A fiber distributor is used for air-laying fibers on an endless, air pervious forming wire in a plant for producing non-woven webs. The fiber distributor includes a forming head with a perforated bottom and rows of rotatable wings situated at a distance above the bottom for during production sweeping supplied fibers along the rows of wings in an air stream before they successively leave the forming head through the openings of the perforated bottom for being deposited in a layer on the upper part of the forming wire. The fibers are, while being swept along in this way, inclined to form nits. The wings are therefore adapted to rotate with an optimal speed of rotation in an interval where the fiber's inclination to form nits changes from being lesser to being larger when the rotation speed of the wings grows. By use of the method and the fiber distributor according to the invention, it is possible to produce non-woven webs with a minimum of fiber loss in form of nits and at the same time also with an extremely high rate of production.
METHOD AND DISTRIBUTOR FOR AIR-LAYING OF FIBERS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of International application PCT/DK2004/000370 filed May 27, 2004, the entire content of which is expressly incorporated herein by reference thereto.

BACKGROUND ART

[0002] The invention relates to a method and a fiber distributor for air-laying fibers on an endless, air pervious forming wire in a plant for producing non-woven webs for us in producing absorbent core material for feminine hygiene articles, incontinence articles, diapers, table top napkins, hospital products such as bed protection sheets, wipes, or towels.

[0003] The fluff, which is usually employed for products of this nature, is fluff of relatively short cellulose fibers, of relatively long synthetic fibers, or of a blend of such fibers. Other materials like e.g., SAP (Super Absorbent Powder) can be mixed into the fluff, if desired.

[0004] The fiber distributor generally comprises a forming head, which is placed above the forming wire and has a perforated bottom and at least one row of rotatable wings situated at a distance above the bottom.

[0005] The fibers supplied to the forming head are, during production, swept along by rows of wings in an air stream in order to be evenly distributed over the bottom. A suction aggregate, placed below the forming wire, simultaneously generates a second air stream through the openings in the perforated bottom of the fiber distributor and through the forming wire, whereby fibers entrained in the air stream are successively deposited in a layer on the upper part of the forming wire. Such a fiber distributor is known from U.S. Pat. No. 5,527,171, which is included in the present application as reference.

[0006] However, the relatively long synthetic fibers are especially inclined to form nits with other similar or differing types of fibers while being swept along in the air stream by the rows of wings in the fiber distributor. Nits are small tangled bundles of fibers, which can be quite hard and difficult to open even when they are re-circulated back to e.g., a hammer mill. The nits contribute neither to the volume, the quality, nor the strength of the non-woven webs. The generation of such undesirable nits during production of the webs should therefore be kept to as low a level as possible.

[0007] In practice, however, up to about 25% of the supplied synthetic fibers can be reduced to useless nits. The fibers lost in this way need to be replaced by the same quantity of good fibers. Since the synthetic fibers are especially costly the finished fiber product will therefore also be costly both due to the production of nits and the need to replace them with additional synthetic fibers. Previous experiments carried out to find a solution to this problem had shown that the contents of fibers per unit of area of the finished non-woven web, which are reduced to nits, grows as a function of the velocity of the air stream, in which the fibers are swept along by means of the rows of wings. The experiments also revealed that the capacity of the fiber distributor and thereby of the entire plant for producing the non-woven webs also grows as a function of the velocity.

[0008] Therefore, since the financial investments in such plants are very high, the plants should be operated with as high a velocity of the air stream along the rows of wings as possible. The velocity should, on the other hand, also be very low in order to keep the contents of fibers per unit of area of the finished non-woven web, which are reduced to nits, to as low a level as possible. In addition, it has, in practice, been necessary to reach a compromise where a plant is operated with relatively small velocities of the air stream along the rows of wings, resulting in that the capacity of the plant is far from being fully utilized.

[0009] The present invention seeks to remedy the above-mentioned drawbacks of the known techniques.

SUMMARY OF THE INVENTION

[0010] The present invention now relates to a fiber distributor and to a method of air-laying fibers that provides a higher production capacity and higher rate of production than hitherto known, and which during operation generates fewer nits than with prior devices and methods. This fiber distributor is arranged to, during operation, regulate the process in such a manner that a minimum of nits are generated.

[0011] The fiber distributor is, according to the invention, arranged for regulating the speed of rotation of the wings into an interval of speeds around an optimal speed where the fibers inclination to form nits changes from being lesser to being larger as the rotation speed of the wings increases. This interval of speeds is much higher than the skilled person in the art has so far believed could lead to a positive result, since experiments carried out to solve the problem of fiber loss due to the formation of nits showed that the loss of fibers increased when the speed of rotation of the wings grows.

[0012] At the optimal speed the production rate at the same time also is increased, whereby the capacity of the fiber distributor and thereby of the entire plant is advantageously utilized much better than hitherto known. The optimal speed of rotation of the wings can in practice vary depending on the prevailing conditions of the fiber structure and fiber composition and also of the production parameters of the fiber distributor. The fiber distributor could therefore be arranged to regulate the speed of rotation of the wings into an interval of speeds of rotation, which could include speeds, which by certain conditions are not completely optimal.

[0013] This interval can be around an average speed of rotation and the regulation can be carried out in agreement only with the composition of the fibers and the arrangement of the actual fiber distributor. That means that the speed of rotation of the wings does not need to be optimal all the time, since the optimal speed can vary as explained above.

[0014] Alternatively, the speed of rotation of the wings can, in another embodiment according to the invention, be optimal all the time by continually regulating the speed to the speed, which at a given moment is optimal. Thereby it advantageously is obtained that the loss of fibers due to the formation of nits, is as low as possible. This embodiment comprises the steps of detecting the amount of nits per unit
of area of the fiber layer on the forming wire or in the resulting non-woven web; sending signals representing the results of the detecting as input to a computer; using this input to calculate, by means of a program in the computer, a value which represents an optimal rotation speed where the number of nits at a given moment are small or smallest; and sending signals representing this value as output from the computer to order the wings to rotate with rotating speeds represented by the value.

[0015] The fiber distributor according to the invention has in this way been self-regulating and will therefore, during operation, automatically produce non-woven webs with a minimum of loss of fibers and at the same time also with an extremely high rate of production. It is significant that the loss of fibers due to the formation of nits is low in order to save expenses by reducing the amount of material employed to form the non-woven webs. The loss is of course lowest at the optimal speed of rotation of the wings. However, if the profit gained from operating the fiber distributor at a higher capacity than the capacity at the optimal rotating speed of the wings is about the same as the expenses due to the loss of fibers in form of nits, the profit can be used to control the process instead of the smallest contents of nits per unit of area of the finished web.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The invention will be explained in greater detail below where further advantageous properties and only exemplary embodiments are described with reference to the drawings, where

[0017] FIG. 1 shows schematically, seen from the side, a fiber distributor according to the invention for air-laying fibers on an endless wire by means of a forming head having a perforated bottom and rotatable wings for sweeping the fibers along the bottom during operation,

[0018] FIG. 2 shows the same, but viewed from above,

[0019] FIG. 3 shows in an enlarged scale a fragment of a non-woven web,

[0020] FIG. 4 are graphs showing the number of nits per unit of area of a non-woven web and also the output per wing per unit of time as a function of the velocity at which the fibers are swept along the perforated bottom of the forming head, and

[0021] FIG. 5 is a block diagram of a controlling system for the air-laying process carried out by means of the fiber distributor shown in FIGS. 1 and 2.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0022] The following detailed description is based on the assumption that the fibers consist of a blend of relatively short cellulose fibers and relatively long synthetic fibers.

[0023] The fiber distributor comprises a forming head with an inlet 3 for the cellulose fibers and another inlet 5 for the synthetic fibers. These inlets 3, 5 admit the respective fibers 4, 6 to enter the forming head in air streams in the direction of the arrows shown.

[0024] The forming head has a perforated bottom 7 with openings 8. Below the bottom is arranged an endless, air pervious forming wire 9 running, during production, over rolls 10 in the direction shown by the arrow. Only part of the forming wire is shown in FIGS. 1 and 2.

[0025] Below the forming wire is placed a suction box 1. An evacuating pump 12 serves for producing a negative pressure in the suction box via an air duct 13.

[0026] At a distance above the perforated bottom are, in this example, mounted five rows 14, each having three rotatable wings 15.

[0027] The wings are, during operation of the fiber distributor, rotated with such a speed of rotation that the supplied fibers are swept along the rows of wings in a first air stream, which is generated by the rotating wings, thereby distributing the fibers all over the bottom as illustrated in FIG. 2 with the arrows.

[0028] The fibers in the first air stream are, by means of the suction box and the evacuating pump, successively sucked down through the openings 8 in the perforated bottom 7 entrained in the generated second air stream, thereby depositing the fibers in a layer 16 on the upper part 17 of the forming wire.

[0029] The forming wire transports this layer into the direction of the arrow for being further treated in the subsequent parts of the associated plant (not shown) in such a way that the desired non-woven web is formed.

[0030] The synthetic fibers 6 are usually supplied as staple fibers, while the cellulose fibers 4 are supplied in the form of a fiber roll (not shown), which is defibrilated to fluff by a hammer mill (not shown).

[0031] FIG. 3 illustrates schematically in a larger scale a fragment of a non-woven web 18, which contains synthetic fibers 6 and cellulose fibers 4. As it appears from the figure are the cellulose fibers formed with protuberances 19. The non-woven web also contains cellulose nits 20 consisting alone of cellulose fibers and compound nits 21 consisting of both cellulose fibers 4 and synthetic fibers 6.

[0032] Nits are small tangle fiber bundles, which decrease the quality of the non-woven web. Another disadvantage is that the nits exist in a very compact form. It is therefore necessary to increase the supply of fibers by a quantity of fibers corresponding approximately to the mass of fibers tied up in the nits, thereby increasing the cost of producing the web.

[0033] The fiber roll contains some nits already from the start. During the defibrilation process some of these fibers are opened and formed to good fibers. But at the same time some other fibers are formed to nits in a normally larger scale than the quantity of fibers tied up in nits, which are opened. The percentage of nits in the defibrilated fluff also increases with the defibrilating speed, and typically are in the range of from about 1% to about 1.4%.

[0034] On the way from the hammer mill to the fluff layer 16 on the forming wire 17 more cellulose nits 20 can be generated in the fluff. The cellulose fibers 20 act as a kind of nucleus for forming the compound nits 21. The protuberances 19 play an important part in this connection in that they are capable of catching the synthetic fibers.

[0035] The nits show a tendency to grow during the air-laying process. Having attained a certain size, the nits
then tend to split up into two or more nits, which then acts as new nucleuses for forming still more nits.

[0036] Experience has shown that the contents of fibers per unit of area of the finished non-woven web tied up in nits, grows with the speed of the first air stream similar to the process in the hammer mill where the percentage of nits also grows with the defibration in feed speed.

[0037] When a non-woven web of good quality that means with a low contents of nits is desired, the production plant therefore needs to be operated at a low production speed, whereby the expenses to the fibers also will be low.

[0038] However, the total production costs depends also on the normally rather large investments in the entire plant. For paying a sufficient interest on these large investments the plant needs to be operated at a high production speed.

[0039] In practice such plants therefore are operated at production speeds, where the produced webs have a relatively poor quality and the entire plant is operated with a relatively low capacity, resulting in relatively high production costs of the webs owing to the large consumption of fibers used in the production and the low interest paid on the investment in the plant.

[0040] The producer of the webs is in this way reduced to come to a compromise where the quality and the price of the product and also the utilization of the potential capacity of the plant are very far from being optimal. This undesirable situation is overcome by means of the present invention, which will be explained more definitively in the following with reference to FIG. 4, which illustrates an exemplary embodiment of the invention FIG. 4 shows with full line the number of nits per m² (n/m²) in the finished web as function of the velocity v (m/sec) of the first air stream, which is the air stream generated by the wings for sweeping the fibers along the perforated bottom of the forming head. Only nits having a sectional size larger than 1 mm² are counted in this example. With dotted line is in the same figure also shown the output per wing per hour (kg/w/hour) of the plant as an approximately linear function of the velocity v (m/sec). The web produced in the example had a weight of 0.120 kg/m² and was composed of 80% cellulose fibers and 20% synthetic fibers. The average length of the cellulose fibers was about 2 mm, while the average length of the synthetic fibers was about 6 mm. The wings in a row were, as illustrated with the arrows in FIG. 2, rotated in the same direction while the wings in two adjacent rows were rotated in opposite directions, whereby the fibers were swept along the perforated bottom and evenly dispersed over the area of this.

[0041] The perforated bottom was of the type described in the applicant’s patent application WO 99/54537 entitled “A Sifting Net for a Fiber Distributor” and the entire content of which is expressly incorporated herein by reference thereto. The mesh size of the net was 4.

[0042] The above-mentioned specifications are common for non-woven webs used for, e.g., incontinence articles and also for existing production plants. The normal velocity of the first air stream used for producing the non-woven web was 3 m/sec. At this velocity the number of nits per m² was found to be 500 n/m with an output per wing per hour of 12 kg/w/h. These result are very unsatisfactory. The quality of the product is poor and a rather high rate of fibers is used for manufacturing the webs. This fact in combination with the fact that the gained output also is rather low results furthermore in high production costs.

[0043] The person skilled in the art, which is trying to obtain a better product, that is to say a product with a lower contents of nits, will by means of experiments find out that lowering the velocity v from the normal 3 m/sec to e.g. 1 m/sec would result in that the nits contents in the web advantageously was decreased from 500 n/m² to a level of only 67 n/m², but also in that this improvement was at the expense of an output as little as 1 kg/w/h. Owing to the resulting high production cost and the demand for being able to supply the customers with a sufficient quantity of products the person skilled in the art soon would realize that lowering the velocity of the first air stream in this way could not lead to a useful solution of the problem, that a low contents of nits and a high production rate are wanted at the same time. Having arrived to this conclusion he will stop further experiments with lowering the velocity of the first air stream.

[0044] When the person skilled in the art, on the other hand, would try to increase the output for lowering the production costs in this way he soon would find out that the gained improvement of output was at the expense of an unacceptable increasing of the number of nits per m², whereby he also in this case would stop further experiments. The skilled person would therefore never get the idea to carry out experiments with velocities, which are far away from the normal used velocities, since he, by carrying out his above mentioned experiments, had learned that changing the velocity up or down from the normal velocity, where the best compromise between the production parameters were found, does not imply any improvements.

[0045] According to the present invention this technical prejudice is overcome by operating the wings with such a high speed of rotation that velocities of the first air stream far away from the normal used velocities are generated. In a preferred embodiment according to the invention are the wings rotated with such a rotation speed that the velocity of the first air stream is between 9 m/sec and 16 m/sec and especially between 11 mm/sec and 14 m/sec.

[0046] In another embodiment according to the invention are the wings rotated with such a rotation speed that the velocity of the first air stream is between 5 m/sec and 26 m/sec, preferentially between 8 m/sec and 17 m/sec, and especially between 10 m/sec and 15 m/sec. As it appears from FIG. 4 the number of nits per m² non-woven web was decreased from 500 n/m² at a velocity of 3 m/sec to only 117 n/m² at a velocity of 12.7 m/sec, while the output at the same time was raised to 60 kg/w/h. By using the technique according to the invention was surprisingly obtained that the contents of nits in the finished non-woven web was only about 24% of the normal while the output was about five times the normal.

[0047] FIG. 4 also shows that the contents of nits in the finished non-woven web increases from 67 n/m² at a velocity of 1 m/sec up to a maximum of 583 n/m² at a velocity of 4.4 m/sec. After that the nits contents decreases to a minimum of 60 n/m² at a velocity of 12.7 m/sec for thereafter to increase again. In this case is the velocity of 12.7 m/sec such an optimal velocity where the optimal lowest nits contents is obtained at the same time as a very large increase of the output has taken place. For other plants and webs with other
fiber compositions there is also an optimal velocity, which could be the same or have another size as in this example.

[0048] In a preferred embodiment of the invention the mutual distance between each of two neighboring rows of wings the mutual distance between two wings in a row plus between 50 mm and 135 mm, especially between 75 mm and 105 mm.

[0049] Production parameters such as the composition and the structure of the fibers can possibly vary during the production of the non-woven web whereby the optimal velocity concurrently will vary. The fiber distributor therefore is equipped with a regulator for regulating the velocity of the first air stream in an interval around an average optimal velocity. The interval has according to the invention a size between 0.5 and 1.5, preferentially between 0.75 and 1.25 and especially between 0.9 and 1.1 times the rotation speed of the wings generating the average optimal velocity.

[0050] The regulating of the velocity of the first air stream can advantageously be performed automatically by means of a controlling system according to the invention, which schematically is illustrated by means of the block diagram shown in FIG. 5. This system comprises a detector 22, which is connected to a computer 23, which again is connected to an actuator 24 for rotating the wings and also to actuators for driving other functions of the plant, which possibly should vary when varying the velocity of the first air stream.

[0051] In FIG. 5 only actuators 25, 26, 27, 28 and 29 are shown for driving the functions of feeding the roll of cellulose fiber to the hammer mill, feeding the cellulose fiber from the hammer mill to the forming head, feeding e.g. synthetic fibers to the forming head, driving the forming wire, and generating the other air stream, but other actuators (not shown) for driving other functions can also be related to the system.

[0052] The detector is, as seen in FIG. 1, placed downstream the forming head and above the fluff on the forming wire and it can be of any suitable type, for example a digital photo detector, a laser detector or an ultrasound detector. The detector is arranged for counting the number of nits per unit of area of fluff on the wire or non-woven web or the number of nits per unit of area of fluff on the wire or non-woven web and also the size of each of these nits.

[0053] The result of the detecting is constantly sent as input to the computer, which also receives input (not shown) for the simultaneous supplying of the different fibers to the forming head. The computer is loaded with a program, which based on this information is adapted to calculate the contents of fibers per m² of fluff on the wire or of the finished non-woven web. The content is, as previously explained, a function of the velocity of the first air stream, which in the example is illustrated with the curve in full line shown in FIG. 4.

[0054] The program of the computer is also adapted to calculate the differential quotient for each point of this curve and to continuously regulate the actuator 24 until the differential quotient is zero in a point of the curve. As the operator of the plant now knows the invention and thereby also the interval where the optimal velocity of the first air stream is expected to be found, the plant will in practice be started with a velocity in this interval, after which the velocity continuously is regulated to the optimal velocity which is precisely the point of the curve where the differential quotient in a given moment is zero.

[0055] The computer of the controlling system for the air-laying process has, in a preferred embodiment of the invention, a memory for saving the relevant data, which are obtained during the production of a specific web. By using this data the plant easily and quickly can be started up next time the same web is going to be produced. Since the differential quotient is zero in both a maximum and a minimum point of the nits contents curve the program is in an embodiment of the invention adapted to reject the maximum zero point for thereby only regulating the velocity of the first air stream into the minimum zero point, which also is the optimal point of the curve. For performing this, the computer is loaded with values for the velocities of the first air stream used by the known technique and the program of the computer is adapted to reject a zero point, which is higher than such a velocity for a given product. In this way it is possible to start the production at any point of the curve. The computer is also adapted to regulate other actuators, e.g. the actuators 25, 26, 27, 28 and 29 in correspondence with the regulating of the velocity of the first air stream.

[0056] According to the invention is the fiber distributor in the above-described way self-regulating and will therefore, during operation, automatically produce non-woven webs with a minimum of fiber loss in form of nits and at the same time also with an extremely high rate of production. The plant is also very easy to start up and operate.

What is claimed is:

1. A method for air-laying fibers on an endless, air pervious forming wire which comprises:

   supplying fibers to a forming head having a perforated bottom and at least one row of rotatable wings situated at a distance above the bottom,

   sweeping the fibers along the at least one row of wings in a first air stream by rotating the wings, during which sweeping the fibers are inclined to form nits, regulating the speed of rotation of the wings into an interval around an optimal speed wherein the inclination of the fibers to form nits changes from being lesser to being greater as the rotation speed of the wings increases, and successively depositing the fibers into a layer on an upper part of the forming wire by sucking the fibers down through the openings in the perforated bottom in a second air stream.

2. The method of claim 1, which further comprises regulating the rotation speeds of the wings in agreement with the composition of the fibers.

3. The method of claim 1, which further comprises choosing an interval of speeds of rotation of the wings around an average optimal rotation speed that provides a relatively small number of nits, with the interval having a value between 0.5 and 1.5 times the rotation speed of the wings generating the average optimal velocity.

4. The method of claim 1, which further comprises choosing an interval of speeds of rotation of the wings around an average optimal rotation speed that provides a relatively small number of nits, with the interval having a
value between 0.9 and 1.1 times the rotation speed of the wings generating the average optimal velocity.

5. The method of claim 1 wherein the speed of rotation of the wings is increased to a velocity that decreases the number of nits per m² of non-woven web to 117 n/m² while increasing output to 60 kg/h.

6. The method of claim 1, which further comprises:

detecting the percentage of nits in the fiber layer on the forming wire or in the resulting non-woven web,

sending signals representing the results of the detecting as input to a computer,

using this input to calculate, by means of a program of the computer, a value which represents an optimal rotation speed where the number of nits at a given moment is small or smallest, and

sending signals representing this value as output from the computer to order the wings to rotate with rotating speeds represented by the value.

7. A method for air-laying fibers on an endless, air pervious forming wire which comprises

supplying fibers to a forming head having a perforated bottom and at least one row of rotatable wings situated at a distance above the bottom,

rotating the wings with such a rotation speed that the fibers are swept along the bottom with a velocity between 5 m/sec and 26 m/sec, and

successively depositing the fibers into a layer on the upper part of the forming wire by sucking the fibers down through the openings of the perforated bottom in a second air stream.

8. The method of claim 7, wherein the wings are rotated with such a rotation speed that the fibers are swept along the bottom with a velocity of between 9 m/sec and 16 m/sec.

9. A fiber distributor of the kind used for air-laying fibers on an endless, air pervious forming wire in a plant for producing non-woven webs, comprising forming head with a perforated bottom and at least one row of rotatable wings situated at a distance above the bottom for during production sweeping supplied fibers along the at least one row of wings in an air stream before they successively leave the forming head through the openings of the perforated bottom for being deposited in a layer on the upper part of the forming wire, whereby the fibers while being swept in this way are inclined to form nits and the wings are rotated with an optimal speed of rotation in an interval where the inclination of the fibers to form nits changes from being lesser to being greater as the rotation speed of the wings increases.

10. The fiber distributor of claim 9, further comprising a regulator for regulating the optimal speed of rotation in accordance with the composition of the fibers and the arrangement of the actual fiber distributor.

11. The fiber distributor of claim 10, wherein the regulator is adapted for regulating the optimal speed of rotation into an interval that provides a relatively small number of nits, with the interval having a value between 0.5 and 1.5 times the rotation speed of the wings generating the average optimal velocity.

12. The fiber distributor of claim 10, wherein the regulator is adapted for regulating the optimal speed of rotation into an interval that provides a relatively small number of nits, with the interval having a value between 0.9 and 1.1 times the rotation speed of the wings generating the average optimal velocity.

13. The fiber distributor of claim 9, further comprising a detector for detecting the percentage of nits in the fiber layer on the forming wire or in the resulting non-woven web and sending signals representing the results of this detecting as input to a computer,

a program of the computer for by means of the input, calculating a value, which represents an optimal rotation speed where the number of nits is small or smallest and generating output representing the value, and

one or more actuators for, by receiving the output, rotating the wings with rotation speeds represented by such values.

14. The fiber distributor of claim 9, comprising that the mutual distance between each of two neighboring rows of wings is the mutual distance between two wings in a row plus between 50 mm and 135 mm.

15. The fiber distributor of claim 9, wherein the distance between the wings and the perforated bottom is between 1 mm and 12 mm.

16. The fiber distributor of claim 9 wherein the speed of rotation of the wings is increased to a velocity that decreases the number of nits per m² of non-woven web to 117 n/m² while increasing output to 60 kg/h.

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