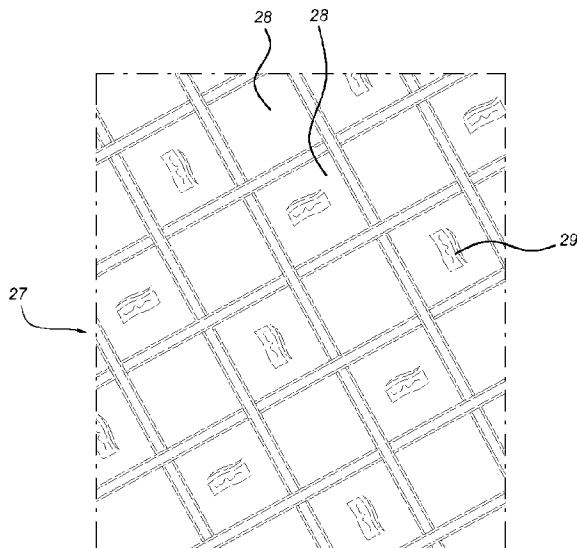




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(54) **Titre : MATERIAU NON TISSE A MOTIF**  
(54) **Title: PATTERNED NONWOVEN MATERIAL**



(57) **Abrégé/Abstract:**

Disclosed herein is a patterned hydroentangled nonwoven sheet material containing at least 25 wt.% of cellulosic pulp, in which a surface area of between 1 and 20 % of at least one surface has been imprinted to form a decorative or informative pattern discernible by visual and/or tactile differences between imprinted and non-imprinted areas. The patterned nonwoven sheet material can be produced by forming a fibrous web comprising thermoplastic fibres and cellulosic pulp, hydroentangling the fibrous web to form a nonwoven sheet material and drying, and then subjecting the dried nonwoven sheet material to an imprinting action provided by an energy transmitter, in particular using ultrasonic energy, on a patterned anvil at a temperature of less than 100°C to form a patterned nonwoven sheet material.

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## PATTERNED NONWOVEN MATERIAL

### *Field of the invention*

[0001] The present invention relates to a nonwoven sheet material provided with a visual non-random pattern and to a process for producing such a patterned nonwoven sheet material.

### 5 *Background*

[0002] Absorbent nonwoven materials are used for wiping various types of spills and dirt in industrial, medical, office and household applications. They typically comprise a combination of thermoplastic polymers (synthetic fibres) and cellulosic pulp for absorbing water and other hydrophilic substances, as well as hydrophobic substances (oils, fats). The nonwoven wipes of  
10 this type, in addition to having sufficient absorptive power, are at the same time strong, flexible and soft. They can be produced by various methods, including air-laying, wet-laying and foam-laying of a pulp-containing mixture on a polymer web, followed by dewatering and hydroentangling to anchor the pulp onto the polymer and final drying. Absorbent nonwoven materials of this type and their production processes are disclosed *i.a.* in WO 2005/042819, WO 2007/108725,  
15 WO 2008/066417, and WO 2009/031951.

[0003] For various applications, it is desired to have visible patterns, such as figures, logotypes, text and the like, on the nonwoven materials, so as to make them identifiable, for indicating their intended use, for promotional purposes etc. Patterns can be applied by printing; however, printing often results in bleeding of the ink into the nonwoven outside the pattern, e.g. when a wipe or the  
20 like is used together with solvents during use of the wipe (wiping), which is clearly undesired.

[0004] WO 95/09261 discloses nonwoven materials having geometrically repeating patterns that are formed by bonded and unbonded regions on the material. The bonded regions occupy 3-50%, in particular 5-35% of the surface area of the material. There are in the order of 8-120, e.g. 34 bonded regions per cm<sup>2</sup> and each unbonded region has an area of less than 0.3 cm<sup>2</sup>. The  
25 nonwoven materials are three-layered laminates having outer spun-bond thermoplastic layers and an inner melt-blown fibre layer. The laminates are patterned by calendaring using heated embossing rolls. A drawback of these materials is that the pattern is connected to bonding of the thermoplast and that, as a consequence, the patterns can only be small and at the same time must occupy a relatively large area of the nonwoven surface. This is particularly disadvantageous  
30 for absorbent nonwoven materials, containing cellulose pulp or the like, where bonding reduces the absorptive power and thermo-bonding is therefore avoided.

[0005] The aim of the present invention is to provide a patterned nonwoven sheet material, wherein the patterning does not entail the disadvantages of prior art techniques, such as bleeding of printed patterns, insufficient distinctness of patterns produced by hydroentangling, or stiffness  
35 and reduced strength or absorptive capacity of embossing techniques.

### **Summary**

[0006] Thus, the invention provides a, preferably hydroentangled, absorbent nonwoven material having a non-random, sharp and distinct visible decorative or identifying pattern on its surface. The visible pattern does not substantially reduce the absorptive power of the material and also  
5 ensures maintenance of other product properties, including softness, abrasion resistance, strength etc. The two sides of the material may have different compositions: the lower side may have a relatively high pulp content, whereas the upper side, on which the pattern is provided, may have a relatively low pulp content, or vice versa.

[0007] The object is further to provide a process for producing a patterned pulp-containing non-  
10 woven, comprising subjecting the non-woven to an imprinting step avoiding high temperatures, in particular a vibrational imprinting step.

### **Brief description of the drawings**

[0008] Figure 1 shows a production line for producing sheet material of the present disclosure.

[0009] Figure 2 shows a patterned nonwoven according to the present disclosure.

### **15 Detailed description**

[0010] The invention pertains to a patterned hydroentangled nonwoven sheet material as defined herein. The invention furthermore pertains to a process of producing a patterned nonwoven sheet material as defined herein.

[0011] Where reference is made herein to sides of the sheet material, this means the effective  
20 surfaces of the sheet, i.e. the front side and back side (also, interchangeably, referred to as upper and lower surface) of the sheet material. Where weight ratios or percentages are mentioned herein, these are on dry matter basis (without any water or more volatile substances), unless otherwise specified. Where water weights or percentages are mentioned herein, these are on wet matter basis.

25 [0012] The patterned hydroentangled nonwoven sheet material contains cellulosic fibres, preferably at least 25 wt.%, more preferably at least 40 wt.%, even more preferably at least 50 wt.%, preferably up to 80 wt.%, most preferably between 60 and 75 wt.% of cellulosic fibres. Cellulosic fibres are further defined below and comprise cellulosic pulp.

[0013] In addition, the sheet material preferably contains thermoplastic fibres, preferably at least  
30 10 wt.%, more preferably at least 15 wt.%, even more preferably at least 20 wt.%, most preferably at least 25 wt.%, up to e.g. 70 wt.%, preferably up to 60 wt.%, more preferably up to 50 wt.%, most preferably up to 40 wt.%. The thermoplastic fibres, also referred to as (manmade or synthetic) polymer fibres, can comprise (continuous) filaments and (short) staples or both. The sheet material (combined web) may preferably contain between 6 and 60 wt.%, more preferably  
35 between 10 and 45 wt.%, most preferably between 15 and 35 wt.% of the synthetic filaments on dry solids basis of the combined web. Alternatively or additionally, the sheet material may

preferably contain between 3 and 50 wt.%, more preferably between 4 and 30 wt.%, most preferably between 5 and 20 wt.% of the synthetic staple fibres on dry solids basis of the combined web. In a preferred embodiment, the sheet material contains both thermoplastic filaments and staple fibres, e.g. in a weight ratio between 9:1 and 1:1, preferably between 5:1 and 1.5:1.

5 Thermoplastic fibres are further defined and illustrated below.

**[0014]** In the present patterned sheet material, between 1 and 20 % of at least one surface has been imprinted and forms a pattern that is discernible by visual and/or tactile means, e.g. by differences in reflection, brightness, smoothness, etc. between imprinted and non-imprinted part, which can be perceived visually or by touch and feel. These differences are in particular  
10 differences in height.

**[0015]** As used herein, imprinting is understood to mean exercising mechanical force resulting in some compression of the sheet material, as further defined and illustrated below. Thus, the patterns are not exclusively discernible by difference in colour, e.g. resulting from printing, dyeing or inking, or in other differences in material composition. In a preferred embodiment, the patterns  
15 essentially only result from imprinting. In particular, the imprinted part of the sheet material has a thickness which is between 75 and 95% of the thickness of the non-imprinted part. This, the imprinting action results in a 5-25 % reduced thickness.

**[0016]** The patterns can be present at either side of the sheet material or on both sides. In a preferred embodiment, the patterning (i.e. the height differences) is present on one side only,  
20 which is called "front side", or "pattern side" for easy reference. The front side can have the same or a different material composition as the back side. The sheet material may have a largely homogeneous composition over its thickness. Alternatively, and preferably, the sheet material may have a gradually changing composition over its thickness, with the two surfaces (front and back) having essentially the same composition (in which case internal areas have a different  
25 composition) or a different composition. In a special embodiment, the sheet material is a layered sheet, with two, three or more layers of different composition, wherein, however, in particular as a result of the hydroentanglement, there are no sharp transitions between adjacent layers. For example, the sheet can be a bilayer sheet, having a relatively high-pulp layer at one side, and a relatively low-pulp layer at the other side. The sheet can also be a three-layer sheet, with adjacent  
30 high-pulp, low-pulp and high-pulp layers. Further variants are equally feasible.

**[0017]** In a particular embodiment, the sheet material has a high-pulp (front side) surface and an opposite low-pulp (back side) surface, with optionally further layers in between, or without such intermediate layers to form a bilayer sheet. A high-pulp surface may contain at least 60 wt.% of pulp fibres and a low-pulp surface may contain less than 50 wt.% of pulp fibres. Such percentages  
35 apply in the outermost regions, e.g. the outermost 5% of the thickness of the sheet. Alternatively, a high-pulp surface may contain less than 30, preferably less than 15 wt.% of thermoplastic fibres and a low-pulp surface may contain at least 30 wt.%, preferably more than 50 wt.% of thermoplastic fibres.

**[0018]** The thickness of the present sheet materials may vary widely, depending on the intended use. As an example the sheet may have thicknesses (of non-imprinted parts) between 100 and 2000  $\mu\text{m}$ , in particular of 250-1500  $\mu\text{m}$ , preferably 400-1000  $\mu\text{m}$ , more preferably 500-800  $\mu\text{m}$ . The thickness can be measured by the method as further described in the accompanying  
5 examples. The height difference between imprinted (pattern) and non-imprinted parts is typically 50-250  $\mu\text{m}$ , preferably 75-150  $\mu\text{m}$ . The height difference can be measured by methods known in the art, e.g. by laser reflection measurement or by white light interference measurement.

**[0019]** The patterns can have any form or design. They can be purely decorative or they can have an information or identification function, or both, and are clearly visible to the user or  
10 observer. They can include figures, like lines, circles etc. as well as pictures, readable characters (letters, numbers), etc. As a suitable example, a part of the imprinted layer area may form readable characters and/or logotypes. As an even more specific example, between 2 and 15% of the imprinted surface forms readable characters and/or logotypes, and between 0.5 and 3% of the imprinted surface forms other patterns than readable characters or logotypes, in particular  
15 geometrical patterns such as straight or curved lines, the percentages being based on the total surface area of the imprinted surface.

**[0020]** For reasons of maximum absorptive power, it is preferred that at least 10% of the total surface area of the imprinted side (or sides) of the sheet material consists of uninterrupted non-imprinted regions of at least 20  $\text{cm}^2$ , preferably at least 25  $\text{cm}^2$ . More preferably at least 20%,  
20 most preferably at least 30% of the total surface area of the imprinted side consists of such uninterrupted non-imprinted regions. Such uninterrupted non-imprinted regions may have any form, such as rectangles, polyhedrons, circles, but also more irregular forms.

**[0021]** The patterned nonwoven sheet may be of any desired degree of softness, strength, and of any size, and it may be non-coloured (white) or coloured, wherein the colour may be applied  
25 before or after the imprinting step. The pattern is stable and resistant to temperature, humidity, UV/vis irradiation and the like, and does not bleed.

**[0022]** The present sheet material has excellent absorption performances for both hydrophilic and hydrophobic substances, which are not reduced by the patterns. In particular, the water absorption capacity of the final sheet material is at least 5 g of water per g of dry sheet material,  
30 preferably at least 6 g/g (distilled water at 23°C as reference).

**[0023]** A process for producing a patterned nonwoven sheet material as described above preferably comprises the steps of:

- forming a fibrous web comprising thermoplastic fibres and cellulosic pulp;
- hydroentangling the fibrous web to form a nonwoven sheet material,
- 35 – drying the nonwoven sheet material to a water content of less than 10 wt.%, preferably less than 5 wt.%, down to e.g. 0.1 wt.%; and characterised by

- subjecting the dried nonwoven sheet material to an imprinting action provided by an energy transmitter on a patterned anvil at a temperature of less than 100°C, preferably less than 60°C, most preferably between 30 and 50 °C, to form a patterned nonwoven sheet material.

5 [0024] The energy to be used for imprinting is especially based on vibrational energy rather than by direct impact or heat. Thus, it is important that the imprinting action does not comprise embossing or thermo-bonding of thermoplastic fibres to a significant degree. Embossing (with moderately heated rolls) was found to result in less sharp patterns, and thermo-bonding (which implies melting of the thermoplast) reduces the absorptive power of the resulting sheet material.

10 [0025] A very useful type of vibrational (oscillating) energy is ultrasound energy. Ultrasound equipment suitable for use in the present process is commonly known in the art. As an example, ultrasonic equipment can be purchased e.g. from Herrmann Ultraschall, Karlsbad, DE, or from Branson Ultrasonics, Danbury CT, USA or Dietzenbach, DE. In a preferred embodiment, the imprinting action is a rotatory action using a patterned anvil roll which conveys the sheet material to be imprinted, as shown in accompanying Fig. 1. The oscillating frequency is preferably in the  
15 upper acoustic range or more preferably in the lower ultrasound range, e.g. between 15 and 100 kHz, especially between 18 and 30 kHz. The oscillating power is preferably in the range of 200-4000 N, more preferably 500-2500 N. The oscillating amplitude will typically be in the range of 10-100 µm.

20 [0026] The distance between the energy transmitter (which is sometimes referred to as sonotrode in an ultrasound equipment) and the anvil is preferably short and may vary in operation. Thus, the clearance between the energy transmitter and protruding parts of the anvil roll has a maximum which is approximately equivalent to or larger than the thickness of the material to be treated and a minimum (imprinting stage) which is somewhat less than the thickness of the material treated. Thus, the clearance is preferably at least 500 µm, more preferably between 600  
25 and 2000 µm, most preferably between 800 and 1500 µm. The clearance is preferably adjustable, so as to allow replacement and processing of sheets of different thicknesses.

30 [0027] The present product and process will now be described in more detail with reference to embodiments and drawings. In particular, further details of the various process steps and materials to be applied in the forming of a patterned hydroentangled nonwoven sheet material are described below.

#### ***Detailed description of Embodiments and Materials and Methods to be used***

##### Natural fibres

35 [0028] Many types of natural fibres can be used, especially those that have a capacity to absorb water and a tendency to help in creating a coherent sheet. Among the suitable natural fibres there are primarily cellulosic fibres such as seed hair fibres, e.g. cotton, flax, and pulp. Wood pulp fibres are especially well suited, and both softwood fibres and hardwood fibres are suitable, and also recycled fibres can be used. The pulp fibre lengths can vary from around 3 mm for softwood fibres

to around 1.2 mm for hardwood fibres and a mix of these lengths, and even shorter, for recycled fibres.

#### Filaments

5 [0029] Filaments are fibres that in proportion to their diameter are very long, in principle endless during their production. They can be produced by melting and extruding a thermoplastic polymer through fine nozzles, followed by cooling, preferably using an air flow, and solidification into strands that can be treated by drawing, stretching or crimping. Spun-bond filaments are produced in a similar way by stretching the filaments using air to provide an appropriate fibre diameter that is usually above 10 µm, usually 10-100 µm. Production of spun-bond filaments is described e.g. 10 in US patents 4,813,864 and 5,545,371. Chemicals for additional functions can be added to the surface of the filaments.

[0030] Spun-bond and melt-blown filaments as a group are called spun-laid filaments, meaning that they are deposited directly, *in situ*, on a moving surface to form a web, that is bonded downstream. Controlling the 'melt flow index' by the choice of polymers and temperature profile 15 is an essential part of controlling the extrusion and thereby the filament formation. The spun-bond filaments normally are stronger and more even. The filaments are laid lengthwise.

[0031] Any thermoplastic polymer that has sufficient coherent properties to allow being cut in the molten state, can in principle be used for producing spun-bond fibres. Examples of useful synthetic polymers are polyolefins, such as polyethylene and polypropylene, polyamides such as 20 nylon-6, polyesters such as poly(ethylene terephthalate) and polylactides. Copolymers and mixtures of these polymers may of course also be used, as well as natural polymers with thermoplastic properties.

#### Staple fibres

25 [0032] Staple fibres can be produced from the same substances and by the same processes as the filaments described above. Other usable staple fibres are those made from regenerated cellulose such as viscose and lyocell. They can be treated with spin finish and crimped, but this is not necessary for the type of processes preferably used to produce the present nonwoven sheet material.

30 [0033] The cutting of the fibre bundle normally is done to result in a single cut length, which can be altered by varying the distances between the knives of the cutting wheel. Depending on the intended use, different fibre lengths are used, between 2 and 50 mm. Wet-laid hydroentangled nonwovens normally use 12-18 mm, or down to 9 mm or less, especially hydroentangled materials produced by wet-laying technology. The strength of the material and its other properties like surface abrasion resistance are increased as a function of the fibre length (for the same thickness and polymer of the fibre). When continuous filaments are used together with staple fibres and 35 pulp, the strength of the material will mostly come from the filaments.

**[0034]** Shorter staple fibres can result in an improved material as they have more fibre ends per gram fibre and are easier to move in the Z-direction (perpendicular to the web plane). More fibre ends will project from the surface of the web, thus enhancing the textile feeling. The secure bonding will result in very good resistance to abrasion. The staple fibres can be a mixture of fibres based on different polymers, with different lengths and dtex, and with different colours.

#### Process

**[0035]** The pulp-containing sheet material can be formed from materials that can be applied by various techniques known in the art, including wet-laying, air-laying, dry laying or spun-laying or it can completely or partly be formed from a pre-fabricated sheet, e.g. a tissue sheet. As an example, the process for producing the patterned nonwoven sheet material of the present disclosure can be as depicted in Figure 1. Such a process comprises the steps of: providing an endless forming fabric 1, on which the continuous filaments 2 can be laid down as, for example, spun-bond filaments, and excess air can be sucked off through the forming fabric, to form a precursor of a web 3; advancing the forming fabric 1 with the continuous filaments to a wet-laying stage and a so-called head box 4, where an aqueous slurry or an aqueous foam comprising a mixture 5 of natural fibres and staple fibres is wet-laid on and partly into the precursor web 3 of continuous filaments 2, and excess water is drained off through the forming fabric 1, forming a fibrous web 6; advancing the fibrous web 6 from the fabric 1 to a second fabric 7 to subject the fibre mixture to a hydro-entangling stage 8, where the filaments 2 and fibres are intermingled intimately and bonded into a nonwoven web 9 by the action of water jets 10. The web is then advanced to a drying stage 11 where the nonwoven web 9 is dried; and further advanced to stages for imprinting between anvil 20 and horn 21, further described below, subsequently for rolling, cutting, packing, etc. (stages 30).

**[0036]** The continuous filaments 2, which can be made from extruded thermoplastic pellets, can be laid down directly onto a forming fabric 1 where they are allowed to form an unbonded web structure 3, in which the filaments can move relatively freely from each other. This can be achieved by making the distance between the nozzles and the forming fabric 1 relatively large, so that the filaments are allowed to cool and thus to have reduced stickiness before they land on the forming fabric. Alternatively, cooling of the filaments before they are laid on the forming fabric can be achieved e.g. by air. The air used for cooling, drawing and stretching the filaments is sucked through the forming fabric, to let the filaments follow the air flow into the meshes of the forming fabric to be stayed there. A good vacuum might be needed to suck off the air. As a further alternative, the filaments can be cooled by spraying water.

**[0037]** The speed of the filaments as they are laid down on the forming fabric may be higher than the speed of the forming fabric, so the filaments can form irregular loops and bends as they are collected on the forming fabric to form a randomized precursor web. The basis weight of the formed filament precursor web 3 can advantageously be between 2 and 50 g/m<sup>2</sup>.

[0038] As described above, the mixture 5 of natural fibres and staple fibres can be wet-laid onto and partly into the precursor web 3 of spun-laid filaments to form a fibrous web 6. However, as mentioned above, such a fibrous web 6 can also be formed from materials applied by various other techniques known in the art.

5 [0039] It should also be emphasized that even though the process of forming a patterned hydroentangled nonwoven sheet material as illustrated in Fig. 1 is mainly described with reference to the use of filaments, the present disclosure of forming a patterned sheet material may also include a material that has been formed of only pulp and thermoplastic fibres that are not filaments, such as staple fibres. For example, such a sheet material may be formed by the laying  
10 the mixture 5 of pulp and staple fibres directly on the forming web 1, removing the water, which is followed by hydroentangling, drying and imprinting of the formed web. Further alternatives are also described hereinbelow.

[0040] In the following, some techniques that can be used in the laying of the pulp and staple fibres as well as in the forming of the precursor web are described in more detail. The process  
15 will also be further illustrated with reference to Fig. 1 with regard to the process stages of hydroentangling and the imprinting stages as well as any further processing that may occur to form a product as exemplified in Fig. 2.

#### *Wet-laying*

[0041] The mixture 5 of pulp and staple fibres (if used) can be slurried in a conventional way,  
20 either mixed together or first separately slurried and then mixed, and conventional papermaking additives such as wet and/or dry strength agents, retention aids, dispersing agents, may be added, to produce a well-mixed slurry of pulp and staple fibres in water. This mixture 5 can, as illustrated in Fig. 1 be pumped out through a wet-laying head box 4 onto moving forming fabric 1 where it is laid down on the unbonded precursor filament web 3 with its freely moving filaments.

25 [0042] Some of the pulp and the staple fibres will enter between the filaments, but the larger part will stay on top of the filament web. The excess water is sucked through the web of filaments and down through the forming fabric, by means of suction boxes arranged under the forming fabric.

[0043] A particularly advantageous way of depositing the short fibres (pulp and/or staple) is by foam formation, which is a variant of wet-laying, in which the cellulosic pulp and staple fibres are  
30 mixed with water and air, in the presence of a surfactant, preferably between 0.01 and 0.1 wt.% of a non-ionic surfactant so as to form the pulp-containing mixture 5. The foam may contain between 10 and 90 vol.%, preferably between 15 and 50 vol.%, most preferably between 20 and 40 vol.% of air (or other inert gas). It is transported to the head box 4 where it is laid on top of the filament web 3 and surplus water and air are sucked off.

#### 35 *Air-laying and Dry-laying*

[0044] Instead of, for example wet-laying, the fibres can be applied by dry-laying (in which fibres are carded and then directly applied on the carrier) or air-laying (in which fibres, which may be short, are fed into an air stream and applied to form a random oriented web).

*Hydroentangling*

**[0045]** The fibrous web 6 of synthetic fibres such as continuous filaments, and staple fibres and pulp is hydroentangled, while it is supported by the fabric 7 and is intensely mixed and bonded into a composite nonwoven material 9. An instructive description of the hydroentangling process is given in CA patent no. 841,938.

**[0046]** In the hydroentangling stage 8 the different fibre types will be entangled by the action of a plurality of thin jets 10 of high-pressure water impinging on the fibres. The fine mobile spun-laid filaments are twisted around and entangled with themselves and with the other fibres, which gives a material with a very high strength in which all fibre types are intimately mixed and integrated. Entangling water is drained off through the forming fabric 7, and can be recycled, if desired after purification (not shown). The energy supply needed for the hydroentangling is relatively low, i.e. the material is easy to entangle. The energy supply at the hydroentangling can appropriately be in the interval 50-500 kWh/ton.

**[0047]** The strength of a hydroentangled material will depend on the amount of entangling points for and thus on the lengths of the fibres, in particular when the material that is hydroentangled is only based on staple and pulp fibres. When filaments are used, the strength will be determined mostly on the filaments, and be reached fairly quickly in the entangling. Thus, most of the entangling energy will be spent on mixing filaments and fibres to reach a good integration.

**[0048]** As illustrated in Fig. 1, the process can include hydroentangling a fibrous web 6 containing a precursor filament web 3 on which a mixture of staple and pulp fibres has been wet-laid or the like. Before the pulp-containing mixture 5 (with or without staple fibres) is laid down through head box 4, the precursor filament web 3 may be subjected to a prebonding stage, or even be supplied as a prebonded web that can be treated as a normal web by rolling and unrolling operations, even if it still does not have the final strength to its use as a wiping material (not shown). The pulp fibres in 5 can be fairly easily mixed and entangled into and also stuck in such a web of filaments, and/or longer staple fibres. The polymer staple fibres that may be present in 5, though, can be harder to entangle and to force down into a prebonded filament web, and it is often required to use longer staple fibres such as 12-18 mm to get enough entangling bonding points to catch the polymer fibres securely in the filament web.

**[0049]** The precursor filament web 3 may preferably be substantially unbonded prior to the laying of the pulp-containing mixture 5, i.e. no extensive bonding (e.g. thermal bonding) of the precursor filament web 3 should occur before the pulp-containing mixture 5 (with or without staple fibres) is deposited through head box 4. The filaments should preferably be largely free to move with respect to each other to the staple and pulp fibres to mix and twirl into the filament web during entangling.

**[0050]** Thermal bonding points between filaments in the filament web at this point of the process would act as blockings to stop the staple and pulp fibres to enmesh near these bonding points, as they would keep the filaments immobile in the vicinity of the thermal bonding points. The 'sieve

effect' of the web would be enhanced and a more two-sided material would be the result. By 'no thermal bondings' it is meant that the filaments have not been exposed to excessive heat and pressure, e.g. between heated rollers, which would compress some of the filaments to such extent that they will be softened and/or molten together to deformation in points of contact. Some bond  
5 points could result from residual tackiness at the moment of laying-down, especially for melt-blown fibres, but these will be without deformation in the points of contact, and thus without significant negative effect on the properties of the materials.

**[0051]** Accordingly, the process as described herein and illustrated in Fig. 1 may result in high flexibility of an unbonded filament web to ease the entraining of polymer staple fibres and thus  
10 allows using shorter fibres. The fibres can be in the range of 2 to 8 mm, preferably 3 to 7 mm, but longer staple fibres can also be used.

**[0052]** The entangling stage 8 can include several transverse bars with rows of nozzles from which very fine water jets  
10 under very high pressure are directed against the fibrous web to provide an entangling of the fibres. The water jet pressure can then be adapted to have a certain pressure profile with different pressures in the different rows of nozzles.  
15

**[0053]** Alternatively, the fibrous web can be transferred to a second entangling fabric before hydroentangling. In this case the web can also prior to the transfer be hydroentangled by a first hydroentangling station with one or more bars with rows of nozzles, drying etc. The hydro-entangled wet web 9 is then dried, which can be done using a conventional web drying equipment,  
20 preferably of the types used for tissue drying, such as through-air drying or Yankee drying.

**[0054]** The structure of the material can be changed by further processing such as micro-creeping, etc. To the material can also be added different additives such as wet strength agents, binder chemicals, latexes, debonders, etc. nonwoven material. A composite patterned nonwoven according to the invention can be produced with a total basis weight of 20-120 g/m<sup>2</sup>, preferably  
25 50-80 g/m<sup>2</sup>.

#### *Imprinting process*

**[0055]** A process and an apparatus for imprinting the nonwoven are represented in Fig. 1. Wet-laid or foam-laid, hydroentangled semi-finalised sheet material 9 is dried in drier 11 and then conveyed over anvil 20 along guiding rolls 22 to produce imprinted sheet material 23. The  
30 ultrasound anvil roll 20 is activated by driving gear 24, which in this figure rotates clockwise. Energy is applied by horn 21 provided with sonotrode 25 and oscillation boosters 26.

**[0056]** The anvil roll 20 has suitable dimensions for allowing a continuous sheet to be moved at a significant speed of e.g. 2-10 m/sec, preferably 3-6 m/sec (180-360 m/min). The anvil roll may have a diameter of e.g. 50-200 cm and a breadth (height of the cylinder) of between 1 and 3 m.  
35 The rotating speed is controllable and, for an anvil roll of 1 m diameter, the rotating speed (in radians per s) will be the same as the speed of the passing sheet, i.e. the tangential speed of the rotating roll, corresponding to e.g. 25-60 revolutions per minute (rpm). It is important to ensure that the rotating speed is closely adjusted to the transporting speed of the sheet material, so that

the sheet material does not move with respect to the anvil 20, while it is in contact with the anvil 20, whereby damage to the sheet material is avoided.

[0057] Ambient conditions can suitably be applied during the ultrasound treatment. The temperature of the sheet at the imprinting site is preferably less than 100°C, more preferably less than 60°C, most preferably between 30 and 50 °C. Further operating conditions for the ultrasound apparatus can be as described above.

#### *Further processing*

[0058] Before or after imprinting, the structure of the material can be changed by further processing such as microcreeping, etc. To the material can also be added different additives such as wet strength agents, binder chemicals, latexes, debonders, etc. to the nonwoven material. After the imprinting step, the material can be wound into mother rolls. The material can then be converted in known ways to suitable formats and packed. A composite patterned nonwoven according to the invention can be produced with a total basis weight of 20-120 g/m<sup>2</sup>, preferably 40-80 g/m<sup>2</sup>.

[0059] Figure 2 shows an example of a patterned sheet 27 of the present disclosure. The squares 28 as depicted (half of which with an internal imprinted figure 29, the other half empty) have unit sizes of about 70x70 mm. It has a relative non-imprinted surface area of about 85% of the total surface and uninterrupted non-imprinted areas of up to 40 cm<sup>2</sup>.

#### *Examples*

##### **Test method – Basis weight**

[0060] The basis weight (grammage) can be determined by a test method following the principles as set forth in the following standard for determining the basis weight: WSP 130.1.R4 (12) (Standard Test Method for Mass per Unit Area). Test pieces of 100x100 mm are punched from the sample sheet. Test pieces are chosen randomly from the entire sample and should be free of folds, wrinkles and any other deviating distortions. The pieces are conditioned at 23°C, 50 % RH (Relative Humidity) for at least 4 hours. A pile of ten pieces is weighed on a calibrated balance. The basis weight (grammage) is the weighed mass divided by the total area (0.1 m<sup>2</sup>), and recorded as mean value with standard deviations.

##### **Test method - Thickness**

[0061] The thickness of a sheet material as described herein can be determined by a test method following the principles of the Standard Test Method for Nonwoven Thickness according to EDANA, WSP 120.6.R4 (12). An apparatus in accordance with the standard is available from IM TEKNIK AB, Sweden, the apparatus having a Micrometer available from Mitutoyo Corp, Japan (model ID U-1025). The sheet of material to be measured is cut into a piece of 200x200 mm and conditioned (23°C, 50 % RH, ≥4 hours). During measurement the sheet is placed beneath the pressure foot which is then lowered. The thickness value for the sheet is then read off after the pressure value is stabilised. The measurement is made by a precision micrometer, wherein a

distance created by a sample between a fixed reference plate and a parallel pressure foot is measured.

5 [0062] The measuring area of the pressure foot is 5x5 cm. The pressure applied during the measurement is 0.5 kPa. Five measurements are performed on different areas of the cut piece to determine the thickness as an average of the five measurements.

**Test method: Water absorption**

[0063] The amount of water in g that can be held per g by the wipe is determined as follows:  
Five square test samples of 100x100 mm cured at 80°C for 30 min and conditioned at 23°C, 50  
10 % RH for at least 4 h. Each conditioned sample is weighed at an accuracy of 0.01 g, and placed in a sample holder which holds the sample in three sample corners so that the sample hung in a planar straight vertical position with the free corner pointing downwards. The hanging sample is lowered into deionised water (23°) in a flat-bottomed bowl and allowed to be soaked in the deionised water during 60 seconds. The sample is then removed from the water and allowed to  
15 hung in the holder in its planar straight vertical direction with the free-hanging corner pointing downward to drip for 120 seconds, and weighed thereafter. The water absorption (WA) is calculated from the formula  $WA = (M_w - M_d) / M_d$ , in which  $M_d$  is the weight before soaking (dry) and  $M_w$  is the weight after soaking and dripping, and is expressed in g/g. The mean water absorption value of the five samples is recorded.

**Test method: Wiping ability**

20 [0064] The amount of fluid (in % of a given amount) that can be wiped off by the wipe is determined as follows:  
Circular test pieces of 190 mm diameter, cured at 80°C for 30 min and conditioned at 23°C, 50 %  
RH for at least 4 h, are weighed and then a number of pieces that together has a weight as close  
to 3.6 g as possible is placed in aligned layers on top of each other forming a wipe sample. The  
25 wipe sample is planarly placed in center to a circular plastic wiping surface of a circular sample holder of plastic foam (Bulpren R 60™ from Recticel), both the surface and the sample holder having a diameter of 113 mm. Excess sample material is folded about the side edge of the sample holder and attached thereto. Water (10 g per 3.6 g sample) is spread as one strand with a length of 200  
mm on a steel plate of 500 x 1200 mm. The sample holder is attached to a robot that is  
30 programmed to perform six straight wipes over the steel surface for each sample and one applied water strand, wherein the circular plastic wiping surface of the holder carrying the wipe sample bears on the steel surface at a pressure of 200 g. The robot and control units can be obtained from Thermo CRS. For each wipe, the robot wipes the steel surface with the wipe sample in a  
straight direction along and aligned to the water strand at a speed of 80 cm/s, wherein each  
35 straight wiping action is 400 mm in length and starts at a point that prior to the first wipe is located 100 mm before the wipe comes in contact with one end of the water strand and the wiping ends 100 mm from the other water strand end that is presented prior to the first wiping. The wipe sample is weighed after each wipe. The amount of absorbed water in % of the amount applied on the plate (10 g per 3.6 g sample) is calculated for each wiping action and sample. The procedure

above is repeated for each one of the six samples and the average amount of water for each wiping action is calculated. In the case a tested material has two different sides, three samples are placed with corresponding sides facing towards the sample holder and three samples are placed with the opposite sides facing the sample holder (as were the case in the Examples below).

5 **Example 1**

[0065] An absorbent sheet material of nonwoven was produced as illustrated in Figure 1 (items 1-11) by laying a web of polypropylene filaments on a running conveyor fabric and then applying on the polymer web a pulp dispersion containing a 88:12 weight ratio of wood pulp and polyester staple fibres, and 0.01-0.1 wt.% of a non-ionic surfactant (ethoxylated fatty alcohol) by foam forming in a head box, introducing a total of about 30 vol.% of air (on total foam volume). The weight proportion of the polypropylene filaments was 25 wt.% on dry solids basis of the end product. The amounts were chosen so as to arrive at a basis weight of the end product of 80 g/m<sup>2</sup>. The combined fibre web was then subjected to hydroentanglement using multiple water jets at increasing pressures of 40-100 bar providing a total energy supply at the hydroentangling step of about 180 kWh/ton as measured and calculated as described in CA 841938, pp. 11-12 and subsequently dried.

[0066] The hydroentangled and dried sheet was then imprinted in an ultrasound apparatus as depicted in Figure 1 (items 21-26). The anvil roll had a protruded part of approximately 15% of the surface area, forming lines and text patterns. The imprinted sheet had the pattern as depicted in Figure 2.

**Reference Example**

[0067] The same nonwoven of Example 1 was produced, but it was not imprinted.

**Results**

[0068] The nonwovens of Example 1 and the Reference Example were analysed and tested according to the Test Methods above. The results are presented in the Table below.

**Table: Test results of reference product (not imprinted) and imprinted product**

<b>Method</b>	<b>Parameter</b>	<b>Unit</b>	<i>Reference</i>	<i>Example 1</i>
			<i>Example</i>	<i>Mean</i>
<b>Thickness nonwoven</b>	Thickness	µm	548	548
<b>Basis weight of nonwoven</b>	Grammage	g/m <sup>2</sup>	74.8	74.3
<b>Water absorption and capacity</b>	Water absorbed	g/g	6.3	6.5
	Absorption cap.	g/m <sup>2</sup>	473.7	485.6
<b>Dry wiping ability</b>	wipe 1	%	81	89
	wipe 2	%	95	97
	wipe 3	%	98	97
	wipe 4	%	98	97
	wipe 5	%	98	97
	wipe 6	%	98	97

**[0069]** The test results show that the imprinted nonwoven (Example 1) has at least equal performance to the non-imprinted nonwoven (reference example).

## Claims

1. A patterned hydroentangled nonwoven sheet material containing at least 25 wt. % of cellulosic pulp and 10-70 wt. % of thermoplastic fibres, in which a surface area of between 1 and 20 % of at least one surface of the hydroentangled nonwoven sheet material has been imprinted to form a pattern discernible by visual and/or tactile differences between imprinted and non-imprinted areas.
2. The sheet material according to claim 1, in which the visual and/or tactile differences comprise differences in height between imprinted and non-imprinted part.
3. The sheet material according to claim 1 or 2, which contains 40-80 wt. % of pulp fibres and 15-60 wt. % of thermoplastic fibres.
4. The sheet material according to claim 1 or 2, which contains 50-75 wt. % of pulp fibres and 25-50 wt. % of thermoplastic fibres.
5. The sheet material according to claim 3 or 4, in which the thermoplastic fibres comprise thermoplastic filaments and/or staple fibres.
6. The sheet material according to claim 5, which contains between 10 and 45 wt. % of thermoplastic filaments.
7. The sheet material according to any one of claims 1-6, in which the sheet material has a high-pulp surface and an opposite low-pulp surface.
8. The sheet material according to claim 7, in which the high-pulp surface contains at least 60 wt. % of pulp fibres and the low-pulp surface contains less than 50 wt. % of pulp fibres and at least 30 wt. % of thermoplastic fibres.
9. The sheet material according to any one of claims 1-8, in which a part of the imprinted layer area forms readable characters and/or logotypes.
10. The sheet material according to any one of claims 1-9, in which at least 10% of the total surface area of the imprinted surface consists of uninterrupted non-imprinted regions of at least 20 cm<sup>2</sup>.
11. The sheet material according to claim 10, in which at least 10% of the total surface area of the imprinted surface consists of uninterrupted non-imprinted regions of at least 25 cm<sup>2</sup>.
12. The sheet material according to any one of claims 1-11, which has a water absorption capacity of at least 5 g/g.
13. A process of producing a patterned nonwoven sheet material comprising the steps of:
  - forming a fibrous web comprising 10-70 wt. % of thermoplastic fibres and at least 25 wt. %

of cellulosic pulp;

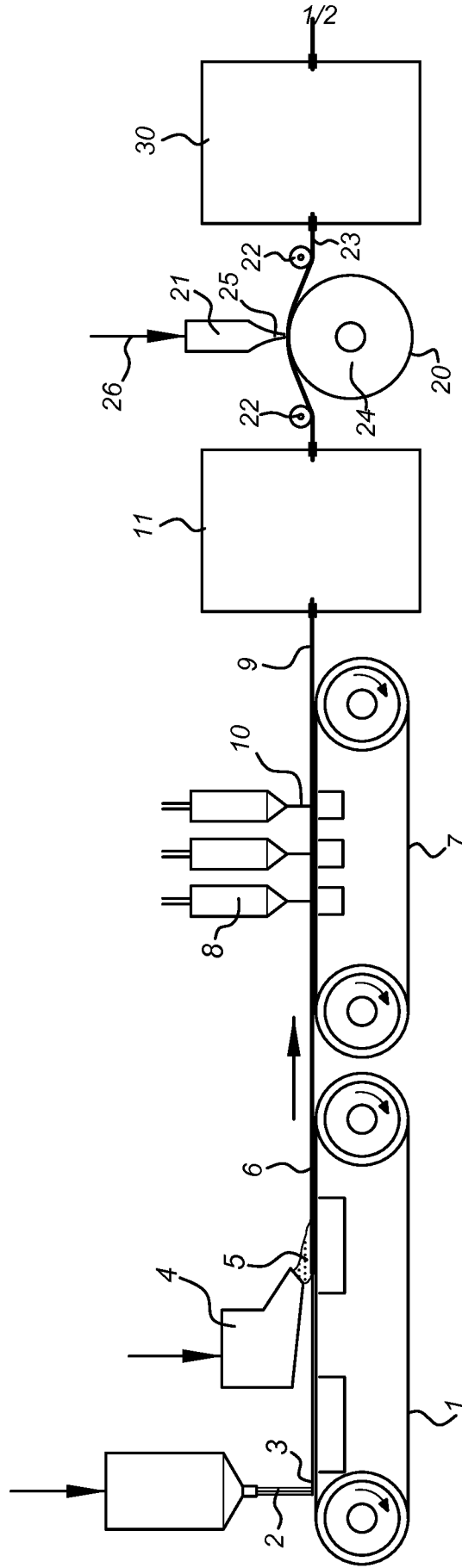
- hydroentangling the fibrous web to form a nonwoven sheet material;
- drying the nonwoven sheet material to a water content of less than 10 wt.%;

*characterised by*

- subjecting the dried nonwoven sheet material to an imprinting action provided by an energy transmitter applying vibrational energy on a patterned anvil at a temperature of less than 100°C to form a patterned nonwoven sheet material.

14. The process according to claim 13, wherein the dried non nonwoven sheet material is subjected to an imprinting action provided by an energy transmitter on a patterned anvil at a temperature of less than 60°C to form a patterned nonwoven sheet material.
15. The process according to claim 13 or 14, in which the energy comprises ultrasound energy.
16. The process according to any one of claims 13-15, in which the distance between the energy transmitter and the anvil roll has an adjustable clearance between 600 and 2000 µm.
17. The process according to any one of claims 13-16, in which the imprinting action is a rotatory action using a patterned anvil roll.
18. The process according to any one of claims 13-17, in which the fibrous web is formed by laying a thermoplastic polymer web, and applying a pulp-containing suspension onto the polymer web.
19. The process according to any one of claims 13-18, wherein the patterned nonwoven sheet material is a sheet material according to any one of claims 1-12.

Fig. 1



*Fig. 2*

