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(54) **METHOD AND APPARATUS FOR MANUFACTURING NONWOVEN FABRIC**

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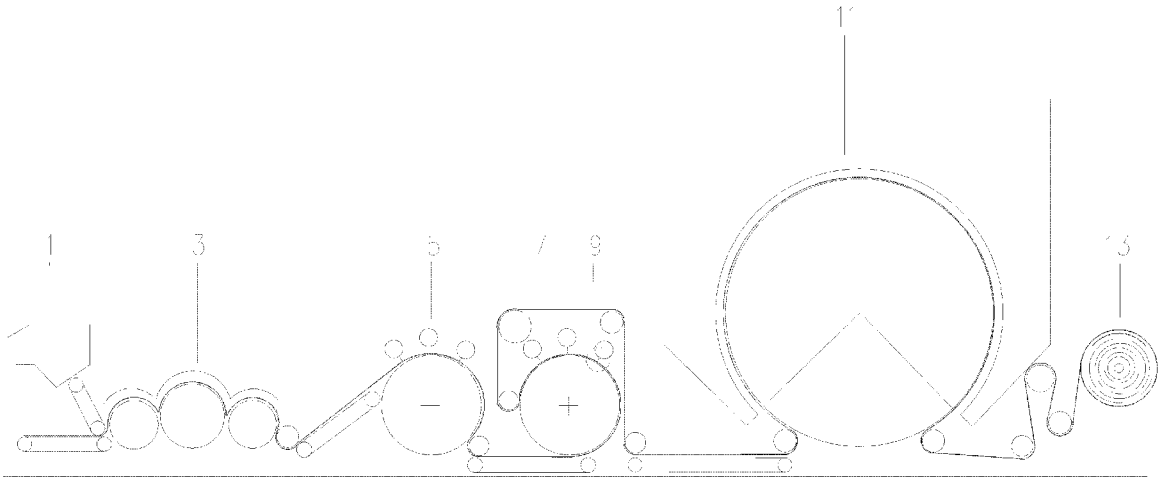
(57) **ABSTRACT**

The invention concerns a method and apparatus for patterning a nonwoven fabric. The method according to the invention is characterized in that the web is supported in the patterning phase on a perforated cylinder to which a 3-dimensional pattern has been formed substantially without removing material (patterning cylinder) for accomplishing a corresponding 3-dimensional pattern to the nonwoven fabric. The apparatus according to the invention comprises an element supporting the web, a vacuum system and water nozzles in order to hydroentangle the fibre web or combined fibre webs. The apparatus is characterized in that the element supporting the web is of a kind of the said pattern cylinder.



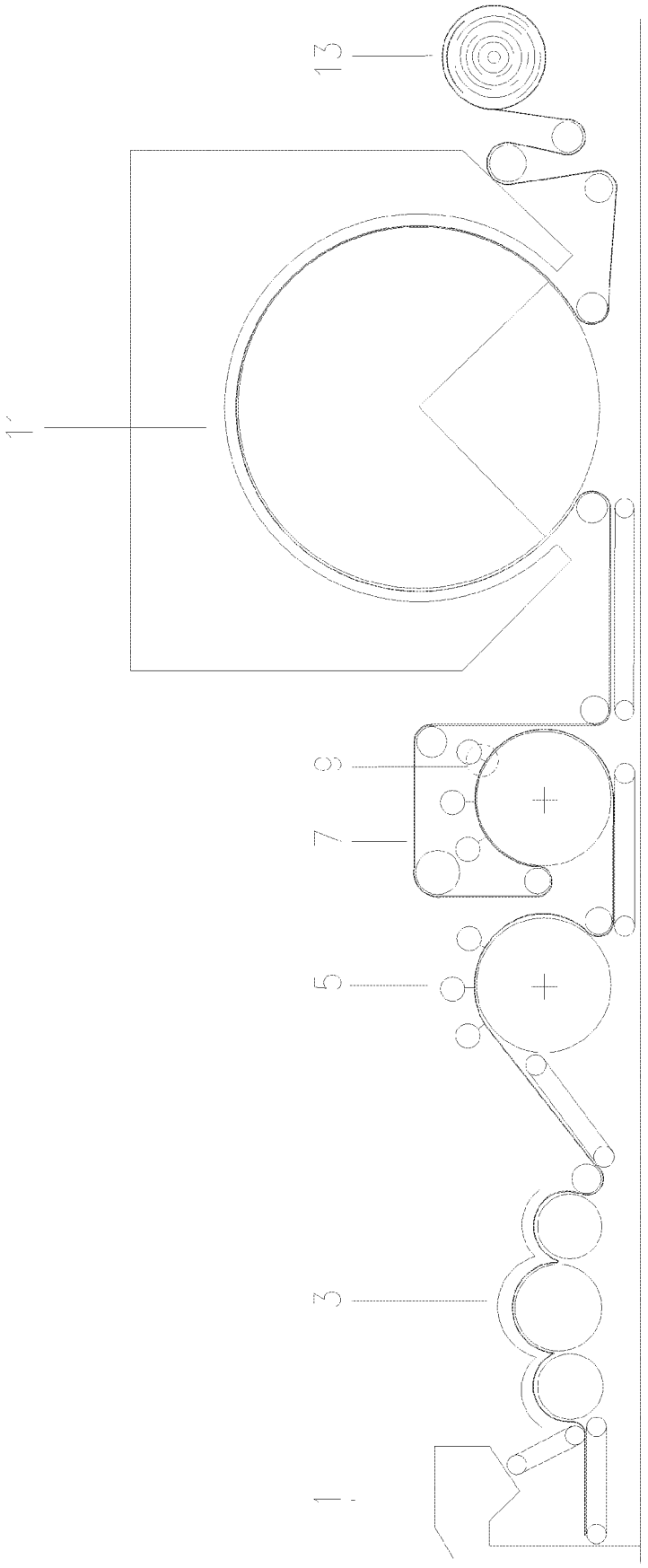


Fig. 1

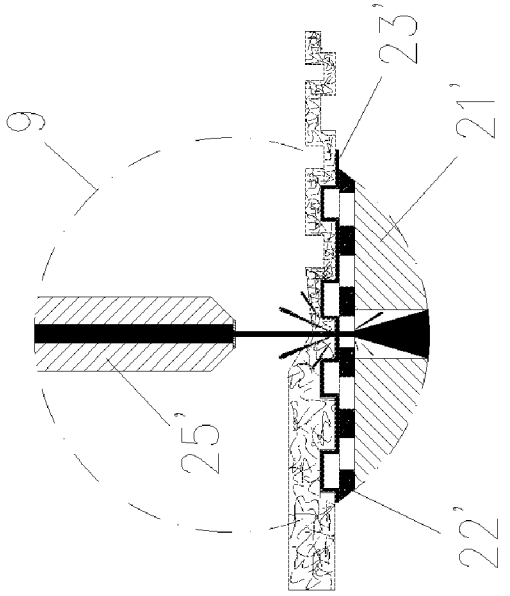


Fig. 2B

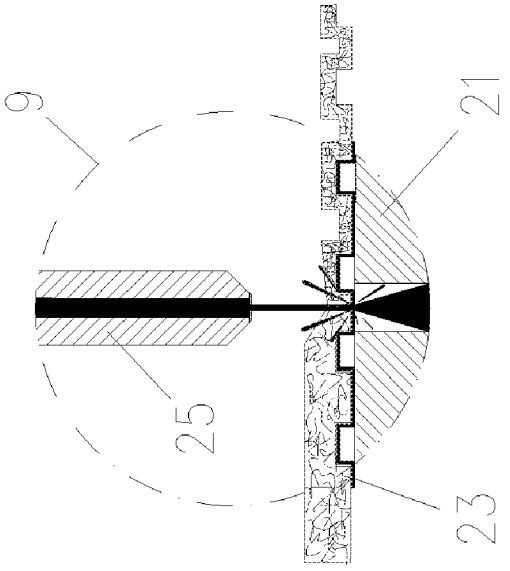


Fig. 2A

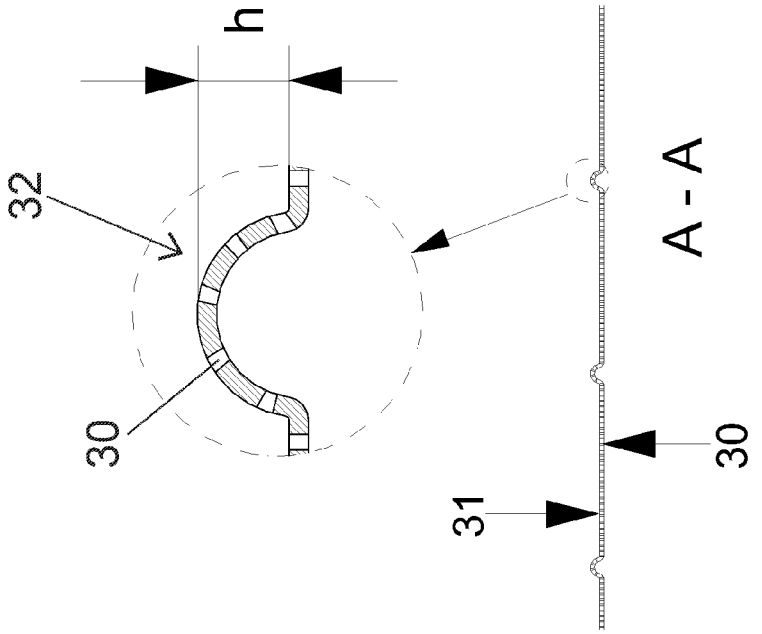


Fig. 3B

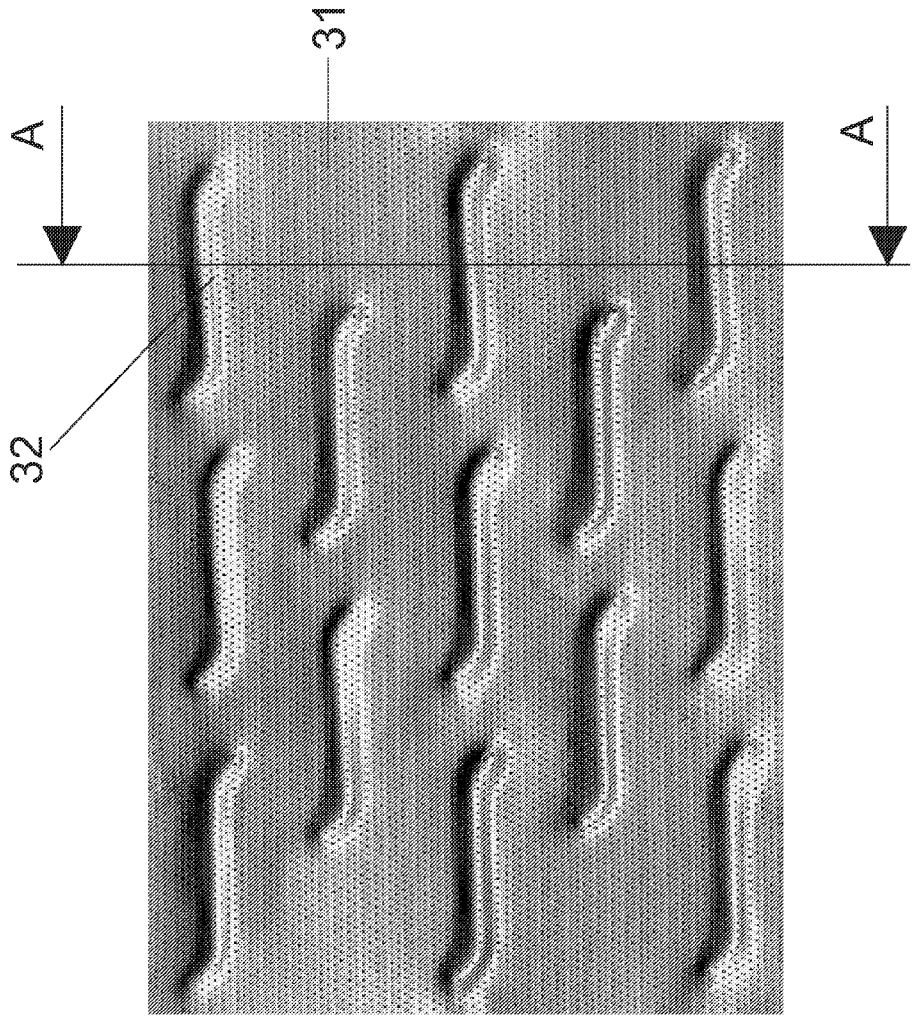


Fig. 3A

METHOD AND APPARATUS FOR MANUFACTURING NONWOVEN FABRIC

[0001] The present invention concerns a method and an apparatus for patterning nonwoven fabric. More particularly, the invention concerns the patterning of the nonwoven fabric so that during the hydroentanglement, one side of the web is supported onto an embossed, perforated plate, to which a three dimensional pattern has been formed without removing material. Patterned nonwoven fabrics can be used for example for towels and for hygienic products as well as for sanitary applications.

[0002] By patterning of a nonwoven fabric for instance the visual properties of the nonwoven fabric and its use properties can be affected. Patterns can be effected into the nonwoven fabric for instance by means of alteration of the density of the nonwoven fabric, by alteration of the grammage or by perforating. One way of patterning the nonwoven fabric is to perform the hydroentangling on a patterned hydreontanglement cylinder.

[0003] In Patent publications EP1036871 and EP1001064 it is suggested that a dotted patterning or a perforation can be achieved into a nonwoven fabric by performing hydroentangling on a plastic mantle set on a supporting cylinder, said plastic mantle being equipped with piked protrusions being surrounded by water orifices on the plane level of the mantle. With this method, however, it is not possible to accomplish a continuous pattern, because at the protrusion of the mantle there are no water orifices that are necessary for providing an uniform and adequate strength to the nonwoven fabric.

[0004] The patent U.S. Pat. No. 5,674,591 discloses a nonwoven fabric being hydroentangled on a cylinder provided with orifices for water removal bored with a laser and in addition being provided with macro sized engraved recesses for forming a permanent, three-dimensional pattern into the nonwoven fabric, the grammage of the nonwoven fabric being at these pattern portions the same or higher than that of the background. In said cylinder there is a micro sized surface topography pattern around the dewatering orifices, whereby the background surface of the nonwoven fabric can be made visually resembling the tricot. The patent publication U.S. Pat. No. 5,906,786 describes the manufacturing of this kind of a cylinder by using among others laser ablation.

[0005] In a method in accordance with a US patent application publication 2002/0160681 A1, a nonwoven fabric web is patterned by hydroentangling on a drum having as its outer structure an embossed metal wire fabric. The three-dimensional pattern of the metal wire screen is transferred onto the nonwoven fabric thus providing a nonwoven fabric having recesses and protrusion areas following each other. A problem with this method is, however, the attachment of the fibres to the pattern wire screen, which causes the clogging of the wire, breaks in production for cleaning the wire and roughening of the nonwoven fabric to be formed. Along with the clogging, also the water removing properties of the wire are deteriorated, whereby the strength of the nonwoven fabric achieved in the hydroentangling is lowered and/or is not formed uniform. Said figure patterning wire always requires also a support cylinder underneath it, in addition to a honeycomb construction.

[0006] The purpose of the present invention is to provide a method and an apparatus due to which, among others, clogging of the patterning elements when patterning the nonwoven fabric is substantially eliminated.

[0007] To accomplish what has been stated above, the apparatus in accordance with the invention, is characterized in that the element supporting the web comprises a perforated cylinder having a three dimensional pattern formed onto it, substantially without removing material from it. The method in accordance with the present invention is characterized in that during the pattern forming phase the web is supported by means of a perforated cylinder having a three dimensional pattern formed onto it, substantially without removing material from it. By means of the three dimensional pattern of the pattern cylinder, a pattern or patterns substantially corresponding to the three dimensional pattern or patterns of the pattern cylinder are accomplished to the nonwoven fabric in the hydroentanglement.

[0008] With a method and apparatus in accordance with the invention, the attachment of the fibres to the element supporting the web in the hydroentangling unit of the web-patterning phase is substantially eliminated. It was observed in the studies that surprisingly substantially no fibres get attached to the patterned element according to the invention supporting the web, the element being embossed to three dimensional form, during hydroentanglement and the nonwoven fabric does substantially not get attached to the hydroentanglement base when removed from the base. Thereby the need for cleaning the apparatus is decreased, thus decreasing the number of service stops and/or breaks in production. The decrease in the attachment of the fibres to the hydroentangling base or the elimination thereof improves the smoothness of the surface of the fabric to be produced. Along with the decreased clogging of the water orifices, the effect of the hydroentangling and/or the uniformity of the hydroentangling in connection with the patterning can be improved. The improved hydroentangling effect means for example the same achieved strength of the nonwoven fabric with a smaller water amount or with smaller pressure, or a higher strength of the nonwoven fabric with the same water amount. In addition, the element for supporting the web when patterned, said element comprising a three-dimensional pattern and being included into an apparatus in accordance with the invention, is simpler and less laborious to manufacture. In addition, it is possible to improve the efficiency of the hydroentangling in the patterning phase, because the pattern cylinder in accordance with the invention does not always require a support cylinder under it.

[0009] The invention will be described in more detail in the following with reference to the enclosed drawings, wherein

[0010] FIG. **1** shows a continuously operating production line of nonwoven fabric for manufacturing patterned nonwoven fabric in accordance with one preferred embodiment of the method in accordance with the present invention,

[0011] FIG. **2**A is a cross-sectional view of some components of one preferred embodiment of the apparatus in accordance with the invention,

[0012] FIG. **2**B shows a cross-sectional view of some components of another preferred embodiment of the apparatus in accordance with the invention,

[0013] FIG. **3**A shows a schematic top view of an element supporting the web, in other words a pattern cylinder, according to one preferred embodiment comprised in the apparatus in accordance with the invention, and

[0014] FIG. **3**B illustrates schematically a part of the pattern cylinder of FIG. **3**A as a cross-sectional view.

[0015] FIG. **1** shows one continuously operating nonwoven fabric production line for manufacturing patterned nonwoven fabric in accordance with one preferred embodiment of the method in accordance with the present invention. Fibres are fed to a conveyor belt with a feeding device (**1**). The fibres are preferably stable fibres that have been crimped and cut from polymer filaments. The fibres are led to the card unit (**3**), for forming them mechanically into a card web. After that the card web proceeds to the first hydroentangling station (**5**) for prebonding. The formed prebonded fibre web is led to another hydroentangling station (**7**) to be hydroentangled in an apparatus, wherein the web during the hydroentangling process is supported on a cylinder being manufactured of a perforated plate, onto which a three-dimensional pattern has been formed substantially without removing material, in this case by embossing. This kind of a cylinder is henceforth also referred to as a pattern cylinder. The hydroentangling unit or station for patterning the web or nonwoven fabric is in this text later also referred to as a patterning unit. After the patterning unit, the patterned nonwoven fabric is led to a drying apparatus (**11**) and further to be reeled with a reeler (**13**). A production line can be provided with a plurality of patterning units. For manufacturing a multilayer carded web, number of fibre feeding devices corresponding to the number of layers and carding stations corresponding to the webs can be arranged for example as described in the patent publication FI 20012426. As shown in the publication FI 20012426, there can be a plurality of hydroentangling stations arranged on the line.

[0016] FIG. **2**A shows as a partial cross-sectional, schematic enlarged view some components of one preferred embodiment of an apparatus, in other words, a patterning unit in accordance with the invention. The patterning unit in accordance with the invention comprises components of prior art of the hydroentangling unit: the pattering unit has a honeycomb structure (**21**), having a vacuum system (not shown) for removing the water coming from the water jets of the water nozzles (**25**) from the surface of the cylinder. The outer part of the cylinder of the patterning unit is a cylinder (**23**) being manufactured of a perforated plate, and having a three-dimensional pattern formed substantially without removing material. The pattern cylinder can be made of one or of a plurality of perforated plates joined together in a suitable way for forming a cylinder, for instance by means of a stapling arrangement or especially by welding. The cross-section of the orifices of the pattern cylinder is for example substantially circular and the orifices preferably have a form of a straight cylinder. The pattern cylinder (**23**) is in this case positioned directly onto the honeycomb construction. This is possible because the structure of the pattern cylinder according to the invention is rigid enough. In the embodiment in accordance with FIG. **2**A, the pattern cylinder (**23**) is arranged to rotate along with the honeycomb structure (**21**). The pattern cylinder can be attached onto the honeycomb structure from the edges by means of sealing, the pattern cylinder being fixed tightly to the honeycomb construction by raising the internal air pressure of the sealing, and made to rotate along with the honeycomb construction. The fibre web is hydroentangled on top of the pattern cylinder by means of water jets coming from the nozzles (**25**), thus providing a patterned nonwoven fabric. During said patterning by hydroentanglement pattern or patterns substantially corresponding to the 3-dimensional pattern or patterns of the pattern cylinder are accomplished to the nonwoven fabric.

[0017] In one embodiment of the apparatus in accordance with the invention, shown in FIG. **2**B, a support cylinder (**22'**) is located on the honeycomb structure (**21'**), said cylinder being arranged to rotate along with the honeycomb structure (**21'**). The support cylinder can be fixed to the honeycomb construction as described above in connection with the pattern cylinder. The support cylinder has apertures (**25'**) for removing the hydroentangling water coming from the water nozzles (**25'**). The open surface of the support cylinder is chosen to be as large as possible for achieving a good water removal. The size of the orifices of the support cylinder and the open surface thereof (the portion of the perforated area) are preferably larger than the corresponding values of the pattern cylinder. The pattern cylinder (**23'**) is located on the support cylinder (**22'**). The pattern cylinder is fixed to the support cylinder for example by welding, for example at the edges of the cylinder, preferably also here and there at the mantle of the cylinder, elsewhere than at the edges. Said support cylinder is used especially when the elongation of the pattern cylinder is increased due to the patterning of the pattern cylinder.

[0018] A patterning unit in accordance with the invention could be installed for example where the hydroentangling unit (**7**) is in the production line shown in FIG. **1**, and in that case the schematic drawings **2**A and **2**B would be enlarged views of the point (**9**) shown in FIG. **1**. A patterning unit in accordance with the invention can easily be added to the process line for patterning the nonwoven fabric.

[0019] FIG. **3**A shows a part of a pattern cylinder in accordance with one preferred embodiment, included in the apparatus in accordance with the invention, as a top view, and FIG. **3**B the same as a schematic section A-A. The perforated plate has patterns (**32**) projecting from the plane level **31** of the plate. In this embodiment, the patterns are projecting outwards from the plane level of the plate and from the central point of the cylinder outwards. The surface of the pattern cylinder **31** which has not been shaped by embossing, forms a plane level **31** from which surface (plane) a 3-dimensional pattern or patterns **32**, accomplished to it by embossing, are protruding upwards, downwards or to both directions. The water nozzles **30** are arranged regularly in ternary (triangle) distribution. The pattern formed to the element supporting the web in an apparatus in accordance with the invention can have any form that can be technically accomplished to the pattern plate. Water orifices of the plate are coinciding the patterns **32**. As a result of this the fibre web is bonded efficiently also at portions where the patterns are located. The ridges of the patterns to be formed onto the plate have preferably a round form and/or the peaks of the patterns can be formed even for instance by rolling (mangling) them after being embossed. When shaping the metal plate, the properties of the material and the way of working of the material define the minimum possible rounding radius to be used, going below of which would damage the plate, for instance through cracking when the pattern is being formed to the plate. In one preferred embodiment of the apparatus in accordance with the invention, the difference in height h between the bottom and the peak of the pattern in the perforated pattern plate is from 1 to 3 mm, especially 1.5 mm. The pattern can be discontinuous or continuous. In one preferred embodiment, the pattern is continuous at least in one direction of the nonwoven web. The patterns to be formed by means of the apparatus and the method in accordance with the invention can be located with even or uneven distances with regard to each other in the

direction of the plane level of the perforated plate. The distance of the patterns from each other can be chosen freely and they can have a different height with respect to each other.

[0020] The method in accordance with the present invention for manufacturing nonwoven fabric with patterns in a continuous method comprises stages including the formation of the fibre web, patterning of the nonwoven web in the hydroentangling station, in other words the patterning by hydroentanglement, and the drying of the nonwoven fabric. In one preferred embodiment of the method in accordance with the invention, the fibre web is prebonded prior to the patterning by hydroentanglement. In the method in accordance with the invention, the nonwoven fabric is patterned so that the web in the pattern hydroentanglement phase is supported onto a perforated surface, in the embodiment of FIG. **1**, on a perforated cylinder, where a three dimensional pattern has been formed substantially without removing material. In the method in accordance with the invention, a pattern cylinder of the apparatus in accordance with the invention or the apparatus in accordance with the invention is preferably used for pattern hydroentanglement. During the hydroentangling the fibres are reorganized. Immediately after the pattern hydroentanglement, before the nonwoven fabric is dried and reeled, the nonwoven fabric formed follows the form of the three-dimensional patterning of the hydroentanglement support used for patterning. In the final product, when unreeled, the pattern is especially perceptible as opacity differences and/or differences in the grammage, so that the fabric at the patterns has on average a lower opacity and/or grammage than the background. The background in this connection means the nonwoven fabric formed into the plane level of the plate, to which the patterns which are protruding from it, are formed. Three dimensional patterns are not accomplished to the plane level. In one preferred embodiment the pattern is observed in the final product as differences in the opacity and/or grammage so that in the peaks projecting outwards from the surface of the cylinder, the opacity and/or grammage are at their lowest.

[0021] The element included in the apparatus in accordance with the present invention, said element supporting the web, is made of a perforated metal plate. In one embodiment it is made of a perforated metal plate ready available on the market, whereby no special equipment is required for perforating the material. The water used in hydroentanglement exits through said orifices **30** from the surface of the pattern cylinder. Patterns or texturing is substantially not accomplished to the nonwoven fabric by perforations of the plate. According to the invention, in patterning by hydroentanglement, substantially only pattern or patterns corresponding to the 3-dimensional pattern or patterns embossed to the pattern cylinder and protruding from it, are accomplished to the nonwoven fabric. The element for supporting the web is preferably manufactured of acid proof or stainless metal, especially of steel. The surface topography of the imperforated portion of the metal plate used for manufacturing the pattern cylinder is substantially smooth. The three dimensional pattern is formed to the plate without removing material, preferably by embossing. In one embodiment the three dimensionally patterned plate is made into a cylinder form by welding.

[0022] In one preferred embodiment of the element for supporting the web, included in the apparatus in accordance with the present invention, the orifices of the surface used for the forming of the pattern are preferably arranged with a regular distribution, especially in ternary (triangle) distribution. The diameter of the orifices can range for example from 0.2 mm to 3.0 mm and is preferably between 0.2 and 1.0 mm. In one preferred embodiment, the diameter of the orifices ranges from 0.3 mm to 0.7 mm, especially 0.5 mm. The distance of the edges of the orifices from each other is at least 0.5 mm, preferably from 1 mm to 1.5 mm, especially about 1.1 mm. In one embodiment the plate is perforated with orifices with a random distribution. The distance of the orifices from each other is defined for example depending on the diameter of the orifices and the perforated surface area. The portion of the orifices from the surface area of the pattern cylinder of the apparatus in accordance with the invention ranges from 8% to 50%, preferably from 8% to 22%, especially from 15% to 20%. In one preferred embodiment of the invention, the portion of the orifices in the surface ranges from 17% to 20%, especially 19%.

[0023] The element supporting the web in the patterning can be manufactured without complicated devices, to make the transfer to a new pattern flexible.

[0024] The patterning of the nonwoven web or fabric by means of an apparatus and a method in accordance with the invention can also be implemented without any support cylinder (**22'**) by placing the pattern cylinder (**23'**) directly onto the honeycomb construction (**21'**). By means of this kind of a patterning unit, the efficiency of the hydroentangling can be increased, because there is no construction of a support cylinder under the pattern cylinder that would prevent the removal of the hydroentanglement water from the surface of the cylinder.

[0025] In the method in accordance with the invention, dry web forming can be used, for example carding or air carding for forming a web. For forming of the web, also the wet web forming is possible, or for example the spunlaid technique. In the spunlaid technique, the web forming includes fibre extrusion, fibre orientation and collecting the filaments to a fibre web. After the web formation the fibre web can be fed directly to the hydroentangling station where it is patterned or preferably to prebonding before that. As a prebonding process for instance chemical bonding, thermal bonding or mechanical bonding like hydroentanglement can be used. In one preferred embodiment of the method in accordance with the invention, solely hydroentangling is used as a prebonding process. Hydroentangling for prebonding the fibre web is preferably not performed in the same hydroentangling unit as the hydroentangling for patterning the nonwoven fabric. In one preferred embodiment of the invention the fibre web is formed of stable fibres by carding.

[0026] The method in accordance with the invention is suitable for patterning of nonwoven fabrics both having a monolayer construction and multilayer construction. According to one embodiment of the invention, a patterned nonwoven fabric having a multilayer construction can be made by adding to the production line of the fabric one or a plurality of fibre web forming stations, like for example a carding station, in order to form a patterned multilayer construction in a continuous process. In accordance with another embodiment, the patterned multilayer construction can be implemented also by bringing to the process one or a plurality of separately (off-line) formed and/or prebonded fibre web(s). The fibre webs (layers) forming the multilayer nonwoven fabric or a part of them can be combined prior to the patterning by hydroentanglement, for example in a hydroentangling unit before the patterning by hydroentanglement, or separate fibre webs can be brought directly to the patterning unit, whereby

the fibre webs are combined and the combined fibre webs are patterned in the same stage of the process.

[0027] For example polyolefin fibres can be used in the method in accordance with the invention, like polythylene of polypropylene fibres, polyester fibres, viscose and pulp fibres and different mixtures of these fibres. The mass proportions of polypropylene or polyester: viscose vary, especially at least in one fibre web, preferably ranging from 10:90 to 90:10, especially from 20:80 to 80:20. In one preferred embodiment said mass proportion ranges from 30:70 to 70:30, especially from 30:70 to 40:60. The fibre fineness of the fibres used in the method in accordance with the invention, preferably ranges from 1 to 3.3 dtex, especially advantageously 1.7 dtex. In one preferred embodiment of the method in accordance with the invention, only polypropylene/viscose fibre mixture is used, and in another preferred embodiment only polyester/viscose mixture of fibres is used at least in one fibre web, preferably in proportions mentioned above. Nonwoven fabrics manufactured using the method in accordance with the invention, especially by using the above-mentioned fibres, are especially suitable for use in wipe and hygienic applications, as well as in sanitary applications, like surgical gauzes.

[0028] In the following, the invention will be illustrated in more detail by means of an example.

EXAMPLE

Sample Preparation

[0029] Nonwoven fabric was manufactured from a mixture of polyester/viscose fibres (mass proportion 33/67). The fineness of the fibres was 1.7 dtex. Stable fibres having a fibre length of 40 mm were used. The grammage of the nonwoven fabric was 55 g/m^2. The nonwoven fabric was manufactured on a nonwoven fabric line as shown in FIG. **1**, where the fibre web was formed by carding, and where two hydroentanglement units were used. The patterning of the nonwoven fabric was performed after that by hydroentangling by means of water jets having a diameter of 0.12 mm and a jet density of 40/inch. The hydroentangling was performed twice, using a pressure of 80 bars. The hydroentangling base was a smooth metal wire screen, with 75 mesh, made of acid proof steel and one embossed into a three-dimensional form, and a smooth perforated metal plate made of acid proof steel and one embossed into a three-dimensional form. The metal plate had orifices of 0.5 mm in triangle (ternary) distribution (distance between the orifices 1.09 mm) and the open surface area, in other words the surface of the perforated portion of the plate was 19%. The metal plate had a thickness of 0.4 mm and the orifices had a form of a straight cylinder.

Detachment Test

[0030] The pulling test was used for testing the detachment of the nonwoven fabric from the base used to support it during the hydroentanglement.

[0031] The force required for removing the nonwoven fabric from the hydroentanglement base was measured with pulling device Zwick BZ2.5/TN1S. A sample having a width of 50 mm was used for the pulling test. The sample was in a state as after the hydroentangling on the hydroentanglement base. The hydroentanglement base was located on the lower jaw of the pulling device and was kept immovable at the lower jaw. The fabric sample was slightly detached from the needling base and attached to the upper jaw of the pulling device. A measuring transducer of 10 N was used in the pulling device, whereby a measuring result could be received from the pulling device when the pulling force of 0.1 N was exceeded. The width of the jaw was 50 mm. The force required for detaching (removing) the sample from the base was measured for a length of 50 mm. The results were recorded from removal length of 15 mm and 50 mm. The pulling interspace was 50 mm and the pulling angle was not lower than 90 degrees. The pulling speed was 100 mm/min and the pulling direction was the machine direction. The results were received as an average force required for removal for 15 mm and 50 mm. Four parallel samples were used in measurements. In case after two measurements no measuring result was obtained, in other words, if the required pulling force did not exceed 0.1 N, the testing of the sample was not continued.

Non-Patterned Hydroentanglement Base

[0032] The force required for removing the sample from the base could not be measured, when a smooth (flat) wire screen was used as a hydroentanglement base, because the sample had not got attached to the base during the hydroentanglement. Also, when a smooth (flat) perforated plate was used as a hydroentanglement base, no result could be received with the pulling device. Visual inspection showed no fibres attached to the base. The structure of the unpatterned hydroentanglement base had no influence on the adhesion of the nonwoven fabric to the base.

Patterned Hydroentanglement Base (Comprising a Three-Dimensional Pattern)

[0033] Forces from four measurements required for attachment of a sample in cases, where a metal wire screen embossed into a three-dimensional pattern was used as a hydroentanglement base, are shown in Table 1, said results being received from four measurements

TABLE 1

Pulling direction	Sample No	Average of detachment force at detachment length of 15 and 50 mm N
MD	1	0.15
MD	2	0.15
MD	3	0.17
MD	4	0.26

[0034] A substantial amount of fibres had adhered into the metal wire screen in the detachment (removal) stage, seen by the visual inspection.

[0035] It was observed that the embossing of the metal wire screen into three-dimensional form causes the movement of the wires and the overlapping of them so that there are gaps formed between the wires into the surface of the wire, so that the fibres get easily stuck into them. In the hydroentanglement, the water jets push the fibres to the gaps between the wires, which makes the removal of the fabric from the wire difficult and fibres get attached to the hydroentanglement base.

[0036] When a perforated metal plate embossed into a three-dimensional form was used as a hydroentanglement base, it was not possible to measure the force required for detachment. Surprisingly, the formed patterned nonwoven fabric did not stick to the base during the hydroentanglement.

No fibres were either seen by the visual inspection been attached to this kind of a patterned, perforated metal plate.

[0037] The present invention concerns a method and an apparatus for patterning nonwoven fabric. More particularly, the invention concerns the patterning of the nonwoven fabric so that during the hydroentanglement, one side of the web is supported onto an embossed, perforated plate, to which a three dimensional pattern has been formed without removing material. Patterned nonwoven fabrics can be used for example for towels and for hygienic products as well as for sanitary applications.

[0038] By patterning of a nonwoven fabric for instance the visual properties of the nonwoven fabric and its use properties can be affected. Patterns can be effected into the nonwoven fabric for instance by means of alteration of the density of the nonwoven fabric, by alteration of the grammage or by perforating. One way of patterning the nonwoven fabric is to perform the hydroentangling on a patterned hydreontanglement cylinder.

[0039] In Patent publications EP1036871 and EP1001064 it is suggested that a dotted patterning or a perforation can be achieved into a nonwoven fabric by performing hydroentangling on a plastic mantle set on a supporting cylinder, said plastic mantle being equipped with piked protrusions being surrounded by water orifices on the plane level of the mantle. With this method, however, it is not possible to accomplish a continuous pattern, because at the protrusion of the mantle there are no water orifices that are necessary for providing an uniform and adequate strength to the nonwoven fabric.

[0040] The patent U.S. Pat. No. 5,674,591 discloses a nonwoven fabric being hydroentangled on a cylinder provided with orifices for water removal bored with a laser and in addition being provided with macro sized engraved recesses for forming a permanent, three-dimensional pattern into the nonwoven fabric, the grammage of the nonwoven fabric being at these pattern portions the same or higher than that of the background. In said cylinder there is a micro sized surface topography pattern around the dewatering orifices, whereby the background surface of the nonwoven fabric can be made visually resembling the tricot. The patent publication U.S. Pat. No. 5,906,786 describes the manufacturing of this kind of a cylinder by using among others laser ablation.

[0041] In a method in accordance with a US patent application publication 2002/0160681 A1, a nonwoven fabric web is patterned by hydroentangling on a drum having as its outer structure an embossed metal wire fabric. The three-dimensional pattern of the metal wire screen is transferred onto the nonwoven fabric thus providing a nonwoven fabric having recesses and protrusion areas following each other. A problem with this method is, however, the attachment of the fibres to the pattern wire screen, which causes the clogging of the wire, breaks in production for cleaning the wire and roughening of the nonwoven fabric to be formed. Along with the clogging, also the water removing properties of the wire are deteriorated, whereby the strength of the nonwoven fabric achieved in the hydroentangling is lowered and/or is not formed uniform. Said figure patterning wire always requires also a support cylinder underneath it, in addition to a honeycomb construction.

[0042] The purpose of the present invention is to provide a method and an apparatus due to which, among others, clogging of the patterning elements when patterning the nonwoven fabric is substantially eliminated.

[0043] To accomplish what has been stated above, the apparatus in accordance with the invention, is characterized in that the element supporting the web comprises a perforated cylinder having a three dimensional pattern formed onto it, substantially without removing material from it. The method in accordance with the present invention is characterized in that during the pattern forming phase the web is supported by means of a perforated cylinder having a three dimensional pattern formed onto it, substantially without removing material from it. By means of the three dimensional pattern of the pattern cylinder, a pattern or patterns substantially corresponding to the three dimensional pattern or patterns of the pattern cylinder are accomplished to the nonwoven fabric in the hydroentanglement.

[0044] With a method and apparatus in accordance with the invention, the attachment of the fibres to the element supporting the web in the hydroentangling unit of the web-patterning phase is substantially eliminated. It was observed in the studies that surprisingly substantially no fibres get attached to the patterned element according to the invention supporting the web, the element being embossed to three dimensional form, during hydroentanglement and the nonwoven fabric does substantially not get attached to the hydroentanglement base when removed from the base. Thereby the need for cleaning the apparatus is decreased, thus decreasing the number of service stops and/or breaks in production. The decrease in the attachment of the fibres to the hydroentangling base or the elimination thereof improves the smoothness of the surface of the fabric to be produced. Along with the decreased clogging of the water orifices, the effect of the hydroentangling and/or the uniformity of the hydroentangling in connection with the patterning can be improved. The improved hydroentangling effect means for example the same achieved strength of the nonwoven fabric with a smaller water amount or with smaller pressure, or a higher strength of the nonwoven fabric with the same water amount. In addition, the element for supporting the web when patterned, said element comprising a three-dimensional pattern and being included into an apparatus in accordance with the invention, is simpler and less laborious to manufacture. In addition, it is possible to improve the efficiency of the hydroentangling in the patterning phase, because the pattern cylinder in accordance with the invention does not always require a support cylinder under it.

[0045] The invention will be described in more detail in the following with reference to the enclosed drawings, wherein

[0046] FIG. **1** shows a continuously operating production line of nonwoven fabric for manufacturing patterned nonwoven fabric in accordance with one preferred embodiment of the method in accordance with the present invention,

[0047] FIG. **2**A is a cross-sectional view of some components of one preferred embodiment of the apparatus in accordance with the invention,

[0048] FIG. **2**B shows a cross-sectional view of some components of another preferred embodiment of the apparatus in accordance with the invention,

[0049] FIG. **3**A shows a schematic top view of an element supporting the web, in other words a pattern cylinder, according to one preferred embodiment comprised in the apparatus in accordance with the invention, and

[0050] FIG. **3**B illustrates schematically a part of the pattern cylinder of FIG. **3**A as a cross-sectional view.

[0051] FIG. **1** shows one continuously operating nonwoven fabric production line for manufacturing patterned nonwoven fabric in accordance with one preferred embodiment of the

method in accordance with the present invention. Fibres are fed to a conveyor belt with a feeding device (**1**). The fibres are preferably stable fibres that have been crimped and cut from polymer filaments. The fibres are led to the card unit (**3**), for forming them mechanically into a card web. After that the card web proceeds to the first hydroentangling station (**5**) for prebonding. The formed prebonded fibre web is led to another hydroentangling station (**7**) to be hydroentangled in an apparatus, wherein the web during the hydroentangling process is supported on a cylinder being manufactured of a perforated plate, onto which a three-dimensional pattern has been formed substantially without removing material, in this case by embossing. This kind of a cylinder is henceforth also referred to as a pattern cylinder. The hydroentangling unit or station for patterning the web or nonwoven fabric is in this text later also referred to as a patterning unit. After the patterning unit, the patterned nonwoven fabric is led to a drying apparatus (**11**) and further to be reeled with a reeler (**13**). A production line can be provided with a plurality of patterning units. For manufacturing a multilayer carded web, number of fibre feeding devices corresponding to the number of layers and carding stations corresponding to the webs can be arranged for example as described in the patent publication FI 20012426. As shown in the publication FI 20012426, there can be a plurality of hydroentangling stations arranged on the line.

[0052] FIG. **2**A shows as a partial cross-sectional, schematic enlarged view some components of one preferred embodiment of an apparatus, in other words, a patterning unit in accordance with the invention. The patterning unit in accordance with the invention comprises components of prior art of the hydroentangling unit: the pattering unit has a honeycomb structure (**21**), having a vacuum system (not shown) for removing the water coming from the water jets of the water nozzles (**25**) from the surface of the cylinder. The outer part of the cylinder of the patterning unit is a cylinder (**23**) being manufactured of a perforated plate, and having a three-dimensional pattern formed substantially without removing material. The pattern cylinder can be made of one or of a plurality of perforated plates joined together in a suitable way for forming a cylinder, for instance by means of a stapling arrangement or especially by welding. The cross-section of the orifices of the pattern cylinder is for example substantially circular and the orifices preferably have a form of a straight cylinder. The pattern cylinder (**23**) is in this case positioned directly onto the honeycomb construction. This is possible because the structure of the pattern cylinder according to the invention is rigid enough. In the embodiment in accordance with FIG. **2**A, the pattern cylinder (**23**) is arranged to rotate along with the honeycomb structure (**21**). The pattern cylinder can be attached onto the honeycomb structure from the edges by means of sealing, the pattern cylinder being fixed tightly to the honeycomb construction by raising the internal air pressure of the sealing, and made to rotate along with the honeycomb construction. The fibre web is hydroentangled on top of the pattern cylinder by means of water jets coming from the nozzles (**25**), thus providing a patterned nonwoven fabric. During said patterning by hydroentanglement pattern or patterns substantially corresponding to the 3-dimensional pattern or patterns of the pattern cylinder are accomplished to the nonwoven fabric.

[0053] In one embodiment of the apparatus in accordance with the invention, shown in FIG. **2**B, a support cylinder (**22'**) is located on the honeycomb structure (**21'**), said cylinder being arranged to rotate along with the honeycomb structure (**21'**). The support cylinder can be fixed to the honeycomb construction as described above in connection with the pattern cylinder. The support cylinder has apertures (**25'**) for removing the hydroentangling water coming from the water nozzles (**25'**). The open surface of the support cylinder is chosen to be as large as possible for achieving a good water removal. The size of the orifices of the support cylinder and the open surface thereof (the portion of the perforated area) are preferably larger than the corresponding values of the pattern cylinder. The pattern cylinder (**23'**) is located on the support cylinder (**22'**). The pattern cylinder is fixed to the support cylinder for example by welding, for example at the edges of the cylinder, preferably also here and there at the mantle of the cylinder, elsewhere than at the edges. Said support cylinder is used especially when the elongation of the pattern cylinder is increased due to the patterning of the pattern cylinder.

[0054] A patterning unit in accordance with the invention could be installed for example where the hydroentangling unit (**7**) is in the production line shown in FIG. **1**, and in that case the schematic drawings **2**A and **2**B would be enlarged views of the point (**9**) shown in FIG. **1**. A patterning unit in accordance with the invention can easily be added to the process line for patterning the nonwoven fabric.

[0055] FIG. **3**A shows a part of a pattern cylinder in accordance with one preferred embodiment, included in the apparatus in accordance with the invention, as a top view, and FIG. **3**B the same as a schematic section A-A. The perforated plate has patterns (**32**) projecting from the plane level **31** of the plate. In this embodiment, the patterns are projecting outwards from the plane level of the plate and from the central point of the cylinder outwards. The surface of the pattern cylinder **31** which has not been shaped by embossing, forms a plane level **31** from which surface (plane) a 3-dimensional pattern or patterns **32**, accomplished to it by embossing, are protruding upwards, downwards or to both directions. The water nozzles **30** are arranged regularly in ternary (triangle) distribution. The pattern formed to the element supporting the web in an apparatus in accordance with the invention can have any form that can be technically accomplished to the pattern plate. Water orifices of the plate are coinciding the patterns **32**. As a result of this the fibre web is bonded efficiently also at portions where the patterns are located. The ridges of the patterns to be formed onto the plate have preferably a round form and/or the peaks of the patterns can be formed even for instance by rolling (mangling) them after being embossed. When shaping the metal plate, the properties of the material and the way of working of the material define the minimum possible rounding radius to be used, going below of which would damage the plate, for instance through cracking when the pattern is being formed to the plate. In one preferred embodiment of the apparatus in accordance with the invention, the difference in height h between the bottom and the peak of the pattern in the perforated pattern plate is from 1 to 3 mm, especially 1.5 mm. The pattern can be discontinuous or continuous. In one preferred embodiment, the pattern is continuous at least in one direction of the nonwoven web. The patterns to be formed by means of the apparatus and the method in accordance with the invention can be located with even or uneven distances with regard to each other in the direction of the plane level of the perforated plate. The distance of the patterns from each other can be chosen freely and they can have a different height with respect to each other.

[0056] The method in accordance with the present invention for manufacturing nonwoven fabric with patterns in a continuous method comprises stages including the formation of the fibre web, patterning of the nonwoven web in the hydroentangling station, in other words the patterning by hydroentanglement, and the drying of the nonwoven fabric. In one preferred embodiment of the method in accordance with the invention, the fibre web is prebonded prior to the patterning by hydroentanglement. In the method in accordance with the invention, the nonwoven fabric is patterned so that the web in the pattern hydroentanglement phase is supported onto a perforated surface, in the embodiment of FIG. **1**, on a perforated cylinder, where a three dimensional pattern has been formed substantially without removing material. In the method in accordance with the invention, a pattern cylinder of the apparatus in accordance with the invention or the apparatus in accordance with the invention is preferably used for pattern hydroentanglement. During the hydroentangling the fibres are reorganized. Immediately after the pattern hydroentanglement, before the nonwoven fabric is dried and reeled, the nonwoven fabric formed follows the form of the three-dimensional patterning of the hydroentanglement support used for patterning. In the final product, when unreeled, the pattern is especially perceptible as opacity differences and/or differences in the grammage, so that the fabric at the patterns has on average a lower opacity and/or grammage than the background. The background in this connection means the nonwoven fabric formed into the plane level of the plate, to which the patterns which are protruding from it, are formed. Three dimensional patterns are not accomplished to the plane level. In one preferred embodiment the pattern is observed in the final product as differences in the opacity and/or grammage so that in the peaks projecting outwards from the surface of the cylinder, the opacity and/or grammage are at their lowest.

[0057] The element included in the apparatus in accordance with the present invention, said element supporting the web, is made of a perforated metal plate. In one embodiment it is made of a perforated metal plate ready available on the market, whereby no special equipment is required for perforating the material. The water used in hydroentanglement exits through said orifices **30** from the surface of the pattern cylinder. Patterns or texturing is substantially not accomplished to the nonwoven fabric by perforations of the plate. According to the invention, in patterning by hydroentanglement, substantially only pattern or patterns corresponding to the 3-dimensional pattern or patterns embossed to the pattern cylinder and protruding from it, are accomplished to the nonwoven fabric. The element for supporting the web is preferably manufactured of acid proof or stainless metal, especially of steel. The surface topography of the imperforated portion of the metal plate used for manufacturing the pattern cylinder is substantially smooth. The three dimensional pattern is formed to the plate without removing material, preferably by embossing. In one embodiment the three dimensionally patterned plate is made into a cylinder form by welding.

[0058] In one preferred embodiment of the element for supporting the web, included in the apparatus in accordance with the present invention, the orifices of the surface used for the forming of the pattern are preferably arranged with a regular distribution, especially in ternary (triangle) distribution. The diameter of the orifices can range for example from 0.2 mm to 3.0 mm and is preferably between 0.2 and 1.0 mm. In one preferred embodiment, the diameter of the orifices ranges from 0.3 mm to 0.7 mm, especially 0.5 mm. The distance of the edges of the orifices from each other is at least 0.5 mm, preferably from 1 mm to 1.5 mm, especially about 1.1 mm. In one embodiment the plate is perforated with orifices with a random distribution. The distance of the orifices from each other is defined for example depending on the diameter of the orifices and the perforated surface area. The portion of the orifices from the surface area of the pattern cylinder of the apparatus in accordance with the invention ranges from 8% to 50%, preferably from 8% to 22%, especially from 15% to 20%. In one preferred embodiment of the invention, the portion of the orifices in the surface ranges from 17% to 20%, especially 19%.

[0059] The element supporting the web in the patterning can be manufactured without complicated devices, to make the transfer to a new pattern flexible.

[0060] The patterning of the nonwoven web or fabric by means of an apparatus and a method in accordance with the invention can also be implemented without any support cylinder (**22'**) by placing the pattern cylinder (**23'**) directly onto the honeycomb construction (**21'**). By means of this kind of a patterning unit, the efficiency of the hydroentangling can be increased, because there is no construction of a support cylinder under the pattern cylinder that would prevent the removal of the hydroentanglement water from the surface of the cylinder.

[0061] In the method in accordance with the invention, dry web forming can be used, for example carding or air carding for forming a web. For forming of the web, also the wet web forming is possible, or for example the spunlaid technique. In the spunlaid technique, the web forming includes fibre extrusion, fibre orientation and collecting the filaments to a fibre web. After the web formation the fibre web can be fed directly to the hydroentangling station where it is patterned or preferably to prebonding before that. As a prebonding process for instance chemical bonding, thermal bonding or mechanical bonding like hydroentanglement can be used. In one preferred embodiment of the method in accordance with the invention, solely hydroentangling is used as a prebonding process. Hydroentangling for prebonding the fibre web is preferably not performed in the same hydroentangling unit as the hydroentangling for patterning the nonwoven fabric. In one preferred embodiment of the invention the fibre web is formed of stable fibres by carding.

[0062] The method in accordance with the invention is suitable for patterning of nonwoven fabrics both having a monolayer construction and multilayer construction. According to one embodiment of the invention, a patterned nonwoven fabric having a multilayer construction can be made by adding to the production line of the fabric one or a plurality of fibre web forming stations, like for example a carding station, in order to form a patterned multilayer construction in a continuous process. In accordance with another embodiment, the patterned multilayer construction can be implemented also by bringing to the process one or a plurality of separately (off-line) formed and/or prebonded fibre web(s). The fibre webs (layers) forming the multilayer nonwoven fabric or a part of them can be combined prior to the patterning by hydroentanglement, for example in a hydroentangling unit before the patterning by hydroentanglement, or separate fibre webs can be brought directly to the patterning unit, whereby the fibre webs are combined and the combined fibre webs are patterned in the same stage of the process.

[0063] For example polyolefin fibres can be used in the method in accordance with the invention, like polythylene of polypropylene fibres, polyester fibres, viscose and pulp fibres and different mixtures of these fibres. The mass proportions of polypropylene or polyester: viscose vary, especially at least in one fibre web, preferably ranging from 10:90 to 90:10, especially from 20:80 to 80:20. In one preferred embodiment said mass proportion ranges from 30:70 to 70:30, especially from 30:70 to 40:60. The fibre fineness of the fibres used in the method in accordance with the invention, preferably ranges from 1 to 3.3 dtex, especially advantageously 1.7 dtex. In one preferred embodiment of the method in accordance with the invention, only polypropylene/viscose fibre mixture is used, and in another preferred embodiment only polyester/viscose mixture of fibres is used at least in one fibre web, preferably in proportions mentioned above. Nonwoven fabrics manufactured using the method in accordance with the invention, especially by using the above-mentioned fibres, are especially suitable for use in wipe and hygienic applications, as well as in sanitary applications, like surgical gauzes.

[0064] In the following, the invention will be illustrated in more detail by means of an example.

Example

Sample Preparation

[0065] Nonwoven fabric was manufactured from a mixture of polyester/viscose fibres (mass proportion 33/67). The fineness of the fibres was 1.7 dtex. Stable fibres having a fibre length of 40 mm were used. The grammage of the nonwoven fabric was 55 g/m^2. The nonwoven fabric was manufactured on a nonwoven fabric line as shown in FIG. **1**, where the fibre web was formed by carding, and where two hydroentanglement units were used. The patterning of the nonwoven fabric was performed after that by hydroentangling by means of water jets having a diameter of 0.12 mm and a jet density of 40/inch. The hydroentangling was performed twice, using a pressure of 80 bars. The hydroentangling base was a smooth metal wire screen, with 75 mesh, made of acid proof steel and one embossed into a three-dimensional form, and a smooth perforated metal plate made of acid proof steel and one embossed into a three-dimensional form. The metal plate had orifices of 0.5 mm in triangle (ternary) distribution (distance between the orifices 1.09 mm) and the open surface area, in other words the surface of the perforated portion of the plate was 19%. The metal plate had a thickness of 0.4 mm and the orifices had a form of a straight cylinder.

Detachment Test

[0066] The pulling test was used for testing the detachment of the nonwoven fabric from the base used to support it during the hydroentanglement.

[0067] The force required for removing the nonwoven fabric from the hydroentanglement base was measured with pulling device Zwick BZ2.5/TN1S. A sample having a width of 50 mm was used for the pulling test. The sample was in a state as after the hydroentangling on the hydroentanglement base. The hydroentanglement base was located on the lower jaw of the pulling device and was kept immovable at the lower jaw. The fabric sample was slightly detached from the needling base and attached to the upper jaw of the pulling device. A measuring transducer of 10 N was used in the pulling device, whereby a measuring result could be received from the pulling device when the pulling force of 0.1 N was exceeded. The width of the jaw was 50 mm. The force required for detaching (removing) the sample from the base was measured for a length of 50 mm. The results were recorded from removal length of 15 mm and 50 mm. The pulling interspace was 50 mm and the pulling angle was not lower than 90 degrees. The pulling speed was 100 mm/min and the pulling direction was the machine direction. The results were received as an average force required for removal for 15 mm and 50 mm. Four parallel samples were used in measurements. In case after two measurements no measuring result was obtained, in other words, if the required pulling force did not exceed 0.1 N, the testing of the sample was not continued.

Non-Patterned Hydroentanglement Base

[0068] The force required for removing the sample from the base could not be measured, when a smooth (flat) wire screen was used as a hydroentanglement base, because the sample had not got attached to the base during the hydroentanglement. Also, when a smooth (flat) perforated plate was used as a hydroentanglement base, no result could be received with the pulling device. Visual inspection showed no fibres attached to the base. The structure of the unpatterned hydroentanglement base had no influence on the adhesion of the nonwoven fabric to the base.

Patterned Hydroentanglement Base (Comprising A Three-Dimensional Pattern)

[0069] Forces from four measurements required for attachment of a sample in cases, where a metal wire screen embossed into a three-dimensional pattern was used as a hydroentanglement base, are shown in Table 1, said results being received from four measurements

TABLE 1

Pulling direction	Sample No	Average of detachment force at detachment length of 15 and 50 mm N
MD	1	0.15
MD	2	0.15
MD	3	0.17
MD	4	0.26

[0070] A substantial amount of fibres had adhered into the metal wire screen in the detachment (removal) stage, seen by the visual inspection.

[0071] It was observed that the embossing of the metal wire screen into three-dimensional form causes the movement of the wires and the overlapping of them so that there are gaps formed between the wires into the surface of the wire, so that the fibres get easily stuck into them. In the hydroentanglement, the water jets push the fibres to the gaps between the wires, which makes the removal of the fabric from the wire difficult and fibres get attached to the hydroentanglement base.

[0072] When a perforated metal plate embossed into a three-dimensional form was used as a hydroentanglement base, it was not possible to measure the force required for detachment. Surprisingly, the formed patterned nonwoven fabric did not stick to the base during the hydroentanglement. No fibres were either seen by the visual inspection been attached to this kind of a patterned, perforated metal plate.

1: A method for patterning nonwoven fabric, including steps in the following order

forming of one or a plurality of fibre webs,

patterning of the fibre web or combined fibre webs by hydroentanglement,

drying of the nonwoven fabric,

characterized in that during the said patterning step, the web is supported on a perforated plate in a cylinder form (**23**, **23'**), to which cylinder has been formed by embossing a three-dimensional pattern or patterns which are provided with orifices (**30**) of the said plate (pattern cylinder), and that in said patterning by hydroentanglement, pattern or patterns substantially corresponding to the 3-dimensional pattern or patterns (**32**) of the pattern cylinder is/are obtained in the nonwoven fabric.

2: A method in accordance with claim **1**, characterized in that in the patterning by hydroentanglement substantially only the pattern or patterns corresponding to the 3-dimensional pattern or patterns (**32**) embossed to the pattern cylinder (**23**, **23'**) is/are obtained in the nonwoven fabric.

3: A method in accordance with claim **1**, characterized in that the opacity of the nonwoven fabric at the said pattern or patterns is on average lower than at non-patterned portion of the nonwoven fabric.

4: A method in accordance with claim **1**, characterized in that the grammage of the nonwoven fabric at the said pattern or patterns is on average lower than that of the non-patterned portion of the nonwoven fabric.

5: A method in accordance with claim **1**, characterized in that at least one fibre web is formed by carding.

6: A method in accordance with claim **1**, characterized in that at least one fibre web is prebonded before the patterning.

7: A method in accordance with claim **1**, characterized in that the fibre web or the fibre webs are prebonded mechanically, especially by hydroentangling.

8: A method in accordance with claim **1**, characterized in that the fibres to be used are stable fibres.

9: A method in accordance with claim **1**, characterized in that a composite of polypropylene or polyester fibres and viscose fibres is used.

10: A method in accordance with claim **9**, characterized in that in the fibre mixture the mass portions polypropylene: viscose or polyester: viscose are ranging from 20:80 to 80:20.

11: An apparatus for patterning nonwoven fabric, said apparatus comprising an element for supporting the web, a vacuum system and water nozzles (**25**) for patterning the fibre web or the combined fibre webs by hydroentanglement, characterized in that the element for supporting the web is a perforated plate, in the form of a cylinder, having a three-dimensional pattern or patterns (**32**) formed onto it by embossing (pattern cylinder) in order to obtain patterns in the nonwoven fabric and that the pattern or patterns in the pattern cylinder are provided with orifices (**30**) of the said plate.

12: An apparatus in accordance with claim **11**, characterized in that the surface (**31**) of the pattern cylinder that has not been formed by embossing, forms a plane level of the plate surface from which surface the 3-dimensional pattern or patterns (**32**), formed by embossing, protrude upwards, downwards or to both directions.

13: An apparatus in accordance with claim **11**, characterized in that said pattern cylinder comprises one or of a plurality of perforated plates.

14: An apparatus in accordance with claim **11**, characterized in that the apparatus comprises a honeycomb structure (**21**) and a pattern cylinder (**23**) is adapted directly onto the honeycomb construction.

15: An apparatus in accordance with claim **11**, characterized in that a support cylinder (**22'**) is arranged between the pattern cylinder (**23'**) and the honeycomb structure (**21'**).

16: An apparatus in accordance with claim **11**, characterized in that the diameter of the orifices (**30**) of the pattern cylinder ranges from 0.2 to 3.0 mm, preferably from 0.2 to 1.0 mm.

17: An apparatus in accordance with claim **11**, characterized in that the distance of the orifices of the pattern cylinder from each other is at least 0.5 mm, preferably from 1 to 1.5 mm.

18: An apparatus in accordance with claim **11**, characterized in that the portion of the perforated surface area of the pattern cylinder ranges from 8 to 50%, preferably from 8 to 22%.

19: An apparatus in accordance with claim **11**, characterized in that the orifices of the pattern cylinder are arranged regularly, especially in ternary (triangle) distribution.

20: An apparatus in accordance with claim **11**, characterized in that the difference between the bottom and the peak of the pattern in the pattern cylinder is from 1 to 3 mm, preferably 1.5 mm.

21: An apparatus in accordance with claim **11**, characterized in that the cross-section of the orifices of the pattern cylinder is substantially round.

22: Use of an apparatus in accordance with claim **11** in the patterning step in accordance with a method for patterning nonwoven fabric, including steps in the following order

forming of one or a plurality of fibre webs,

patterning of the fibre web or combined fibre webs by hydroentanglement,

drying of the nonwoven web,

characterized in that during the said patterning step, the web is supported on a perforated plate in a cylinder form (**23**, **23'**), to which cylinder has been formed by embossing a three-dimensional pattern or patterns which pattern or patterns coincide with orifices (**30**) of the said plate (pattern cylinder), and that in said patterning by hydroentanglement pattern or patterns substantially corresponding to the 3-dimensional pattern or patterns (**32**) embossed to the pattern cylinder are accomplished to the nonwoven fabric.

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