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(54) **Title**: A ROLL FOR A FIBRE-WEB MACHINE DRYER SECTION AND A METHOD OF MANUFACTURING A FIBRE-WEB MACHINE DRYER SECTION ROLL

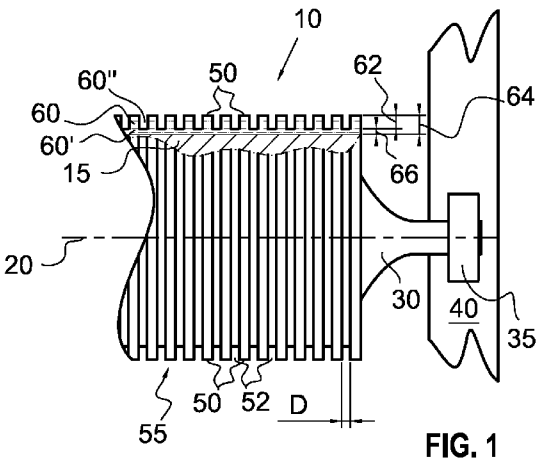


FIG. 1

(57) **Abstract**: The present invention relates to a roll (10) for a fibre-web machine comprising a roll body (15), by means of which the roll can be fitted to rotate in the fibre-web machine, a surface structure (60) arranged in conjunction with the body comprising a plurality of ribs (50) spaced at a distance from one another and extending around the roll body thus forming a surface (55) that is open in a slot-like manner. The ribs (50) and the substructure (60') of the surface structure (60) inside them in the radial direction of the roll form a substantially uniform structure. The invention also relates to a method of manufacturing a roll for a fibre-web machine and to machining tools for providing adjacent grooves (52) in the surface structure (60) of the fibre-web machine roll (10).

A ROLL FOR A FIBRE-WEB MACHINE DRYER SECTION AND A METHOD OF MANUFACTURING A FIBRE-WEB MACHINE DRYER SECTION ROLL

The invention relates to a roll for a fibre-web machine dryer section according to the preamble of claim 1 comprising a roll body, by means of which the roll can be fitted to rotate in the fibre-web machine, a surface structure arranged in conjunction with the body comprising a plurality of ribs spaced at a distance from one another and extending around the roll body thus forming a surface that is open in a slot-like manner, which ribs and the substructure of the surface structure inside them in the radial direction of the roll form a substantially uniform structure.

The invention also relates to a method of manufacturing a roll for a fibre-web machine dryer section according to the preamble of claim 9, in which method composite material is brought to the roll body to form the outer surface of the roll, and in which method the outer surface is formed to comprise a plurality of ribs spaced at a distance from one another and extending around the roll body thus forming a surface that is open in a slot-like manner.

The behaviour of air and the pressure conditions in fibre-web machines have become ever more important factors along with the increasing running speed. In a fibre-web machine, many efforts have been made to affect especially on the contact between the rolls/cylinders and the travelling web as well as to provide an undisturbed web travel. Particularly, the guiding of the web travel over the roll surface without a web support fabric external with respect to the roll may easily cause runnability problems for the web both in the normal run and in the tail-threading phase. In the nip area formed in the junction point of the web coming to the roll and the roll surface, an overpressure of several pascals is generated with smooth rolls at higher speeds aiming at releasing the web from the roll surface.

In order to improve runnability, several types of suction and blow boxes with the purpose of solving this problem are known from prior art. The suction and blow boxes require, however, large-sized air ducts and fans for driving them. Naturally, these kinds of solutions also consume energy.

WO 9827274 A1 discloses a roll structure, in which the roll surface structure connected to the axle by means of support pieces is in a slot-like manner open so that its openness is higher than 10 %, preferably higher than 20 %, for providing a suction effect during the rotation of the roll for sucking air inwards into the roll, whereby a flow of air through the roll arises. By the solution according to the document the runnability in single-wire draw can be improved, as the problem related to the generation of detrimental overpressure in the inlet nip is solved, and thus the use of above-mentioned suction or blow boxes may be decreased and even avoided by utilising the disclosed roll structure. The roll according to the document is provided by composing the shell section of the roll of plate-like annular disks, which are spaced at a distance from one another, open in the middle and interconnected by means of a fastening bar passing through the ends of the arms arranged on the support piece. The document also discloses a structure, in which the roll shell is composed of bars or of a net supported onto the axle, and the formation of the shell section by winding a sheet band spirally around the axle.

US 7,351,309 discloses a roll having a surface structure with a large open area. According to the document, the surface structure may be composed of plate disks provided on the centre shaft of the roll or alternatively, of grooves machined in the roll body.

DE 10 2007 055 897 A1 discloses a roll of similar type, in which the shell section is composed by mounting at least two-part wreaths on the roll body.

In the above-described solutions the problem is the complexity of manufacture. Since the important functionality of this type of rolls is to improve the runnability especially in the single-wire draw in a fibre-web machine by solving the problem of detrimental overpressure generated in the inlet nip, the dimensions of the outer surface of the roll are of crucial importance. To manufacture a technical solution according to prior art includes a lot of repeated work, which is relatively precise and thereby also relatively slow. A special problem related to the above-described solutions is their poor applicability on rebuilds.

One purpose of the invention is to provide a roll for a fibre-web machine, which is simple to manufacture and which operates efficiently and reliably in a fibre-web machine thus providing a functionality that improves its runnability.

One purpose of the invention is also to provide a method, by which it is possible to manufacture or rebuild a fibre-web machine roll in an efficient and simple way.

The objects of the invention are achieved primarily as disclosed in the appended claims 1 and 9.

Additional characteristic features of the invention are disclosed in the appended claims and in the following description of the embodiments shown in the figures.

A roll for a fibre-web machine dryer section according to one embodiment comprises a roll body, by means of which the roll can be fitted to rotate in the fibre-web machine, a surface structure arranged in conjunction with the body comprising a plurality of ribs spaced at a distance from one another and extending around the roll body thus forming a surface that is open in a slot-like manner. The ribs and the substructure of the surface structure inside them in the radial direction of the roll form a substantially uniform structure, in which the surface that is open in a slot-like manner is formed of grooves, the depth of each groove being 10 - 155 mm and the groove width 1 - 50 mm.

Thus, the ribs and the substructure are solidly integrated as one structure. The monolithic uniform structure formed by the ribs and the substructure is preferably a fibre-reinforced composite structure.

According to one embodiment, the surface structure is through its entire thickness composed of the same fibre material, fibre type and matrix material.

According to another embodiment, the fibre-containing reinforcing composition of the composite structure is different within the area of the substructure from the one within the rib area.

The advantages of the invention are mainly its efficiency and simplicity. A roll of this kind is simple to manufacture and its structure is rigid.

In the method of manufacturing a roll for a fibre-web machine dryer section according to one embodiment of the invention, material is brought to the roll body to form the outer surface structure of the roll, and the surface structure of the outer surface is formed to comprise a plurality of ribs spaced at a distance from one another and extending around the roll body thus forming a surface that is open in a slot-like manner. Composite material is brought to the body to form an essentially even surface structure and the ribs extending around the roll body are formed by providing the surface structure with 10 - 150 mm deep slots spaced at a distance from one another.

Preferably, the surface structure is composed of composite material so that the surface structure is formed by winding fibre-containing reinforcing material around the roll body and by bringing matrix material into the fibre-containing reinforcing material, which matrix material is cured at least partially before forming the ribs.

The roll according to the invention can be manufactured by machining tools for providing adjacent grooves in the surface structure of the fibre-web machine roll. The machining tools according to the invention comprise cutters arranged on a rotatable drive shaft, which cutters are discoid cutters, the working face of which is located on their periphery, and the cutters are arranged on the drive shaft at a distance from one another.

In the following, the invention and its operation will be explained with reference to the appended schematic drawings, of which

- Figure 1 shows schematically one embodiment of the roll for a fibre-web machine according to the invention,
- Figure 2 shows schematically one apparatus and one method stage in the solution according to the invention,
- Figure 3 shows schematically another apparatus and method stage in the solution according to the invention, and

- Figure 4 shows schematically yet another apparatus and method stage in the solution according to the invention.

Figure 1 shows schematically one embodiment of the roll 10 for a fibre-web machine according to the invention. Only one end of the roll is shown for the sake of clarity and the shown structure illustrates the structure of the entire roll. The roll comprises a roll body 15, by means of which the roll 10 can be fitted to rotate around its longitudinal shaft 20 in the fibre-web machine. The roll comprises end sections 25 at both ends of the roll body, which are provided with shafts 30. The roll can be supported onto the frame 40 of the fibre-web machine by means of the shafts via the bearings 35 arranged at their ends. The roll body is preferably of steel construction, typically of cast iron.

The outer surface of the roll body 15 is provided with a surface structure 60 arranged directly on the body surface, in which surface structure several ribs 50 spaced at a distance D from one another are arranged. Here, the ribs and the slots 52 between them extend around the roll body 15 perpendicularly with respect to the longitudinal shaft 20 of the roll. Thus, there is a slot between two successive ribs, whereby the surface is a surface 55 that is open in a slot-like manner. This kind of a surface, which is open in a slot-like manner, has a positive impact on the operation of the fibre-web machine roll as a runnability component, while the fibre-web machine is running, such as described e.g. in the applicant's earlier patent specification US 7,351,309. According to one advantageous embodiment of the invention a structure that is open in a slot-like manner is achieved by a slot-shaped surface structure, in which the openness of the surface structure is more than 10 %, preferably more than 20 %. The openness of the surface structure refers to the ratio of the area of the slots to the area of the outer surface of the entire roll.

In a roll according to one embodiment of the invention the surface structure is formed so that a grooving is provided, in which the depth 62 of each groove is about 10 - 155 mm and the width D of the groove 52 is 1 - 50 mm. More advantageously, the ratio of the groove width to the rib width is 0.6 - 2.0.

According to another embodiment of the invention, the roll is a dryer section roll in a fibre-web machine and the surface structure of the roll is provided with a set of

grooves, in which the depth 62 of each groove is about 18 - 85 mm and the width D of the groove 52 is 6 - 10 mm. Also in this embodiment, the ratio of the groove width to the rib width is 0.6 - 2.0. A roll of this kind is particularly advantageous in the single-wire draw of the dryer section in a position, in which the web travels supported by a support fabric and goes around the roll on the outer surface of the support fabric with respect to the rotation shaft of the roll.

According to yet another embodiment of the invention, the roll is a web support roll in the impingement dryer of a fibre-web machine and the surface structure of the roll is provided with a set of grooves, in which the depth 62 of each groove is preferably about 18 - 85 mm and the width D of the groove 52 is 6 - 10 mm. Also in this embodiment, the ratio of the groove width to the rib width is 0.6 - 2.0. A roll of this kind is advantageous as a web support roll in the impingement dryer of the dryer section, in which the web is led over the roll with a relatively small coverage.

The thickness 64 of the surface structure 60 is larger than the depth 62 of the grooves 52 to be formed, whereby the surface structure of the roll comprises a substructure 60' under the bottom of the grooves in the radial direction of the body, which substructure covers essentially uniformly the functional shell surface of the entire roll body. The thickness 66 of the substructure is preferably over 2 mm. The ribs 50 on the roll and the substructure 60' below the ribs comprise a uniform structure in the radial and axial direction. In this context, this is also called a monolithic surface structure 60. Here, the contact surface of the ribs via the substructure to the body 15 is very wide.

The surface structure is preferably formed of a fibre-reinforced composite structure that comprises reinforcing fibres bonded together by means of a polymeric matrix. The fibre material, as such, may be of several types. Some suitable types are continuous fibre, non-woven mat or chopped staple fibre. Examples of typical fibre materials are glass, carbon and aramid fibre. A polymeric matrix is typically made of epoxy, but also other polymers having a sufficient high-temperature stability, such as vinyl ester urethane, may be used. According to one embodiment of the invention, the surface structure is through its entire thickness composed of the same fibre material, fibre type and matrix material.

According to another embodiment of the invention, the substructure 60' may have a different composition of reinforcing fibres from the one in the perpendicular part of the surface structure, in which the grooves 52 and ribs 50 are formed (hereafter referred to as a rib area 60"). In the substructure 60', for instance glass fibre may be used and in the rib area 60" carbon fibre, and/or the fibre in the substructure may be in the form of continuous fibre or non-woven mat, whereas in the rib area or in the part thereof staple fibre or even very small-sized fibre particles, such as fibre powder or nanofibre, may be used. Also, the fibre content may vary. The fibre content is preferably about 10 – 70 %. Preferably, the fibre content varies so that the fibre content in the area of the substructure 60' is higher than that in the rib area 60". The fibre content in the area of the substructure 60' is preferably about 50 - 90 %, whereas the fibre content in the rib area 60" is about 50 %. When using different types of fibres, the shortest or smallest fibres are preferably used in the rib area 60", and most advantageously close to the surface. A lower fibre content and/or a smaller fibre length make/-s it easier to form the grooving by machining. Preferably, the matrix material is, however, the same both in the substructure 60' and in the rib area 60".

In the following, the process of manufacture of a roll provided with a surface that is open in a slot-like manner according to one embodiment of the invention will be explained with reference to Figures 2 and 3. The roll 10 is placed to be rotated on its bearings 35 or on another arrangement and the roll body 15 is cleaned and, when necessary, pre-treated to improve the adhesion of the surface structure. As shown schematically in Figure 2, new material is brought onto the surface of the body 15 of the roll 10, which material is preferably a fibrous strand 71 or the like containing matrix material and essentially impregnated. For this purpose, a feed system 70 for the fibrous strand is used in the method. The fibrous strand may be pre-impregnated with matrix material, whereby it can be fed and guided on top of the roll body essentially as such. The feed system 70 comprises an unwinding station 74 for the roller/-s of fibrous strand and, as an option following it in the travel direction of the fibrous strand 71, a wetting system 75 for the fibrous strand, for wetting the strand with matrix material. This is required, if the fibrous strand is not pre-impregnated.

The fibrous strand is brought onto the surface of the roll 10 by winding it as a relatively narrow strip of about 5 - 30 cm and at the same time rotating the roll. The

feed system 70 is movable in the longitudinal direction of the roll 10 over the entire length of the roll, whereby successive layers of fibrous strand are formed, while rotating the roll and simultaneously moving the feed system. In the figure, the various directions of motion of the feed system 70 are shown by a solid line and a dashed line. In this manner, an essentially smooth surface structure 60 is formed on the body of the roll 10, which surface is of substantially uniform structure in the radial and axial direction, in other words a monolithic surface structure 60. As soon as the thickness of the surface structure is as desired, typically 15 - 20 mm, in any case at least 2 mm thicker than the depth of the grooves made by the method, the surface structure is pre-cured by utilising a heat source, for instance an infrared radiator 72. During the pre-cure, the temperature of the surface material is raised to about 60°C, whereby it cures, but is still relatively easy to machine.

After this, as shown in a simplified manner in Figure 3, ribs 50 spaced at a distance D from one another are formed on the surface structure 60 by machining, whereby slots 52 are formed between the ribs. Several successive slots 52 in the longitudinal direction of the roll 10 are formed simultaneously so that the slots are, however, formed in several different steps in the longitudinal direction of the roll body 15.

As soon as all the necessary slots and ribs are made on the surface structure 60, the final cure of the surface structure is performed for instance by using an infrared radiator 72. In the final cure, the temperature of the surface structure is raised to exceed 100°C, whereby it is ultimately cured. After this, the finish grinding and surface treatment that smoothens the outer surface of the ribs are performed.

With reference to Figure 3, the invention also relates to machining tools 100 for providing adjacent grooves 52 in the surface structure 60 of the roll 10. The machining tools 100 comprise a cutter head, at which a plurality of cutters 115 or the like are arranged at a distance from one another. The cutters 115 may be separate or the cutters may also form a cutter unit that comprises several machining points. The machining tools 100 comprise a drive shaft 110, on which the cutters 155 are adapted. The drive shaft is rotatably adapted in the machining tools and arranged in force transmission connection with a motor 120. The cutters are discoid cutters, the periphery of which is provided with a working face. The cutters 115 extend 10 - 155 mm, preferably 18 - 85 mm, from the outer surface of the machining tools. The width

of the cutter is 1 - 50 mm, more advantageously 6 - 10 mm. The cutters are discoid cutters.

The grooves are formed by utilising the machining tools 100, while the cutters 115 rotate on the drive shaft. The machining tools in this embodiment are adapted in a support structure 130 in the longitudinal direction of the roll, along which support structure they may be moved during the transfer of the cutter head. The machining tools are brought in connection with the surface structure 60 and guided so as to make the cutters 115 reach the desired groove depth in the surface structure by simultaneously rotating the roll 10. As soon as the first set of adjacent grooves are made to extend around the roll shell in the final groove depth, the cutters are lifted up from the grooves and the machining tools 100 are moved to the next machining position in the longitudinal direction of the roll, in which position the next set of adjacent grooves are formed in the surface structure. This is continued till the surface structure of the entire roll is grooved. Figure 3 shows the starting point of machining one set 52.1 of adjacent grooves. Figure 3 shows machining tools 100 with three adjacent cutters 115. In practise, the number of cutters is preferably at least three.

The roll 10 may be a roll, a cylinder or the like already existing in a fibre-web machine (in this context a roll refers generally to rolls, cylinders, or similar components in a fibre-web machine), whereby in the method according to one embodiment of the invention the roll is manufactured so that an existing roll in a fibre-web machine is converted to a roll having a surface that is open in a slot-like manner. It is often necessary to pre-treat the surface of the existing roll. In practise, this means at least cleaning. Preferably, the method comprises the method steps described below. After the pre-treatment, a surface structure 60 is formed on the roll surface, preferably as explained in the above with reference to Figure 2.

One embodiment of the method of converting an existing roll in a fibre-web machine to a roll provided with a surface that is open in a slot-like manner, is realised as explained in the following with reference to Figure 4. It shows schematically how material is brought onto the surface of the body 15 of the roll 10 in a fibre-web machine, which material is a fibrous strand 71 or the like essentially impregnated with matrix material. For this purpose, a feed system 70 for a non-woven mat

arranged outside the fibre-web machine is used in the method. Here, the feed system 70 is arranged to feed the fibrous strand first in the longitudinal direction of the roll 10 and then in a substantially perpendicular direction with respect to the longitudinal direction of the roll. For this purpose, the feed system 70 comprises a folding section 76 for a non-woven mat to fold the travel direction of the non-woven mat. The folding section is arranged movably in a guide 77 running in the transverse direction of the fibre-web machine (in the longitudinal direction of the roll 10). For carrying out the method, the guide is temporarily mounted to run parallel with the roll. The feed system 70 comprises an unwinding station 74 for the roller/-s of fibrous strand and a wetting system 75 for the non-woven mat following it in the travel direction of the web 71 of fibrous strand.

The fibrous strand is brought onto the surface of the roll 10 by winding it as a relatively narrow strip of about 5 - 30 cm and at the same time rotating the roll. The folding section 76 of the feed system 70 is movable in the longitudinal direction of the roll 10 over the entire length of the roll, whereby successive layers of fibrous strand are formed, while rotating the roll and simultaneously moving the folding section 76. In this manner, an essentially smooth surface structure 60 is formed on the body of the roll 10, i.e. a monolithic surface structure 60. As soon as the thickness of the surface structure is as desired, the surface structure is pre-cured by utilising a heat source, for instance an infrared radiator 72, as explained in the description of Figure 2. This embodiment involves a temporary adaptation of a heat source in the vicinity of the roll 10 in the fibre-web machine.

Material may be brought onto the surface of the body 15 of a roll 10 being installed in a fibre-web machine, i.e. to form a surface structure 60 also as explained in the above with reference to Figure 2, whereby the feed system is preferably located below the roll 10, when forming the surface structure. The feed system 70 is placed on that side of the roll 10, where there is most or enough space.

After this, as shown in a simplified manner in Figure 3, ribs 50 spaced at a distance D from one another are formed on the surface structure 60 by machining, whereby slots are formed between the ribs. Especially when carrying out the method of converting an existing roll in a fibre-web machine to a roll 10 provided with a surface that is open in a slot-like manner, the support structure 130 for the machining tools

100 is preferably arranged to be supported onto other rolls and/or drying cylinders in the vicinity of the roll 10.

As soon as all the necessary slots and ribs are made on the surface structure 60, the final cure of the surface structure is performed by means of a heat source adapted in the fibre-web machine. As mentioned in the above, e.g. an infrared radiator 72 may be used as a heat source. According to one embodiment, the heat source affects only a relatively small area and it is mounted in the fibre-web machine traversingly in the cross direction. According to another embodiment, the heat source extends in the direction of the roll over the entire surface material. In the final cure, the temperature of the surface structure is raised to exceed 100°C, whereby it is ultimately cured. The roll is rotated during both the pre-cure and the final cure. After this, the finish grinding and surface treatment that smoothen the outer surface of the ribs are performed.

In the above description, the forming of the surface structure 60 is carried out by utilising a fibrous strand. Depending on the application, the fibrous material may, however, be fed as a strand or as a mat. The strand itself may comprise an unwoven continuous fibre, a lump of fibre or a woven strand. The mat is wider than the strand and as widest it may extend even over the length of the entire roll shell. Then, the surface structure is formed in one go over the entire roll width by winding the mat around the roll and it is not necessary to move the feed system 70 in the longitudinal direction of the roll. The fibre material may be pre-impregnated or it may also be impregnated after spreading it on the roll surface, for instance by brushing, spraying or by another suitable method.

It is to be noted that only a few most advantageous embodiments of the invention are described in the above. Depending on the matrix, the details of the manufacturing of the composite construction may vary. Thus, it is clear that the invention is not limited to the above-described embodiments, but may be applied in many ways within the frame of the appended claims. The features described in conjunction with the different embodiments may be used in conjunction with other embodiments as well and/or various combinations of the described features may be made within the frame of the basic idea of the invention, if so desired, and if technical feasibility for this exists.

CLAIMS

1. A roll (10) for a fibre-web machine dryer section comprising a roll body (15), by means of which the roll can be fitted to rotate in the fibre-web machine, a surface structure (60) arranged in conjunction with the body comprising a plurality of ribs (50) spaced at a distance from one another and extending around the roll body thus forming a surface (55) that is open in a slot-like manner, which ribs (50) and the substructure (60') of the surface structure (60) inside them in the radial direction of the roll form a substantially uniform structure, **characterised** in that the surface (55) that is open in a slot-like manner comprises a grooving, the depth (62) of each groove being 10 - 155 mm and the width (D) of the groove (52) 1 - 50 mm.

2. A roll according to claim 1, **characterised** in that the surface (55) that is open in a slot-like manner comprises a grooving, the depth (62) of each groove being 18 - 85 mm and the width (D) of the groove (52) 6 - 10 mm.

3. A roll according to claim 3, **characterised** in that the ratio of the groove width to the rib width is 0.6 - 2.0.

4. A roll according to claim 1, **characterised** in that the roll body (15) and the uniform surface structure (60) are of different material, respectively, and that the uniform structure formed by the ribs (50) and the substructure (60') is a fibre-reinforced composite structure.

5. A roll according to claim 1, **characterised** in that the surface structure is through its entire thickness composed of the same fibre material, fibre type and matrix material.

6. A roll according to claim 1, **characterised** in that within the area of the substructure (60') the fibre-reinforced composition of the composite structure is different from the one within the rib area (60").

7. A roll according to claim 6, **characterised** in that in the substructure (60') the fibre reinforcement is composed of glass fibre and in the rib area (60") of carbon fibre.

8. A roll according to claim 5, **characterised** in that within the area of the substructure (60') the fibre material is essentially in the form of continuous fibre or non-woven mat, and that within the rib area (60") or within a part thereof the fibre material is of staple fibre or of fibre particles.

9. A method of manufacturing a roll (10) for a fibre-web machine dryer section, in which method material is brought onto the roll body (15) to form the surface structure (60) of the roll, and in which the surface structure is formed to comprise a plurality of ribs (50) spaced at a distance from one another and extending around the roll body (15) thus forming a surface (55) that is open in a slot-like manner, **characterised** in that composite material is brought onto the body (15) to form an essentially uniform surface structure (60), and that the ribs (50) extending around the roll body are formed by providing the surface structure (60) with 10 - 150 mm deep slots (52) spaced a distance from one another.

10. A method according to claim 9, **characterised** in that the fibre content in the composite material of the surface structure (60) is arranged to be about 50 - 90 % within the area of the substructure (60') under the grooves, whereas the fibre content in the rib area 60" is arranged to be about 50 %.

11. A method according to claim 9, **characterised** in that the slots (52) are formed in several different steps in the longitudinal direction of the roll body, and that several successive slots in the longitudinal direction of the roll are formed simultaneously.

12. A method according to claim 9, **characterised** in that the depth of the slots in the radial direction of the roll body (15) is less than the thickness of the formed surface structure (60).

13. A method according to claim 9, **characterised** in that the cure of the composite material of the surface structure is performed in at least two steps so that the ribs are formed in the surface structure between the steps of pre-cure and final cure.

14. A method according to claim 9, **characterised** in that the surface structure is formed by winding fibre-containing reinforcing material, essentially impregnated with matrix material, around the roll body.

15. A method according to claim 9, **characterised** in that the surface structure is formed by winding fibre-containing reinforcing material around the roll body (15) and by bringing matrix material into the fibre-containing reinforcing material.

16. A method according to claim 9, **characterised** in that the ribs (50) are formed by providing the surface structure (60) with 18 - 85 mm deep slots (52) spaced at a distance from one another.

17. A method according anyone of claims 9 - 16, **characterised** in that the method is carried out without removing the roll (10) from the fibre-web machine.

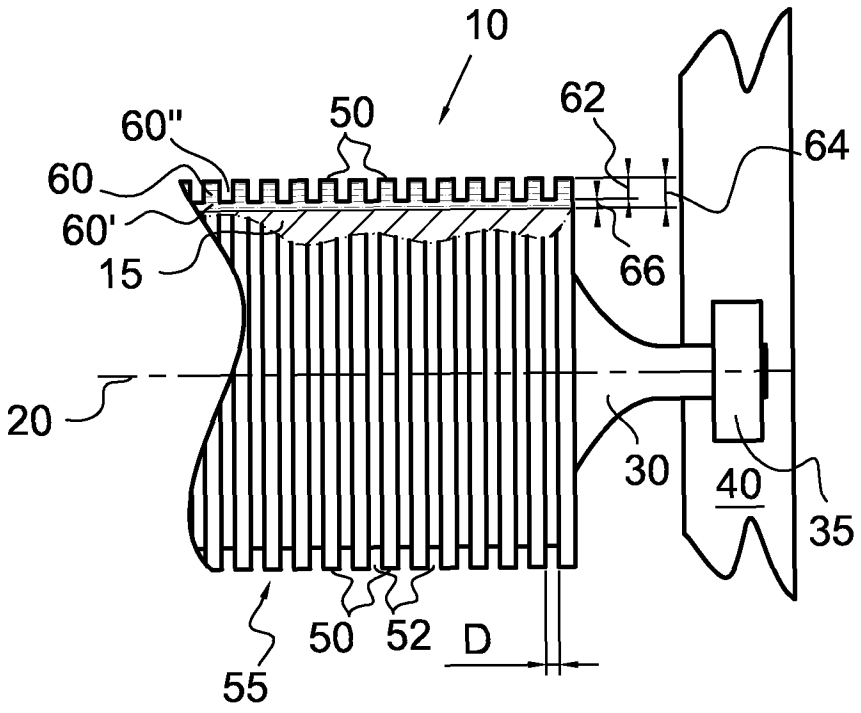


FIG. 1

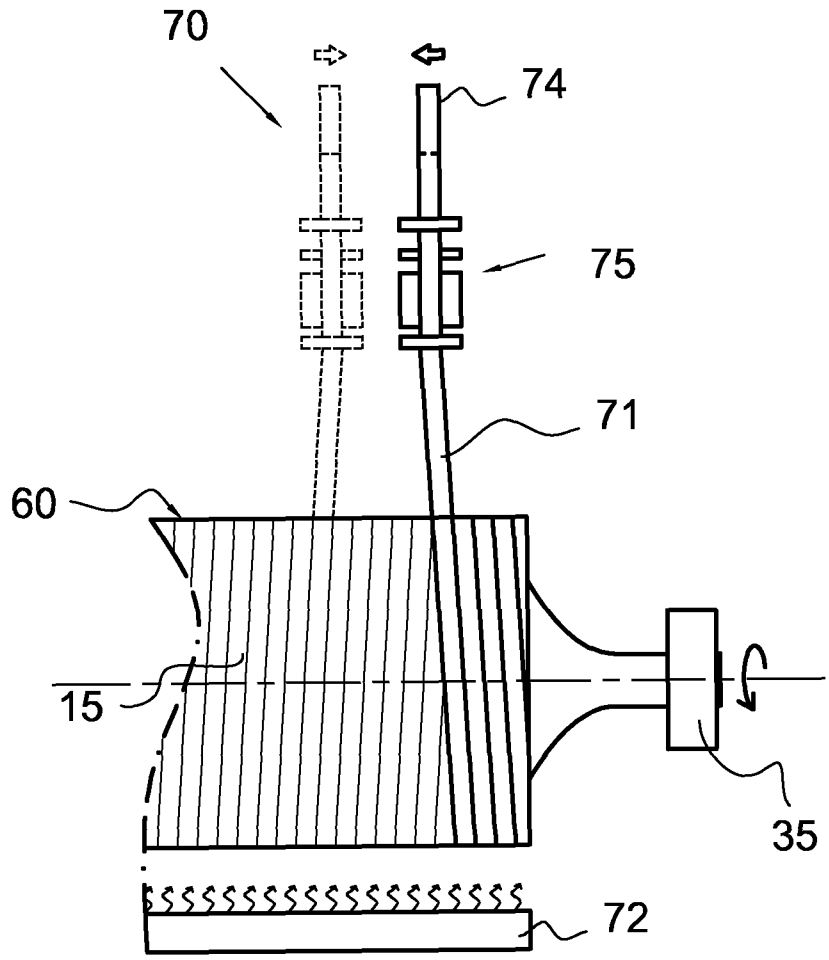


FIG. 2

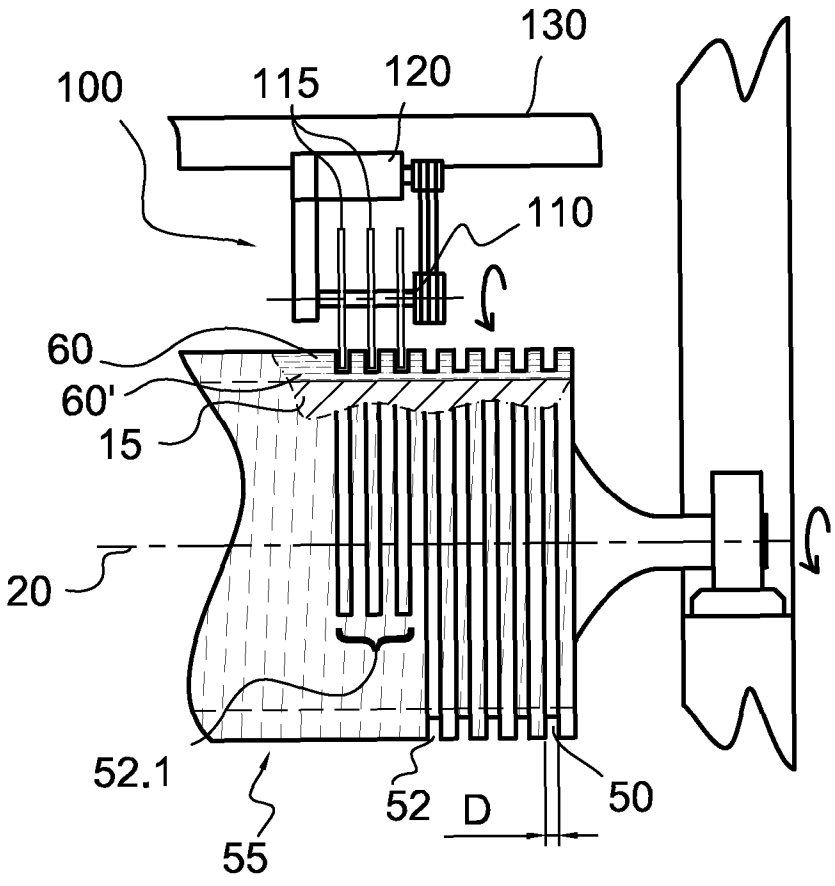


FIG. 3

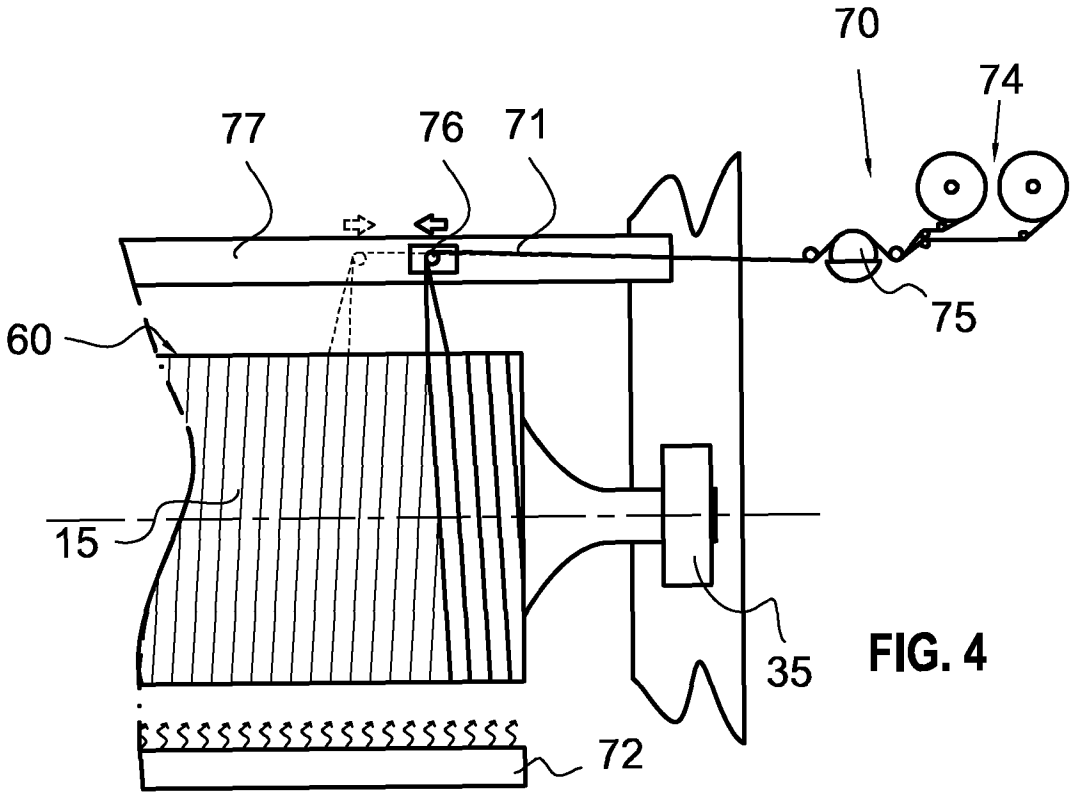


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2009/050848

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: F16C, D21F

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

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI, COMPDX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	FI 50159 B (BELOIT CORPORATION) 01 September 1975 (01.09.1975) page 3; page 4, lines 21-28; figures 1-4	1-5, 9, 12-17 6-8, 10, 11
X Y	FI 56251 B (BELOIT CORPORATION) 31 August 1979 (31.08.1979) whole document	1-5, 9, 12-17 6-8, 10, 11
X Y	US 3599306 A (BRAFFORD DONALD A) 17 August 1971 (17.08.1971) whole document	1-5, 9, 12, 13, 16, 17 6-8, 10, 11
Y	EP 0655561 A1 (SIGRI GREAT LAKES CARBON GMBH - SGL TECHNIK GMBH) 31 May 1995 (31.05.1995) whole document	6-8, 10

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 January 2010 (11.01.2010)	14 January 2010 (14.01.2010)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2009/050848

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 3829648 A1 (RAVENSBURG MASCHF) 21 December 1989 (21.12.1989) whole document	11

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2009/050848

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
FI 50159 B	01/09/1975	None	
FI 56251 B	31/08/1979	None	
US 3599306 A	17/08/1971	None	
EP 0655561 A1	31/05/1995	DE 4340724 A1	01/06/1995
DE 3829648 A1	21/12/1989	None	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2009/050848

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
F16C 13/00 (2006.01)
D21F 3/08 (2006.01)