and is connected in a non-rotating manner to its base, such as the subframe 150. This solution can be further implemented as a single-drive, whereby there is a drive 110 at one end of the reel drum only, or as a dual-drive, whereby there are similar drives 110 at each end of the reel drum. The advantage of two drives 110 over the single-drive version is the smaller size of the drives, which in turn gives more freedom in designing other structural solutions. A further advantage is the symmetry of the structure of the reel drum 10, which furthers the exact controllability and adjustability of each end of the reel drum with respect to the nip load. On the other hand, a minor extra challenge is presented by adjusting the two drives to work in optimal synchronization with each other.

Fig. 4B shows another alternative embodiment, wherein the drive 110 is directly connected to the transmission 109 without the actual drive shaft 1101. This solution can also be implemented by means of one or two drives 110, as in Fig. 4A.

Fig. 4C further shows an alternative embodiment, wherein a sprocket is connected to the axis 105 of the reel drum, and another sprocket is connected to the axis of the drive 110. In this way, the drive 110 can either be arranged static or to be moved along with the subframe 150.
As a summary, it could be stated that a common factor of the embodiments according to Figs. 4A, 4B and 4C is that the drive(s) 110 are in the free clearance 201. Furthermore, all of these embodiments can comprise one or two drives 110, either at one or both ends of the reel drum 10. The advantages of these embodiments include that the scalability of the reel is facilitated, among others; particularly, in the two-drive embodiments. Scalability herein refers to a property that can be used to change the scale of the structural solutions, when necessary, without a considerable redesign. Another advantage is the possibility to use a relatively small-diameter reel drum 10 and/or a relatively small-diameter reel spool 5, if desired.

Fig. 5 shows a reel according to a preferred embodiment in the z direction. The figure shows one way of arranging the centre drive that provides the centre torque of the jumbo roll, for example. The figure shows a first drive 7 and a second drive 8. They can be arranged in various ways. The first drive 7 can be fixed or movable, so can the second drive 8. The first drive 7 and the second drive 8 can alternately take care of the reeling of the jumbo roll 6 from the beginning to the end. This can be implemented, for example, by a direct drive, wherein the rotor of a synchronous motor is connected to the reel spool substantially without a clearance. In that case, one direct-use synchronous motor can thus arrange the entire reeling from the beginning to the completion of the roll. The direct drive technology has developed in quite a positive direction, regarding the reeling applications of fibrous webs; therefore, this technology can be applied to most end uses in the field of fibrous web reeling. Other applications can include the press rolls of reels or slitter-winders, winding drums, king rolls and possible auxiliary rollers alone or in combinations with the electric drives of the conventional technology. This technology, i.e., the combination of a permanently magnetized motor and a supporting software application makes it possible to obtain more torque by the drive motor than what was possible earlier by conventional short circuit motors of the same size. An especially positive feature in many applications is the possibility to omit the gear.

Another alternative according to Fig. 5 is to arrange the reeling sequentially, so that the first drive 7 starts reeling, reels for a while, whereafter the second drive 8 is connected, while running, to the reel spool 5 through a coupling 59, a turn-up is carried out, and the second drive 8 completes the reeling and stops the finished jumbo roll 6. Also in this embodiment, either one or both of the drives can be direct drives or drives that work through gearing. The press roll 30 (not shown in Fig. 5)
preferably also moves into a nip contact with the jumbo roll 6 slightly before the nip
between the reel drum 10 and the jumbo roll 6 is opened. In this way, the turn-up
with the nip open, which is one possibility in the turn-up sequence of the jumbo
roll, can be carried out, the surface layers of the jumbo roll still remaining high-
quality.

The reel 1 according to Fig. 1 can be used to carry out the reeling sequence ac-
cording to Figs. 6a-6d, which can be called "a turn-up with the nip closed". Alter-
natively, the sequence shown in Figs. 7a-7d can be carried out. This sequence
according to Figs. 7a-7d can be called an "OptiReel turn-up" or "a turn-up with the
nip open".

Fig. 6a shows a sequential phase, where the reel 1 is in its normal reeling mode,
wherein the fibrous web W is reeled into the jumbo roll 6 around the reel spool 5.
The reel drum 10 is pressed against the jumbo roll 6 in a rolling manner. The nip
force F acts between the jumbo roll 6 and the reel drum 10. There are empty reel
spools 5, waiting for their turn. The first one of them, i.e., the reel spool 5a that will
be reeled next, has already been placed in contact with the first drive 7. The first
drive 7 starts to rotate the reel spool 5a well in time before the turn-up, so that any
deformation caused by storing the reel spool 5a can be eliminated before starting
the actual reeling.

Fig. 6b shows the sequence phase immediately before the turn-up or at the mo-
ment of turn-up. The jumbo roll 6 has reached its target value, i.e., generally, the
target length of the fibrous web W that is to be reeled. The press roll 30 is driven
against the jumbo roll 6 that is being completed to prevent unreeling of the jumbo
roll at the deceleration phase. The next reel spool 5a is in contact with the reel
drum 10 upstream of the top dead centre of the reel drum, wherein the reel spool
5a is ready to receive the fibrous web W, starting from the moment of turn-up.
Thus, the fibrous web W is cut between the jumbo roll 6 and the reel spool 5a,
whereby the fibrous web W moves to be reeled around the reel spool 5a.

Fig. 6c shows a situation, where the old jumbo roll 6b is being stopped or has
stopped, and the press roll 30 is still in contact with the surface of the jumbo roll
6b. A new jumbo roll 6a is forming around the reel spool 5a. The reel drum 10
slightly yields (moves slightly downwards in the z direction) to allow the new parent
drum 6a with its reel spool 5a to move from upstream of the reel drum 10 over the
top dead centre and downstream.
Fig. 6d shows a sequence phase, where the old jumbo roll 6b has stopped, i.e., the rotating of the jumbo roll 6b has stopped. After stopping, the press roll 30 is no longer needed to ensure that the jumbo roll 6b stays together; therefore, the press roll is moved to wait for the next implementation. Figs. 6a-6d show one possible location or loading point of the press roll 30, i.e., slightly upstream of the lower dead centre of the jumbo roll that is being completed. The next implementation of the press roll 30 is preferably carried out immediately after the previous jumbo roll has stopped; however, before the next turn-up, at the latest. In Fig. 6d, the new jumbo roll 6a has already been reeling for some time around the reel spool 5a; therefore the diameter of the jumbo roll 6a has already increased to some extent. The jumbo roll 6a continues to increase from here, until the situation according to Fig. 6a has been reached again.

Figs. 7a-7d show another alternative reeling sequence. In Figs. 6a-6d and 7a-7d, the incoming direction of the fibrous web to the reel drum is vertical. However, this is not the only possible implementation, but the angle of arrival can be selected as desired, when taking into account the effect of the tension of the fibrous web on the reel drum.

Fig. 7a shows a sequence phase, where the reel drum is in its normal reeling condition, where the fibrous web W is reeled into a jumbo roll 6 around the reel spool 5. The reel drum 10 is pressed against the jumbo roll 6 in a rolling manner. The nip force F acts between the jumbo roll 6 and the reel drum 10. There are empty reel spools 5 waiting for their turn. The first one of them, i.e., the reel spool 5a that will be reeled next, has already been placed in contact with the first drive 7. The first drive 7 starts to rotate the reel spool 5a well in time before the turn-up, so that any deformation caused by storing the reel spool 5a can be eliminated before starting the actual reeling.

Fig. 7b shows a sequence phase immediately before the turn-up or at the moment of turn-up. The jumbo roll 6 has reached its target value, i.e., generally, the target length of the fibrous web W that is to be reeled. The press roll 30 is driven against the jumbo roll 6 that is being completed to prevent unreeling of the jumbo roll at the deceleration phase. The next reel spool 5a is not in contact with the reel drum 10 upstream of the top dead centre of the reel drum, preferably not until downstream. In that case, the reel drum 10 has thus moved slightly downwards in the z direction, whereby a new reel spool 5a has been able to move from upstream of the reel drum 10 over the top dead centre and downstream. The reel drum 10 may have been able to move downwards already during the reeling of the jumbo roll 6,
so that the next reel spool 5a can pass the top dead centre of the reel drum 10 almost any time during reeling. Before the turn-up, the reel drum 10 is lifted back to its upper position, whereby a nip contact is formed between the reel spool 5a and the reel drum 10. In this position, the reel spool 5a is ready to receive the fibrous web W, starting from the moment of turn-up. Thus, the fibrous web is cut between the jumbo roll 6 and the reel spool 5a, whereby the fibrous web moves to be reeled around the reel spool 5a.

Fig. 7c shows a case, where the old jumbo roll 6b is being stopped or has been stopped and the press roll 30 is still touching the surface of the jumbo roll 6b. A new jumbo roll 6a is forming around the reel spool 5a.

Fig. 7d shows a sequence phase, where the old jumbo roll 6b has stopped, i.e., the rotation of the jumbo roll 6b has stopped and the fibrous web W is being reeled into the jumbo roll 6a. After stopping, the press roll 30 is no longer needed to ensure that the jumbo roll 6b stays together; therefore, the press roll 30 is moved to wait for the next implementation. Figs. 7a-7d show one possible location or loading point of the press roll 30, i.e., slightly upstream of the lower dead centre of the jumbo roll that is being completed. Also in this sequence, the next implementation of the press roll 30 is preferably carried out immediately after the previous jumbo roll has stopped; however, before the next turn-up, at the latest. In Fig. 7d, the new jumbo roll 6a has already been reeling for some time; therefore the diameter of the jumbo roll 6a has already increased to some extent. The jumbo roll 6a continues to increase from here, until the situation according to Fig. 7a has been reached again.

The press roll 30 can have the same properties or almost same properties as the reel drum. One suitable criterion, regarding the operation of the press roll 30, is its capability to produce enough nip force - up to the level of about 5 kN/m. The coating can be slightly rough, flexible or otherwise antiskid, for example. In that case, an antiskid contact can be formed between the fibrous web W and the press roll 30, whereby a reeling force can be provided by the press roll 30 by means of a torque to affect the tension of the jumbo roll 6. This reeling force can be used as an active reeling parameter between a positive reeling force (=pulling) - a negative reeling force (=deceleration). When a smooth surface of the press roll 30 is selected, the torque cannot be used due to slipping; however, the jumbo roll 6 can be tightened by means of the nip force of the press roll 30. If the reel drum 10 and the press roll 30 are selected so as to have similar constructions, then, in addition to the capability to produce identical reeling parameters, a considerable advantage is also
achieved in terms of spare parts, since only one type of spare roll is needed. On the other hand, the press roll that has a smaller diameter than the reel drum can provide some advantages related to the geometry of the reel, such as a flat reel structure.

Fig. 8 illustrates the effect of the use of the press roll 30 on the tension of the jumbo roll 6. In fig. 8, the x axis includes the diameter $D$ of the jumbo roll 6 from the initial diameter $D_0$ to the final diameter $D_3$, and the y axis shows the achieved hardness or reeling tension $H$. The effect of the nip force $F$ and the tension $T$ of the fibrous web on the reeling tightness remains almost constant irrespective of the diameter of the jumbo roll, but the effect of the centre moment $M$ decreases substantially when the diameter increases. This decrease can be compensated by tightening $W_{Ti_2}$ the jumbo roll, which is carried out by the press roll 30. The tightening can be based on the nip force or the torque of the press roll 30 or a combination thereof. Now, the construction of the reel 1 enables the inclusion of such an additional parameter at a very early state of forming the roll. This introduction of the additional parameter $W_{Ti}$ is possible almost immediately after stopping the completed jumbo roll 6, as long as the press roll 30 has been moved to its loading position, where the press roll is pressed against the jumbo roll. In that case, the diameter of the jumbo roll is $D_i$. To be more precise, the introduction can be carried out simultaneously with the stopping, or even before the finished jumbo roll stops, if the fibrous web has properties, which enable the jumbo roll to stay without unreeling at the final stage of the deceleration. Another alternative is not to introduce the same reeling tightness $W_{T_2}$ that is provided by the press roll until at the final stage of the reeling, when the diameter of the jumbo roll is $D_2$. In that case, the effect on the hardness $H$ remains considerably smaller than in the previous alternative. The said loading station can be placed in various places, but to provide a free movability for the jumbo rolls 6, one preferred location is slightly upstream of the lower dead centre of the jumbo roll. In this way, the diameter of the press roll 30 can be selected relatively freely without having to lift the completed jumbo roll over the press roll 30 or arranging an especially "low" position for the press roll for this bypass procedure.

Furthermore, the preferred embodiments that are shown in Fig. 1 include a feature, wherein the doctor blade 45 of the reel drum 10 is placed in the same functional entity, e.g., in the subframe 150, as the reel drum, whereby the doctor blade 45 is arranged to move along with the reel drum 10. In an especially preferred embodiment, the cutting device 40, or more generally, the turn-up device 40 is inte-
grated into the structure of the doctor blade 45, thus cuts the fibrous web, by order of the operator or the control system, guiding it to be reeled around the new reel spool 5. The turn-up device can be, for example, a water-jet turn-up device, a (lower) gooseneck, a cut blade turn-up device or another similar turn-up device.

The reel according to the invention enables a few very attractive alternatives. When so desired, the reel drum can be selected so as to have a relatively small-diameter roll, which enables a nip that effectively prevents air from entering the roll. Another advantage of a certain embodiment of the invention is its applicability to what are called re-build cases, whereby there is a reel that is to be modernized in the paper mill or the like. The reel presented above is easy to apply to such cases, as the diameter of the reel spool is no longer a critical factor regarding the geometry of the reel; certainly, it still determines the largest possible jumbo roll 6 that is to be reeled. Secondly, no problems should be presented by the height of the machine hall due to the low layout of the reel 1.
The reference numbers used in the figures:

1 reel

10 reel drum

5 100 shell
101 rotation axis
103 end
105 axis
106 web-feeding zone (suction zone)

10 107 bearing housing
108 bearing
109 transmission
1091 distance
110 drive

15 110R rotor
110S stator
1101 drive shaft
120 horizontal guide
121 vertical guide

20 130 first transfer means/power transmission
131 second transfer means/power transmission
150 subframe

20 frame

25 200 distance of frames
201 free clearance
205 thickness of frame in the z direction

30 press roll

30 40 cutting device, turn-up device
45 doctor blade

5 reel spool
5a reel spool

35 50 shell
51 nominal bearing distance
53 end
55 axis
57 bearing housing
570 groove
58 bearing
5 coupling
6 jumbo roll
7 first drive
8 second drive
10 C centre line
   F nip force
   W fibrous web
CLAIMS:

1. A reel (1) for continuously reeling a fibrous web into a jumbo roll (6) around a reel spool (5), characterized in that the reel drum (10) with its axis (105) in the y direction is shorter than the nominal bearing distance (51) of the reel spool (5), and that the reel drum (10) is movable in the z direction in the free clearance (201) of the frames (20), as examined at the rotation axis (101).

2. A reel (1) according to claim 1, characterized in that the reel drum (10) is movable in the x direction.

3. A reel (1) according to claim 1, characterized in that a drive shaft (1101) is arranged to convey a rotational power from a drive (110) to the reel drum (10), the drive shaft (1101) being arranged so as to connect to a transmission (109) in the z direction at a distance (1091) from the rotation axis (101) of the reel drum.

4. A reel (1) according to claim 1, characterized in that a drive shaft (1101) is arranged to convey a rotational power from the drive (110) to the reel drum (10), the drive shaft (1101) being arranged so as to connect to a transmission (109) in the z direction at a distance from the rotation axis (101) of the reel drum, the distance being 0.5-1.5 times the radius of the reel drum (10).

5. A reel (1) according to claim 2, characterized in that the reel drum (10) is available, when so desired, for producing a nip force (F) between the jumbo roll (6) and the reel drum (10) in an optional direction on the xz plane.

6. A reel (1) according to Claim 1, characterized in that the reel drum (10) is arranged so as to produce a nip force (F) between the jumbo roll (6) and the reel drum (10) in the z direction.

7. A reel (1) according to claim 1, characterized in comprising a second transfer means/power transmission (131) for arranging movements and power in the z direction.

8. A reel (1) according to claim 1, characterized in that the transmission (109) of the reel drum (10) is in the area of the free clearance (201).

9. A reel (1) according to claim 1, characterized in that the bearings of the reel drum (108) are placed in the free clearance (201).
10. A reel (1) according to claim 1, characterized in that the reel drum (10) is connected to vertical guides (121).

11. A reel (1) according to claim 1, characterized in that there are transfer means (121, 131) in the z direction placed in the free clearance (201), outside the free clearance (201) or next to the nominal bearing distance (51).

12. A reel (1) according to claim 2, characterized in comprising a first transfer means/power transmission (130) for arranging movements in the x direction.

13. A reel (1) according to claim 2, characterized in that the reel drum (10) is connected to horizontal guides (120).

14. A reel (1) according to claim 2, characterized in that the transfer means (120, 130) of the reel drum in the x direction are placed in the free clearance (201).

15. A reel (1) according to claim 1, characterized in that the doctor blade (45) of the reel drum (10) is placed in the same functional entity, such as a subframe (150), as the reel drum (10), whereby the doctor blade (45) is arranged so as to move along with the reel drum (10).

16. A reel (1) according to claim 1, characterized in that a changing device (40) is integrated into the structure of the doctor blade (45).

17. A reel (1) according to claim 1, characterized in that there is at least one drive (110) in the free clearance (201).

18. A reel (1) according to claim 1, characterized in that all of the drives (110) are in the free clearance (201).

19. A reel (1) according to claim 1, characterized in that the rotor (110R) that comprises the outer shell of the drive (110) is integrated to rotate together with the shell (100) of the reel drum (10).

20. A reel (1) according to claim 1, characterized in that the drive (110) is connected directly to the transmission (109).

21. A reel (1) according to claim 1, characterized in that a sprocket is connected to the axis (105) of the reel drum (10) and a second sprocket is connected to the axis of the drive (110).
22. A reel (1) according to claim 1, characterized in that there can be one or two drives (1 10), either at one end only or at both ends of the reel drum (10).

23. A method of continuously reeling a fibrous web into a jumbo roll (6) around a reel spool (5), characterized in that the tightness of the roll that is formed by the reel (1) according to claim 1 is affected by means of a press roll (30) by connecting the press roll (30) into a nip contact with the jumbo roll (6) that is to be reeled.

24. A method according to claim 23, characterized in that the press roll (30) can be connected into a nip contact with the jumbo roll (6), which is to be reeled, before stopping the jumbo roll (6), simultaneously with stopping the jumbo roll (6), after stopping the jumbo roll (6) or, at the latest, before releasing the jumbo roll (6) from the nip contact with the reel drum (10).

25. A method according to claim 23, characterized in that between the fibrous web (W) and the press roll (30), a firm contact can be formed, whereby the tightening (WT₁, WT₂) of the jumbo roll (6) that is provided by the press roll (30) can be based on the nip force or the torque of the press roll (30), or a combination thereof.

26. A method according to claim 23, characterized in that the effect of the press roll (30) that tightens the jumbo roll (6) is used to compensate the effect of the increasing radius of the jumbo roll (6) on the reeling tightness provided by the centre moment (M).
FIG. 8
PCT/EP2005/00089

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2000/00221

The applicant has been informed of the international filing date (24 November 1994) and the priority date (20 December 1993).

Acknowledgment of receipt of the international request

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

B65H

Minimum documentation searched (classification system followed by classification symbols)

B65H

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Further documents are listed in the continuation of Box C

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Additional Information

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Date of the actual completion of the international search

3 April 2009

Date of mailing of the international search report

16/04/2009

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