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(54) FILTER MATERIAL FOR SMOKING ARTICLES HAVING IMPROVED EXPANSION BEHAVIOUR

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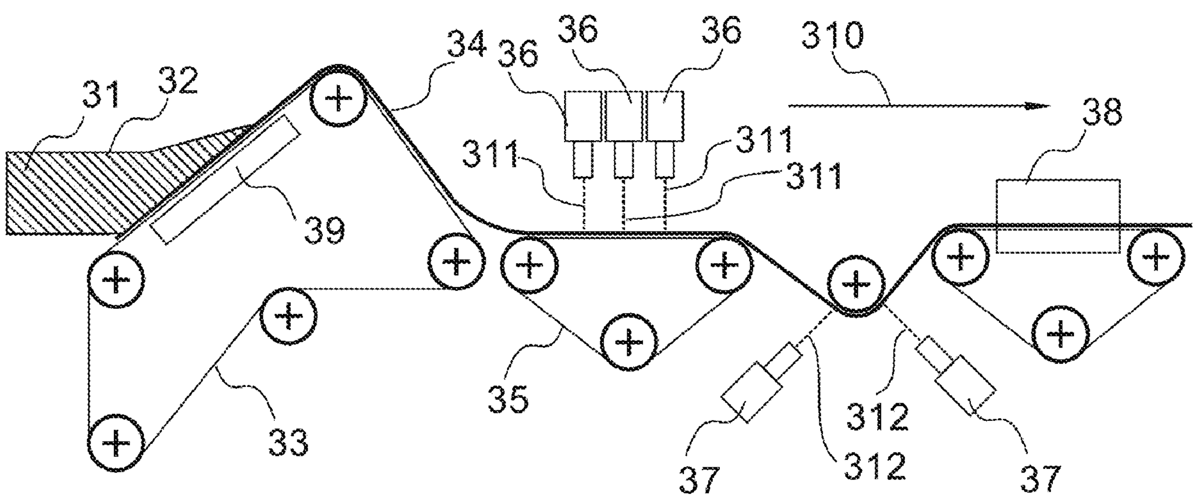
(57) **ABSTRACT**

Shown is a filter material for manufacturing a segment for a smoking article, wherein the filter material is web-shaped and contains at least 50% and at most 100% cellulose fibers, each with respect to the mass of the filter material, wherein the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011, is at least 25 μm and at most 1000 μm, wherein the filter material has a machine direction and a cross direction orthogonal thereto and lying in the plane of the web of the filter material, and wherein the filter material has a characteristic plastic deformability in the cross direction which is characterized in that in a tensile test in the cross direction in accordance with ISO 1924-2:2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break.



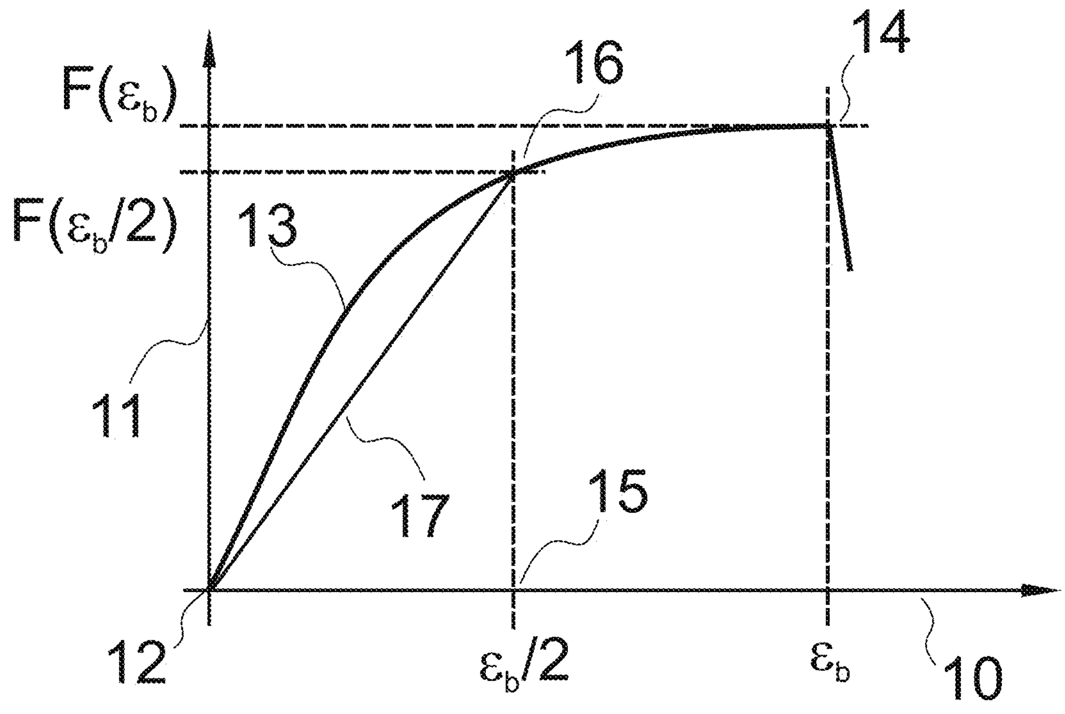

F(εb)
F(εb/2)
16
14
13
11
17
15
12
εb/2
εb
10

Fig. 1

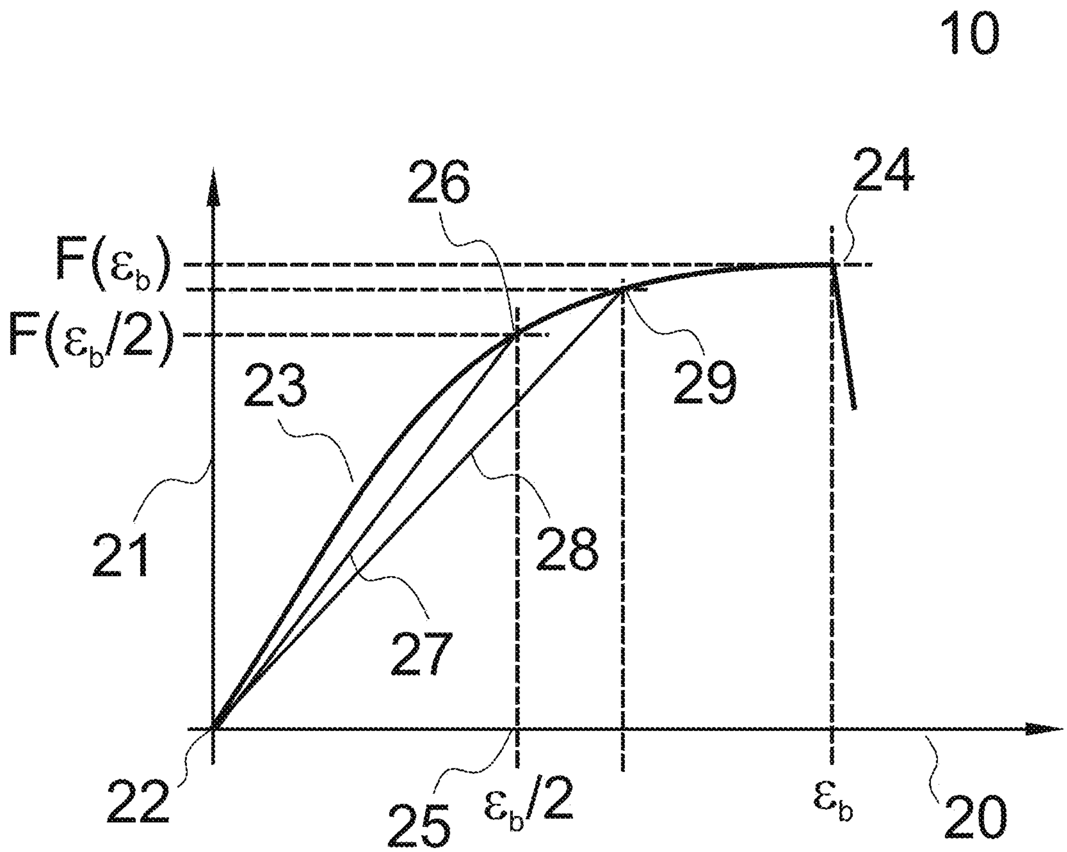
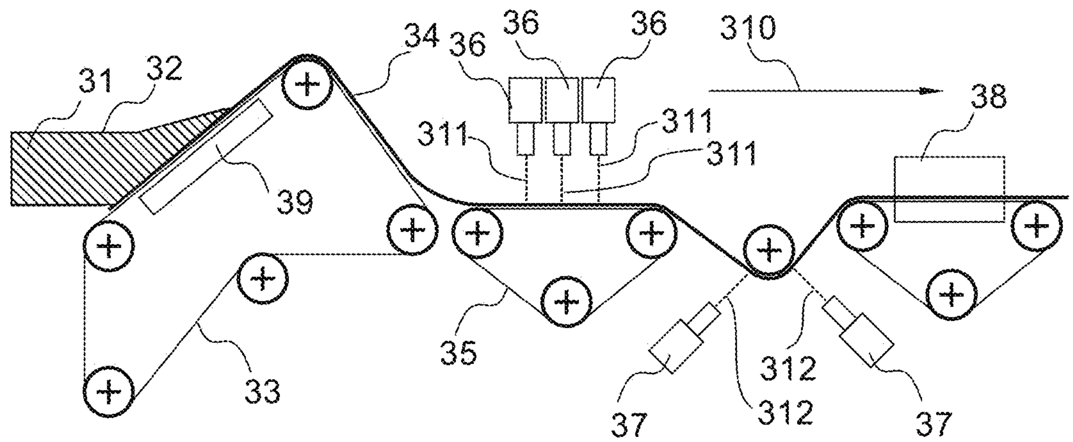

10
26
24
F(εb)
F(εb/2)
23
29
21
28
27
22
25
εb/2
εb
20

Fig. 2


31
32
34
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36
36
310
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312
37

Fig. 3

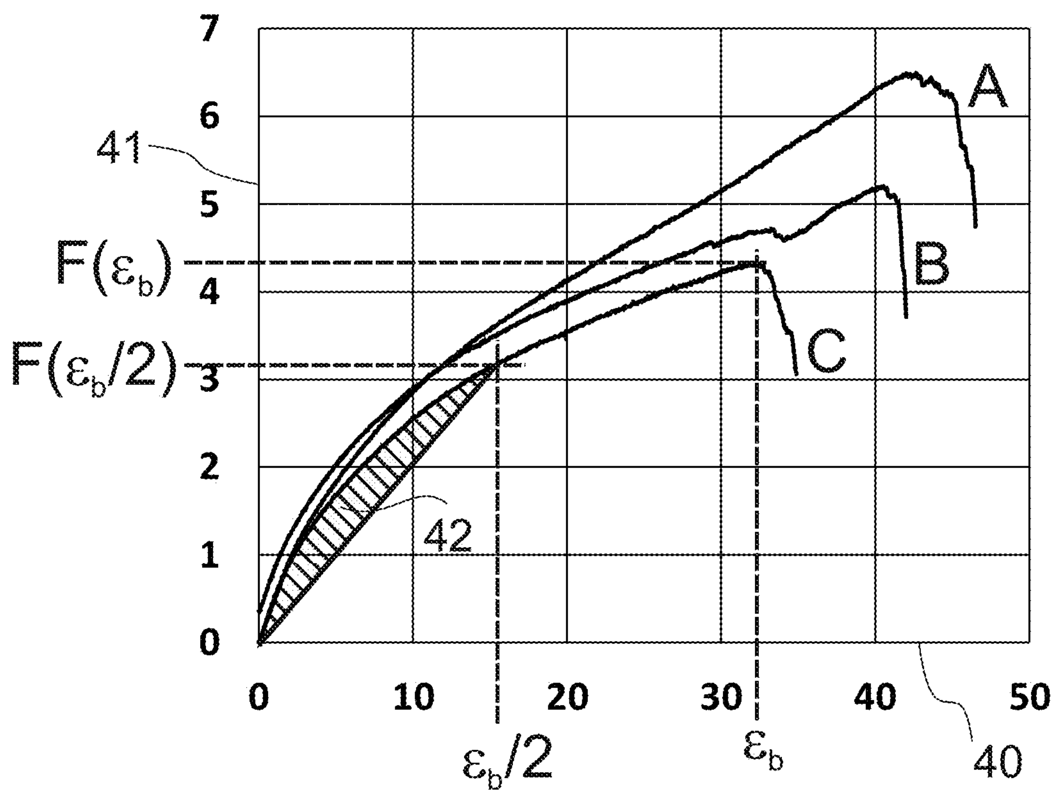
7
6
5
4
3
2
1
0
0
10
20
30
40
50
41
A
B
C
F(εb)
F(εb/2)
42
εb/2
εb
40

Fig. 4

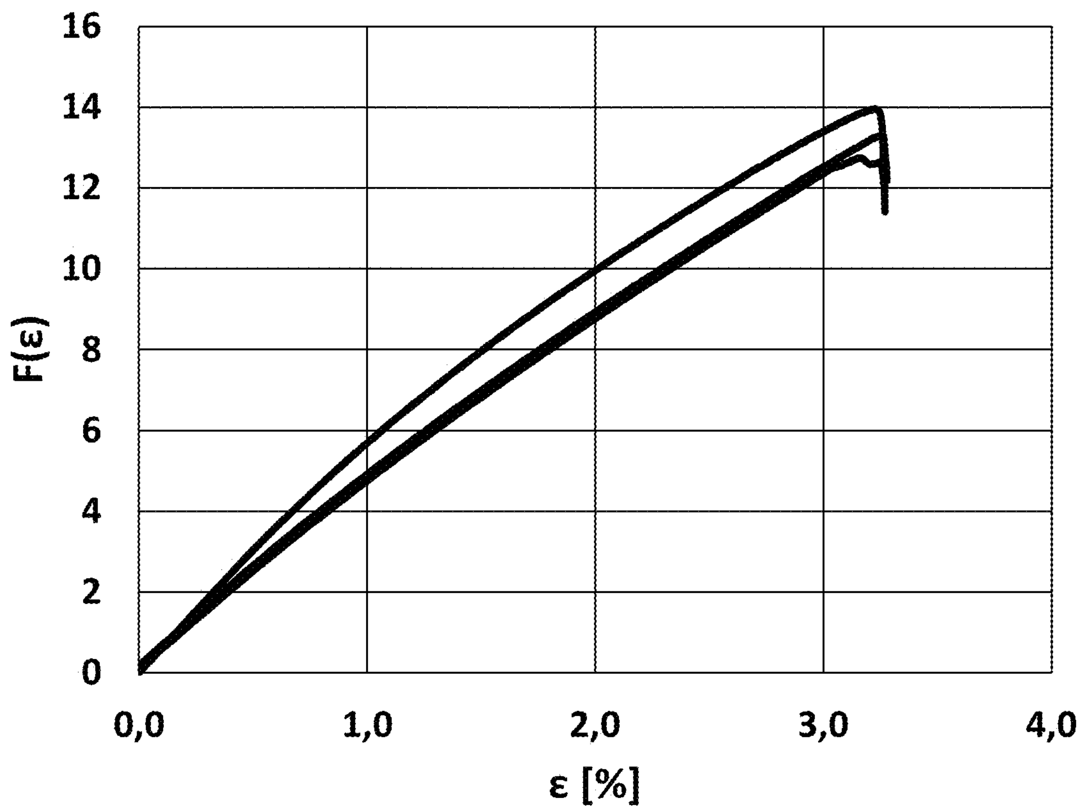

Fig. 5

FILTER MATERIAL FOR SMOKING ARTICLES HAVING IMPROVED EXPANSION BEHAVIOUR

FIELD OF INVENTION

[0001] The invention relates to a filter material suitable for manufacturing a segment in a smoking article, which has an advantageous plastic deformability in the cross direction, so that segments for smoking articles can be manufactured therefrom in an efficient manner. The invention also relates to a segment for a smoking article manufactured from this filter material.

BACKGROUND AND PRIOR ART

[0002] Smoking articles are typically rod-shaped articles which consist of at least two rod-shaped segments disposed next to each other. One segment contains a material which is capable of forming an aerosol upon heating and at least one further segment serves to influence the properties of the aerosol.

[0003] The smoking article can be a filter cigarette, in which a first segment contains the aerosol-forming material, in particular tobacco, and a further segment is designed as a filter and acts to filter the aerosol. In this regard, the aerosol is generated by combustion of the aerosol-forming material and the filter primarily serves to filter the aerosol and to provide the filter cigarette with a defined draw resistance.

[0004] The smoking article, however, can also be what is known as a heated tobacco product, wherein the aerosol-forming material is only heated but not burned. This means that the number and amount of substances in the aerosol which are damaging to health are reduced. Such a smoking article also consists of at least two, more often, however, of more, in particular of four segments. One segment contains the aerosol-forming material, which typically comprises tobacco, reconstituted tobacco or tobacco prepared by other processes. Further, optional segments in the heated tobacco product serve to transfer the aerosol, to cool the aerosol or to filter the aerosol.

[0005] The segments are usually wrapped with a wrapper material. Very often, paper is used as wrapper material.

[0006] Unless it is explicitly stated below or is directly clear from the context, the "segment" should be understood to refer to the segment of a smoking article that does not contain the aerosol-forming material, but rather serves, for example, to transfer, cool or filter the aerosol.

[0007] In the prior art, it is known to form such segments from polymers such as cellulose acetate or polylactides. After consumption of the smoking article, the smoking article has to be disposed of properly. In many cases, however, the consumer simply disposes of the spent smoking article in the environment, and attempts to restrict this behavior by information or fines have had little success.

[0008] Because cellulose acetate and polylactides biodegrade only very slowly in the environment, paper and cellulose-based nonwovens have increased in importance.

[0009] As an example, during the manufacture of a segment, it is possible to initially crimp a web of paper or of a cellulose-based nonwoven in the longitudinal direction, before forming it into a continuous tow and wrapping with a wrapper material. Then the continuous tow is cut into pieces suitable for further processing.

[0010] During crimping, the web runs through two rollers provided with a pattern, which emboss this pattern onto the web. As an example, this pattern is a line pattern oriented in the machine direction of the web. The embossed lines stretch and deform the web in the direction orthogonal to the machine direction, the cross direction, so that then, a continuous tow can be formed more easily by gathering the web in the cross direction.

[0011] During crimping, however, it can happen that the web tears in the cross direction. Thus, there is a need for a filter material that does not suffer from this disadvantage, or only to a lesser extent, but otherwise is as identical as possible to the preferred filter materials.

[0012] In the not pre-published international patent application PCT/EP2019/085125 of the same inventor, a hydroentangled filter material is described which can serve as the starting point for the filter material according to the invention.

SUMMARY OF THE INVENTION

[0013] An objective of the invention is to provide a web-shaped filter material for a smoking article that can be processed into a segment of a smoking article with high productivity and that with respect to its properties is otherwise as similar as possible to preferred filter materials.

[0014] This objective is achieved by means of a filter material as claimed in claim **1**, a segment for a smoking article according to claim **17**, and a smoking article according to claim **24**, as well as by a process for manufacturing a segment according to claim **23** and a process for manufacturing the filter material according to the invention according to claims **28**, **31** and **32**. Advantageous embodiments are provided in the dependent claims.

[0015] The inventors have found that this objective can be achieved by means of a filter material for manufacturing a segment for a smoking article, wherein the filter material is web-shaped and contains at least 50% and at most 100% cellulose fibers, each with respect to the mass of the filter material, and wherein the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2.

[0016] The thickness of one layer of the filter material, measured in accordance with ISO 534:2011, is at least 25 μm and at most 1000 μm. The thickness influences the amount of filter material that can be packed into the segment of the smoking article and therefore the draw resistance and the filtration efficiency of the smoking article, but also the processability of the filter material, in particular if it is crimped or pleated for manufacturing a segment for a smoking article. For such process steps, too great a thickness is disadvantageous and thicknesses in the said intervals allow a particularly good processability of the filter material according to the invention to form a segment of a smoking article.

[0017] Furthermore, the filter material has a machine direction and a cross direction orthogonal thereto, lying in the plane of web of the filter material. Furthermore, the filter material has a characteristic plastic deformability in the cross direction, which is characterized in that in a tensile test in the cross direction in accordance with ISO 1924-2:200,8 the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break. This characteristic plastic deformability is more strongly pronounced than is the case with common filter materials.

[0018] During manufacturing and processing of the filter material, the filter material runs in a direction, the so-called machine direction, through the machine and the filter material has a direction orthogonal to the machine direction, lying the plane of the web of filter material, the cross direction.

[0019] During processing of the filter material into a segment of a smoking article, the filter material is preferably crimped. In this regard, the filter material is, for example, passed through two rolls provided with a pattern, which emboss this pattern onto the web. Preferably, this pattern is a line pattern oriented in the machine direction of the web. The embossed lines stretch and deform the filter material in the direction orthogonal to the machine direction, the cross direction. A filter material deformed in this manner can be gathered more easily in the cross direction, and thus a continuous tow can be produced for manufacturing the segments.

[0020] A problem with this process is that the two rolls have to exert a high elongation in the cross direction on the web in order to cause the desired deformation of the filter material, and thus there is the danger that the filter material will tear in the cross direction. The skilled person could now be tempted to increase the elongation at break of the filter material in the cross direction, so that the filter material tolerates larger deformations without tearing. The inventors, however, have found that this does not solve the problem because, in order to achieve a permanent deformation in the cross direction, the elongation has to be increased even further, so that the danger of exceeding the breaking strength in the cross direction increases further.

[0021] According to the findings of the inventors, it is more important that at the elongation in the cross direction to which the filter material is exposed during crimping, a permanent, plastic and not an elastic deformation is brought about. If such a plastic deformation can already be achieved with a greater separation of the rolls during crimping, the risk that the filter material will tear in the cross direction during processing is reduced. Generally, it should be sufficient to stretch the filter material in the cross direction up to about half of its elongation at break.

[0022] The inventors have found that by suitable processes, the filter material can be provided with a structure that allows a good plastic deformability in the cross direction and thus simplifies crimping. Processes suitable for this are explained further below.

[0023] This plastic deformability in the cross direction can be characterized in a tensile test in accordance with ISO 1924-2:2008. In this tensile test, a strip with a width of 15 mm is taken from the sample in the cross direction and is stretched at a speed of 20 mm/min until it breaks.

[0024] In this regard, the elongation s and the applied force F are recorded, so that a force-elongation-curve F(ε) results. Also, the elongation at break ε_b and the tensile strength $F(\varepsilon_b)$ are recorded. The deformation energy absorbed by the filter material up to half the elongation at break $\varepsilon_b/2$ is then

$$E = \int_{\varepsilon=0}^{\varepsilon_b/2} F(\varepsilon)d\varepsilon,$$

[0025] wherein in practice, the integral is calculated numerically.

[0026] This deformation energy consists of an elastic and a plastic portion. The elastic deformation energy is released upon removal of the load, so that it does not contribute to the result of the crimping. The plastic deformation, however, is irreversible, so that even at a smaller elongation in the two rolls, a good result for crimping can be expected if the proportion of the plastic deformation energy with respect to the total deformation energy is higher than for comparable filter materials in the prior art.

[0027] The elastic deformation is generally associated with a proportionality between elongation and force. Under the fictitious assumption that the filter material behaves ideally linearly elastically up to half the elongation at break, the deformation energy E_{lin} up to half the elongation at break is calculated by

$$E_{lin} = \frac{1}{2}F\left(\frac{\varepsilon_b}{2}\right)\frac{\varepsilon_b}{2} = \frac{1}{4}F\left(\frac{\varepsilon_b}{2}\right)\varepsilon_b.$$

[0028] The nonlinear portion E_{nl} of the deformation energy absorbed by the filter material up to half the elongation at break exceeding the linear deformation energy is then

$$E_{nl} = \int_{\varepsilon=0}^{\varepsilon_b/2} F(\varepsilon)d\varepsilon - E_{lin} = \int_{\varepsilon=0}^{\frac{\varepsilon_b}{2}} F(\varepsilon)d\varepsilon - \frac{1}{4}F\left(\frac{\varepsilon_b}{2}\right)\varepsilon_b.$$

[0029] According to the findings of the inventors, very good results during crimping can be achieved if the nonlinear portion of the deformation energy absorbed up to half the elongation at break in the cross direction is at least 10% of the total deformation energy absorbed up to half the elongation at break in the cross direction, i.e.

$$\frac{E_{nl}}{E} \geq 0.1.$$

[0030] These considerations for quantifying the plastic behavior can be illustrated by the diagram shown in FIG. **1**, which can result upon carrying out a tensile test in accordance with ISO 1924-2:2008. On the x-axis **10**, the elongation s is shown, while on the y-axis **11**, the force F(ε) applied to cause this elongation is shown. Starting from an unstressed state **12**, the elongation ε is increased at a rate of 20 mm/min and at the same time the force F(ε) is measured, wherein the force-elongation-curve **13** is created. The elongation is thereby increased until the sample tears in state **14**, and the elongation at break ε_b and the tensile strength $F(\varepsilon_b)$ are determined therefrom.

[0031] During manufacture of a segment from the filter material, the filter material can in certain locations be loaded, for example, up to about half the elongation at break $\varepsilon_b/2$, point **15**, with the corresponding force $F(\varepsilon_b/2)$, so that the state **16** is reached.

[0032] The line **17**, which connects points **12** and **16**, would represent a fictitious linear elastic behavior and the linear deformation energy Ea, corresponds to the area of the triangle formed by the points **12**, **16** and **15**. The total deformation energy, however, corresponds to the area enclosed by the lines from point **12** to point **15**, from point **15** to point **16** and the line **13** from point **16** to point **12**. The nonlinear portion E_{nl} of the deformation energy, which is used for characterizing the filter material according to the invention in the context of this invention, corresponds to that area which is delimited by the lines **17** and **13**, each between the points **12** and **16**. The more strongly the force-elongation-curve bends upwards and the more it deviates from a fictitious linear elastic behavior, the greater is the potential for plastic and thus irreversible deformation.

[0033] During the manufacture of segments from the filter material according to the invention, the elongation in the cross direction can naturally deviate from half the elongation at break during crimping, the nonlinear portion of the deformation energy up to half the elongation at break was, however, independent of the actually applied elongation and the actual elastic-plastic behavior, found to be a suitable parameter to characterize the structure of the filter material according to the invention and to predict the behavior of the filter material during crimping.

[0034] For comparison, FIG. **2** shows the behavior of a typical common filter material not according to the invention. Here too, a tensile test in accordance with ISO 1924-2:2008 is carried out on a sample in the cross direction. On the x-axis **20**, the elongation E is shown, while on the y-axis **21**, the force $F(\varepsilon)$ applied to cause this elongation is shown. Starting from an unstressed state **22**, the elongation ε is increased at a rate of 20 mm/min and at the same time the force $F(\varepsilon)$ is measured, whereupon the force-elongation-curve **23** is created. The elongation is increased thereby until the sample tears in state **24**, and the elongation at break ε_b and the tensile strength $F(\varepsilon_b)$ are determined therefrom.

[0035] During the manufacture of a segment from the filter material, the filter material can, for example, be loaded up to about half the elongation at break $\varepsilon_b/2$, point **25**, with the corresponding force $F(\varepsilon_b/2)$, so that the state **26** is reached.

[0036] The line **27**, connecting points **22** and **26**, would represent a linear elastic behavior and the corresponding deformation energy E_{lin} corresponds to the area of the triangle formed by the points **22**, **26** and **25**. The total deformation energy E, however, corresponds to the area enclosed by the lines from point **22** to point **25**, from point **25** to point **26** and by the line **23** from point **26** to point **22**. The nonlinear portion E_{nl} of the deformation energy corresponds to that area which is delimited by the lines **27** and **23**, each between the points **22** and **26**. It can be seen that at very similar elongations at break and for very similar linear portions of the deformation energy, the portion of the nonlinear deformation energy is substantially smaller.

[0037] Such a filter material will therefore react primarily elastically to a deformation and after removal of the load, will reverse essentially the entire deformation. In order to introduce a similar plastic deformation energy as for the filter material shown in FIG. **1**, indicated by line **28**, the filter material would have to be stretched up to point **29**. The required elongation is substantially higher and, above all, the required force is close to the tensile strength in the cross direction. With small deviations in the machine or variations in the quality of the filter material, the filter material can tear in the cross direction. The filter material according to the invention from FIG. **1**, however, has a structure which already at small elongations allows for a permanent deformation in the cross direction, for which reason segments for smoking articles can be manufactured more reliably therefrom.

[0038] The filter material according to the invention is web-shaped, so that it is eminently suitable for crimping.

[0039] In a preferred embodiment of the filter material, the filter material is a hydroentangled nonwoven or a paper.

[0040] In a preferred embodiment of the filter material, the filter material is a hydroentangled nonwoven.

[0041] In a preferred embodiment of the filter material, the filter material is a paper.

[0042] Although the term "hydroentangled" at first indicates the underlying manufacturing process, it should be considered that a hydroentangled nonwoven has characteristic structural properties, which differentiate it from other nonwovens and which, to the knowledge of the inventors, cannot be obtained by other manufacturing processes in an identical manner. Other than, for example, with paper, where the strength is primarily caused by hydrogen bonds and the fibers are primarily oriented in the plane of the paper, the strength of the hydroentangled nonwoven is achieved by entanglement of the fibers. A hydroentangled nonwoven has a particularly porous structure, which makes it particularly suitable as a filter material for segments of smoking articles.

[0043] In the case in which the filter material is a paper, a similar porous structure can preferably be produced by an inclined wire paper machine. The properties of the filter material according to the invention, of the segments according to the invention manufactured from the filter material and of the smoking articles according to the invention manufactured from the segment described below thus hold independently of whether the filter material according to the invention is a hydroentangled nonwoven or a paper.

[0044] In particular, the third process according to the invention for manufacturing the filter material according to the invention, explained below, comprises a combination of paper manufacturing and hydroentangling, so that the filter material obtained cannot be unambiguously designated as paper or hydroentangled nonwoven.

[0045] The filter material according to the invention contains cellulose fibers. According to the findings of the inventors, cellulose fibers are required in order to provide a sufficient strength to the filter material, so that it can be processed into a segment. According to the invention, the proportion of cellulose fibers in the filter material is at least 50% and at most 100% of the mass of the filter material, preferably, however, at least 60% and at most 100% and particularly preferably at least 70% and at most 95%, each with respect to the mass of the filter material.

[0046] The cellulose fibers can be pulp fibers or fibers from regenerated cellulose or mixtures thereof.

[0047] The pulp fibers are preferably sourced from coniferous woods, deciduous woods, or other plants such as hemp, flax, jute, ramie, kenaf, kapok, coconut, abaca, sisal, bamboo, cotton or from esparto grass. In addition, mixtures of pulp fibers from various sources can be used for manufacturing the hydroentangled filter material. Particularly preferably, the pulp fibers are sourced from coniferous woods, because even in small proportions, such fibers provide the filter material with good strength.

[0048] The filter material according to the invention can contain fibers from regenerated cellulose. Preferably, the proportion of fibers from regenerated cellulose is at least 5% and at most 50%, particularly preferably at least 10% and at most 45% and more particularly preferably at least 15% and at most 40%, each with respect to the mass of the filter material.

[0049] The fibers from regenerated cellulose are preferably at least partially, in particular to more than 70%, formed by viscose fibers, Modal fibers, Lyocell® fibers, Tencel® fibers or mixtures thereof. These fibers have a good biodegradability and can be used to optimize the strength of the filter material and to adjust the filtration efficiency of the segment manufactured therefrom for the smoking article. Due to the manufacturing process, they are less variable than the pulp fibers sourced from natural sources and contribute to the fact that the properties of a segment manufactured from the filter material vary less than if exclusively pulp fibers are used. Their manufacture, however, requires more effort and usually, they are also more expensive than pulp fibers.

[0050] According to the invention, the basis weight of the filter material is at least 15 g/m^2 and at most 60 g/m^2, preferably at least 18 g/m^2 and at most 55 g/m^2 and particularly preferably at least 20 g/m^2 and at most 50 g/m^2. The basis weight influences the tensile strength of the filter material, wherein a higher basis weight generally leads to a higher tensile strength. The basis weight should not be too high, however, because then the filter material cannot be processed into segments for smoking articles at high speed. The values refer to a basis weight measured in accordance with ISO 536:2019.

[0051] For the filter material according to the invention, in a tensile test in the cross direction in accordance with ISO 1924-2:2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break.

[0052] Preferably, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 15% and at most 40% of the total deformation energy absorbed by the filter material up to half the elongation at break and particularly preferably, the nonlinear portion is at least 15% and at most 35% and in particular at least 1^{8}% and at most 32%. In the preferred and particularly preferred intervals, a very good result during crimping can be achieved at a moderate elongation and the risk of the filter material tearing in the cross direction is particularly low.

[0053] To obtain specific properties, the filter material according to the invention can contain additives such as alkyl ketene dimer (AKD), acid anhydrides such as alkenyl succinic acid anhydride (ASA), polyvinyl alcohol, waxes, fatty acids, starch, starch derivatives, carboxy methyl cellulose, alginates, chitosan, wet strength agents or substances to adjust the pH such as, for example, organic or inorganic acids or bases. Alternatively or additionally, the filter material according to the invention can also contain one or more additives that are selected from the group consisting of citrates such as trisodium citrate or tripotassium citrate, malates, tartrates, acetates such as sodium acetate or potassium acetate, nitrates, succinates, fumarates, gluconates, glycolates, lactates, oxalates, salicylates, α-hydroxy caprylates, phosphates, polyphosphates, chlorides and hydrogen carbonates, and mixtures thereof.

[0054] The skilled person is able to determine the type and amount of such additives from his experience.

[0055] The filter material according to the invention can also comprise yet more substances which better match the filtration efficiency of the filter material to that of cellulose acetate. In a preferred embodiment of the filter material according to the invention, the filter material comprises a substance selected from the group consisting of triacetin, propylene glycol, sorbitol, glycerol, polyethylene glycol, polypropylene glycol, polyvinyl alcohol, triethyl citrate or mixtures thereof.

[0056] In a preferred embodiment of the filter material, at least a portion of the cellulose fibers is loaded with a filler, wherein the filler is particularly preferably formed by mineral particles and in particular by calcium carbonate particles. As the structure of the filter material is very porous, it is not suitable for retaining fillers, so that it is advantageous to load the cellulose fibers with the fillers and thereby retain them in the structure of the filter material. Fillers can serve to provide the filter material with special properties.

[0057] The thickness of one layer of the filter material, measured in accordance with ISO 534:2011, is at least 25 μm and at most 1000 μm, preferably at least 30 μm and at most 800 μm, particularly preferably at least 35 μm and at most 600 μm.

[0058] The mechanical properties of the filter material are important for processing the filter material according to the invention into a segment of a smoking article. The tensile strength of the filter material with respect to width in the cross direction, measured in accordance with ISO 1924-2:2008, is preferably at least 0.05 kN/m and at most 5 kN/m, particularly preferably at least 0.07 kN/m and at most 4 kN/m.

[0059] The elongation at break of the filter material in the cross direction, measured in accordance with ISO 1924-2:2008 is thus preferably at least 0.5% and at most 50% and particularly preferably at least 0.8% and at most 40%. The elongation at break is primarily determined by the length of the fibers, wherein longer fibers lead to a higher elongation at break, and it can thus be adjusted to the specific requirements of the filter material within a wide range.

[0060] Segments according to the invention for smoking articles can be manufactured from the filter material according to the invention according to processes known in the prior art. These processes comprise, for example, crimping the filter material, forming a continuous tow from the crimped filter material, wrapping the continuous tow with a wrapper material and cutting the wrapped tow into individual rods of a defined length. In many cases, the length of such a rod is an integer multiple of the length of the segment that will then be used in the smoking article according to the invention, and therefore, the rods are cut into segments of the desired length before or during manufacture of the smoking article.

[0061] The segment according to the invention for smoking articles comprises the filter material according to the invention and a wrapper material.

[0062] Specifically, the segment comprises a filter material gathered in the cross direction and a wrapper material, wherein the filter material contains at least 50% and at most 100% cellulose fibers, each with respect to the mass of the filter material. In this regard, the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, and the thickness of one layer of the filter material, measured in accordance with ISO 534:2011, is at least 25 μm and at most 1000 μm. For the determination of the basis weight, the area of the filter material is used, if it is spread out (i.e., no longer gathered) and also the thickness of one such layer, of course, refers to the spread-out filter material. The filter material has a cross direction, in which the filter material is gathered. In order to facilitate the gathering of the filter material, it can be pre-formed by crimping or pleating. The term "gathering" should be construed broadly, and the verb "gather" does not suggest any particular mechanical method by which the "gathered" state is achieved. Also, a "pleated" state is, for example, a "gathered" state in the context of the present disclosure, irrespectively of which mechanical way the pleating or shortening in the cross direction is achieved. Furthermore, in the non-gathered state, the filter material has a characteristic plastic deformability in the cross direction, which is characterized in that in a tensile test in the cross direction in accordance with ISO 1924-2:2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break.

[0063] In a preferred embodiment of the segment according to the invention, the segment is cylindrical with a diameter of at least 3 mm and at most 10 mm, particularly preferably at least 4 mm and at most 9 mm and more particularly preferably at least 5 mm and at most 8 mm. These diameters are advantageous for using the segments according to the invention in smoking articles.

[0064] In a preferred embodiment of the segment according to the invention, the segment has a length of at least 4 mm and at most 40 mm, particularly preferably at least 6 mm and at most 35 mm and more particularly preferably at least 10 mm and at most 28 mm.

[0065] The draw resistance of the segment determines, inter alia, which pressure difference needs to be applied by the consumer during use of the smoking article in order to generate a certain volumetric flow through the smoking article, and it thus essentially influences the acceptance of the smoking article by the consumer. The draw resistance of the segment can be measured in accordance with ISO 6565:2015 and is given in mm water gauge (mmWG). To very good approximation, the draw resistance of the segment is proportional to the length of the segment, so that the measurement of the draw resistance can also be carried out on rods that differ from the segment only in their length. The draw resistance of the segment can easily be calculated therefrom.

[0066] The draw resistance of the segment per unit length of the segment is preferably at least 1 mmWG/mm and at most 12 mmWG/mm and particularly preferably at least 2 mmWG/mm and at most 10 mmWG/mm.

[0067] The wrapper material of the segment according to the invention is preferably a paper or a film.

[0068] The wrapper material of the segment according to the invention preferably has a basis weight in accordance with ISO 536:2019 of at least 20 g/m^2 and at most 150 g/m^2, particularly preferably at least 30 g/m^2 and at most 130 g/m^2. A wrapper material with this preferred or particularly preferred basis weight provides the segment according to the invention wrapped therewith with a particularly advantageous hardness.

[0069] Smoking articles according to the invention can be manufactured from the segment according to the invention in accordance with processes which are known in the prior art.

[0070] The smoking article according to the invention comprises a segment that contains an aerosol-forming material and a segment that comprises the filter material according to the invention and a wrapper material.

[0071] As the cut surface of the segment according to the invention is optically very similar to that of a segment from cellulose acetate, in a preferred embodiment, the segment located next to the mouth end of the smoking article is a segment according to the invention.

[0072] In a preferred embodiment, the smoking article is a filter cigarette, and the aerosol-forming material comprises tobacco.

[0073] In a preferred embodiment, the smoking article is a smoking article, during the intended use of which the aerosol-forming material is only heated but not burned and the aerosol-forming material preferably comprises a material selected from the group consisting of tobacco, reconstituted tobacco, nicotine, glycerol, propylene glycol or mixtures thereof. here, the aerosol-forming material can also be present in liquid form and can be located in a suitable container in the smoking article.

[0074] According to the findings of the inventors, the nonlinear portion of the deformation energy can be obtained by orienting the fibers in the filter material more strongly in the machine direction of the filter material. This can be achieved by the method according to the invention described below.

[0075] The filter material according to the invention can be manufactured according to a first process according to the invention that comprises the steps A1 to A3.

- **[0076]** A1—providing a fiber web comprising cellulose fibers, which has a machine direction and a cross direction orthogonal thereto lying in the plane of the web,
- **[0077]** A2—hydroentangling the fiber web by water jets directed onto the fiber web, to produce a hydroentangled fiber web,
- **[0078]** A3—drying the hydroentangled fiber web,
- **[0079]** wherein in step A1, the amount or the proportion of cellulose fibers in the fiber web is selected such that the filter material after drying in step A3 contains at least 50% and at most 100% cellulose fibers with respect to the mass of the filter material, and
- **[0080]** wherein in step A2, the number, pressure or arrangement of the water jets is selected such that the filter material is provided with a characteristic plastic deformability which is characterized in that in a tensile test in the cross direction in accordance with ISO 1924-2:2008 carried out on the filter material after drying in step A3, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break, wherein the filter material after drying in step A3 has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, and wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011 after drying in step A3, is at least 25 μm and at most 1000 μm.

[0081] The water jets directed onto the fiber web in step A2 cause an entanglement of the cellulose fibers, whereupon the structure conducive to the advantageous plastic behavior in the cross direction can be created. Under "pressure of the water jet", the skilled person will understand here the pressure which is applied to generate the water jet, for example, in a pressure chamber. According to the findings of the inventors, it is important for achieving an advantageous plastic behavior of the filter material that the proportion of the fibers oriented in the cross direction in the filter material is low and the fibers are oriented more in the machine direction and the thickness direction. In order to create this structure according to the invention in the filter material, the water jets should be arranged close to each other in the cross direction. Due to the proximity of the water jets hitting the fiber web simultaneously, the water spreads in the machine direction rather than in the cross direction and orients the fibers in this direction.

[0082] The pressure of the water jets can thereby be reduced compared to the commonly used pressure. The distance and the pressure of the water jets also substantially depends on the size of the openings from which the water jets exit, and above all on the speed of the fiber web, so that the skilled person can select the specific value according to experience, in consideration of the specific embodiments and by simple experiments.

[0083] In a preferred embodiment of the first process according to the invention, a plurality of water jets is used to carry out the hydroentangling in step A2, wherein the water jets are arranged in at least one row transverse to the machine direction of the fiber web.

[0084] In a preferred embodiment of the process according to the invention, the hydroentangling in step A2 is carried out by at least two rows of water jets directed onto the fiber web, wherein particularly preferably, at least one row of water jets acts on each of the two sides of the fiber web.

[0085] The filter material manufactured according to this first process should be suitable for use in segments for smoking articles. This means that it can in particular have all features, individually or in combination, that were described above in respect of the filter material and are defined in the dependent claims directed to the filter material.

[0086] The filter material according to the invention can be manufactured according to a second process according to the invention comprising the steps B1 to B4.

- **[0087]** B1—producing an aqueous suspension comprising cellulose fibers,
- **[0088]** B2—applying the suspension from step B1 to a running wire,
- **[0089]** B3—de-watering the suspension through the running wire to form a fiber web,
- **[0090]** B4—drying the fiber web of step B3,
- **[0091]** wherein in step B1, the amount or the proportion of cellulose fibers in the fiber web is selected such that after drying in step B4, the filter material contains at least 50% and at most 100% cellulose fibers with respect to the mass of the filter material, and
- **[0092]** wherein in step B3, a machine direction of the fiber web is defined by the running direction of the wire and a cross direction is defined by a direction orthogonal thereto and lying in the plane of the fiber web, and
- **[0093]** wherein in step B2, the suspension is applied to the wire at a speed which is lower than the speed of the running wire, and the difference between these speeds is selected such that the filter material is provided with a characteristic plastic deformability, which is characterized in that in a tensile test in the cross direction in accordance with ISO 1924-2:2008 carried out on after drying in step B4, the filter material the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break, wherein after drying in step B4, the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, and wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011 after drying in step B4, is at least 25 μm and at most 1000 μm.

[0094] In this regard, the speeds of the running wire and the suspension should be understood to refer to the same frame of reference, so that differing speeds lead to a relative speed between the suspension and the running wire, which is utilized in this embodiment of the process.

[0095] The filter material manufactured according to this second process should be suitable for use in segments for smoking articles. This means that it can in particular have all features, individually or in combination, that were described before in connection with the filter material and are defined in the dependent claims directed to the filter material.

[0096] In this second process according to the invention, the fiber web achieves the desired structure in that the speed with which the suspension in step B2 flows onto the running wire, and the speed of the running wire in step B2 are suitably adjusted relative to each other. In particular, according to the findings of the inventors, the speed at which the suspension in step B2 flows onto the wire should be lower than the speed of the running wire. Due to the speed difference, the suspension is carried along with the wire and shearing forces are created in the suspension, which orient the cellulose fibers in the machine direction and thus contribute to a structure of the filter material that leads to the plastic deformability in the cross direction according to the invention.

[0097] The skilled person can select the magnitude of the speed difference according to his experience and in consideration of the embodiments or by simple experiments. According to the experience of the inventors, a structure with the desired plastic deformability in the cross direction can be obtained in many cases, if in step B2 the suspension is applied to the running wire with a speed that is only about 90% of the speed of the running wire, for example between 88% and 93% of the speed of the running wire. This value just serves as a reference point; a suitable numerical value of the speed difference will at least partially depend on the remaining process parameters and thus in practice, the skilled person will determine it experimentally, wherein the guiding principle and ultimately decisive criterion is the resulting characteristic plastic deformability in the cross direction of the filter material manufactured thereby, which, as described above, is characterized with reference to the tensile test in the cross direction in accordance with ISO 1924-2:2008.

[0098] The filter material according to the invention can also be manufactured in a third process according to the invention, which is a combination of the first and the second processes according to the invention and comprises the steps C1 to C6.

[0099] C1—producing an aqueous suspension comprising cellulose fibers,

[0100] C2—applying the suspension from step C1 to a running wire,

[0101] C3—de-watering the suspension through the running wire to form a fiber web,

[0102] C4—transferring the fiber from step C3 to a support wire,

[0103] C5—hydroentangling the fiber web by water jets directed onto the fiber web, to produce a hydroentangled fiber web,

[0104] C6—drying the hydroentangled fiber web,

[0105] wherein in step C1, the amount or the proportion of cellulose fibers is selected such that, after drying in step C6, after drying in step C6, the filter material contains at least 50% and at most 100% cellulose fibers with respect to the mass of the filter material, and

[0106] wherein in step C3, a machine direction of the fiber web is defined by the running direction of the wire and a cross direction is defined by a direction orthogonal thereto and lying in the plane of the fiber web, and

[0107] wherein after drying in step C6, the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, and wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011 after drying in step C6, is at least 25 μm and at most 1000 μm,

[0108] wherein in step C2, the suspension is applied to the wire at a speed which is lower than the speed of the running wire, and wherein the difference between these speeds in step C2 and the number, pressure and/or arrangement of the water jets in step C5 is selected such that the filter material is provided with a characteristic plastic deformability in the cross direction that is characterized in that in a tensile test in the cross direction in accordance with ISO 1924-2:2008 carried out on after drying in step C6, the filter material the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break.

[0109] In a preferred embodiment of the second or third process according to the invention the aqueous suspension in step B1 or C1, respectively, has a solids content of at most 3.0%, particularly preferably at most 1.0%, more particularly preferably at most 0.2% and in particular at most 0.05%. The particularly low solids content of the suspension allows a fiber web to be formed with a low density in step B3, which is advantageous for the filtration efficiency of a segment manufactured therefrom.

[0110] In a preferred embodiment of the second or third process according to the invention, the running wire in steps B2 and B3 or C2 and C3, respectively, is inclined in the machine direction of the fiber web upwards with respect to the horizontal by an angle of at least 3° and at most 40°, particularly preferably by an angle of at least 5° and at most 30° and more particularly preferably by an angle of at least 15° and at most 25°.

[0111] In a preferred embodiment of the second or third process according to the invention, the process comprises a step in which a pressure difference between the two sides of the running wire is applied to support the de-watering of the suspension in step B3 or C3, respectively, wherein particularly preferably, the pressure difference is generated by vacuum boxes or suitably shaped foils.

[0112] In a preferred embodiment of the first, second or third process according to the invention, the drying in step A3, B4 or C6, respectively is at least partially carried out by contact with hot air, by infra-red radiation or by microwave radiation. Drying by direct contact with a heated surface is also possible, but less preferred, because the thickness of the filter material could be reduced thereby.

[0113] The preferred embodiments of the first process according to the invention are also applicable to the third process according to the invention, wherein step A2 corresponds to step C5 and step A3 to step C6. In addition, the preferred embodiments of the second process according to the invention can also be applied to the third process according to the invention, wherein step B1 corresponds to step C1, step B2 to step C2, step B3 to step C3 and step B4 to step C6.

[0114] In a preferred embodiment of the first, second or third process according to the invention, the process comprises a further step in which one or more additives are applied to the fiber web. The additives are preferably selected from the group consisting of alkyl ketene dimers (AKD), acid anhydrides such as alkenyl succinic acid anhydride (ASA), polyvinyl alcohol, waxes, fatty acids, starch, starch derivatives, carboxy methyl cellulose, alginates, chitosan, wet strength agents or substances for adjusting the pH such as, for example, organic or inorganic acids or bases and mixtures thereof. Alternatively or additionally one or more additives can be applied which are selected from the group consisting of citrates such as trisodium citrate or tripotassium citrate, malates, tartrates, acetates such as sodium acetate or potassium acetate, nitrates, succinates, fumarates, gluconates, glycolates, lactates, oxalates, salicylates, α-hydroxy caprylates, phosphates, polyphosphates, chlorides and hydrogen carbonates and mixtures thereof.

[0115] In a preferred embodiment, the application of one additive or the additives is carried out between the steps A2 and A3 of the process according to the invention or after step A3, followed by a further step for drying the fiber web.

[0116] In a preferred embodiment of the second process according to the invention, the application of the one additive or the additives is carried out between the steps B3 and B4 of the process according to the invention or after step B4, followed by a further step for drying the fiber web.

[0117] In a preferred embodiment of the third process according to the invention, the application of the one additive or the additives is carried out between the steps C3 and C4 or C4 and C5 or C5 and C6 or after step C6, followed by a further step for drying the fiber web.

BRIEF DESCRIPTION OF THE FIGURES

[0118] FIG. **1** shows, by way of example, a force-elongation-diagram of a filter material according to the invention.

[0119] FIG. **2** shows, by way of example, a force-elongation-diagram of a filter material not according to the invention.

[0120] FIG. **3** shows a device, by means of which the third process according to the invention for manufacturing a filter material according to the invention can be carried out.

[0121] FIG. **4** shows force-elongation-curves measured in the cross direction on embodiments A, B and C according to the invention.

[0122] FIG. 5 shows force-elongation-curves measured in the cross direction on comparative example Z, not according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS AND A COMPARATIVE EXAMPLE

[0123] Some preferred embodiments of the filter material, of the processes for manufacturing the filter material, of the segment for smoking articles and of the smoking article are described below. Further, a comparative example not according to the invention is described.

Exemplary Embodiments A, B and C

[0124] The device shown in FIG. **3** was used to manufacture the embodiments A, B and C according to the invention.

[0125] A suspension **31** from pulp fibers and fibers from regenerated cellulose was provided in a storage tank **32**, step C1, and from there was pumped to a running wire **33**, inclined upwards relative to the horizontal, step C2, and was de-watered by vacuum boxes **39**, step C3, so that a fiber web **34** was formed on the wire, the general direction of movement of which is indicated by arrow **310**. In this regard, the speed at which the wire **33** moved was selected to be about 10% higher than the speed of the suspension **31** flowing from the storage tank **32**, in order to orient the fibers primarily in the machine direction. The fiber web **34** was taken off the wire **33** and transferred to a running support wire **35** which was also running, step C4. There, from devices **36**, water jets **311** arranged in several rows transverse to the machine direction of the fiber web **34** were directed onto the fiber web **34** to entangle the fibers and to consolidate the fiber web **34** into a nonwoven, step C5. In continuation of step C5, water jets **312** were also directed onto the other side of the fiber web **34** by additional devices **37**. Then the still-moist nonwoven ran through a drying unit **38** and was dried there, step C6, to obtain the filter material.

[0126] To manufacture the filter material, a mixture of pulp fibers produced from coniferous woods and Lyocell® fibers was used, wherein the amount of fibers was selected such that the finished filter material consisted of 65% pulp fibers and 35% Lyocell® fibers. The finished filter material had a basis weight, in accordance with ISO 536:2019, of 55 g/m^2.

[0127] In step C5 of the manufacturing process, firstly, water jets in three rows, **311** in FIG. **3**, were directed onto the first side of the fiber web **34** and then water jets in one row, **312** in FIG. **3**, were directed onto the second side of the fiber web **34**. The pressure of the water jets here was varied between 2 MPa and 40 MPa in three steps (low, medium, high), in order to obtain different filter materials according to the invention A, B and C. The diameter of the openings from which the water jets exited was different between the rows and was selected to be between 80 μm and 120 μm; the distance of the openings from center to center was 0.3 mm.

[0128] Samples were taken in the cross direction from these filter materials and the force-elongation-diagram was recorded in a tensile test in accordance with ISO 1924-2:2008. The result is shown in FIG. **4**. On the x-axis **40**, the elongation in % is shown, while on the y-axis **41**, the force in N is shown. The three lines designated by A, B and C show the force-elongation diagrams of the three filter materials according to the invention A, B and C. By way of example, the determination of the nonlinear portion of the deformation energy absorbed up to half the elongation at break with respect to the total deformation energy absorbed up to half the elongation at break is explained for filter material C.

[0129] At the half elongation at break $\varepsilon_b/2$, the corresponding force $F(\varepsilon_b/2)$ is determined and the linear portion of the deformation energy E_{lin} a can be calculated therefrom by

$$E_{lin} = \frac{1}{4}F\left(\frac{\varepsilon_b}{2}\right)\varepsilon_b.$$

[0130] The total deformation energy absorbed up to half the elongation at break corresponds to the area spanned by the x-axis **40** and curve C from $\varepsilon=0$ to $\varepsilon=\varepsilon_b/2$ and can be determined with sufficient accuracy by methods of numerical integration without problems. If the linear portion of the deformation energy E_{lin} is subtracted therefrom, the hatched area remains, which corresponds to the nonlinear portion of the deformation energy E_{nl}.

[0131] The determination of the deformation energies up to half the elongation at break was carried out for all filter materials A, B and C and the results are shown in Table 1, wherein E is the total deformation energy, E_{lin} is the linear portion of the deformation energy, and E_{nl} is the nonlinear portion of the deformation energy, each in the cross direction up to half the elongation at break. The deformation energies were determined numerically from the force-elongation-curves and thus formally have the unit N-%. In order to reach the usual unit of J/m^2, the sample geometry needs to be considered. Since only the proportions relative to each other are important here, and since the sample geometries are identical, this was not done. The elongation at break ε_b and the force at half the elongation at break $F(\varepsilon_b/2)$ are also shown.

TABLE 1

Ex	Pressure	ε_b [%]	$F(\varepsilon_b/2)$ [N]	E	E_{lin}	E_{nl}	E_{nl}/E [%]
A	Low	43.0	4.28	59.3	46.0	13.3	22.4
B	Medium	40.8	3.92	55.3	40.0	15.3	27.7
C	High	32.4	3.24	34.1	26.2	7.9	23.0

[0132] The values from Table 1 show that for the embodiments according to the invention A, B and C, the nonlinear portion of the deformation energy is about 20% to about 30%. It is also noticeable that with increasing pressure of the water jets, the elongation at break decreases. For this reason, it can be of advantage to select a lower pressure for the water jets, because apart from the good plastic elongation behavior, then larger permanent deformations are also possible during crimping.

Exemplary Embodiment D

[0133] To manufacture the exemplary embodiment according to the invention D, the second process according to the invention, comprising the steps B1 to B4, was selected.

[0134] To manufacture the filter material, a mixture of pulp fibers from coniferous woods and Lyocell® fibers was used, wherein the amount of fibers was selected such that the finished filter material consisted of 80% pulp fibers and 20% Lyocell® fibers. The finished filter material had a basis weight, in accordance with ISO 536:2019, of 15 g/m^2.

[0135] In step B2 of the process according to the invention the speed of the suspension flowing out was selected to be about 10% lower than the speed of the running wire.

[0136] Four samples in the cross direction were taken from the filter material D obtained thereby and the force-elongation-diagram was recorded in a tensile test in accordance with ISO 1924-2:2008. The evaluation of the force-elongation-diagrams was carried out analogously to the embodiments A, B and C. The results of the four measurements are shown in Table 2.

TABLE 2

Ex.	ε_b [%]	F(ε_b/2) [N]	E	E_{lin}	E_{nl}	E_{nl}/E [%]
D	4.20	5.97	9.19	6.27	2.92	31.8
D	3.13	5.43	5.91	4.25	1.66	28.1
D	3.56	5.79	7.39	5.15	2.24	30.3
D	4.08	5.90	8.55	6.02	2.53	29.6

[0137] The values from Table 2 show that the filter material according to the invention D has a nonlinear portion of the deformation energy of about 30% and that repeated measurements on the same sample material have a low variance. This proves that the steps B1 to B3 indeed contribute to the desired plastic deformability in the cross direction when the suspension in step B2 is applied to the running wire with reduced speed.

Exemplary Embodiment E

[0138] On the other hand, the special execution of step C2 (with reduced speed of the suspension) used in the exemplary embodiments A, B and C is not needed in order to obtain the characteristic plastic deformability in the cross direction according to the invention in the hydroentangled nonwoven. This can be seen from the exemplary embodiment E described below. To manufacture the exemplary embodiment according to the invention E, the first process according to the invention comprising the steps A1 to A3 was used.

[0139] To manufacture the filter material in embodiment E, a mixture of pulp fibers from coniferous woods and Lyocell® fibers was used, wherein the amount of fibers was selected such that the finished filter material consisted of 80% pulp fibers and 20% Lyocell® fibers. Step A1 was carried out without providing the pulp fibers in the fiber web with a preferred direction transverse to the machine direction by a reduced speed of application of the suspension as in steps B2 or C2, respectively, of the second or third process. The finished filter material had a basis weight, in accordance with ISO 536:2019, of 15 g/m^2.

[0140] Hydroentanglement step A2 was carried out in the same manner as step C5 of exemplary embodiment B.

[0141] Two samples in the cross direction were taken from the filter material E obtained thereby and the force-elongation-diagram was recorded in a tensile test in accordance with ISO 1924-2:2008. The evaluation of the force-elongation-diagrams was carried out analogously to the embodiments A to C. The results of the two measurements are shown in Table 3.

TABLE 3

Ex.	ε_b [%]	F(ε_b/2) [N]	E	E_{lin}	E_{nl}	E_{nl}/E [%]
E	3.26	2.75	3.01	2.47	0.53	17.72
E	3.95	2.85	3.42	2.82	0.59	17.37

[0142] The values from Table 3 show that the filter material E manufactured according to the first process according to the invention has a proportion of the nonlinear deformation energy of about 17%. A comparison with embodiments A to C, which were manufactured by means of a combination of suitable execution of the hydroentangling in step C5 and a pre-structuring of the fiber web by reduced application speed in step C2, i.e. a combination of the first and the second process according to the invention, shows that this combination provides larger proportions of the nonlinear deformation energy of about 22% to about 28%, and can thus lead to a better performance during crimping. The effort of the combined process is, of course, slightly higher than that of the first process alone, i.e. if, as in embodiment E, the characteristic plastic deformability in the cross direction is only obtained by suitable execution of the hydroentangling in step A2. Embodiment E demonstrates that with this simpler process too, filter materials according to the invention can be manufactured.

Comparative Example Z

[0143] To manufacture a filter material not according to the invention, the same mixture of fibers was used as in exemplary embodiment D. The basis weight was still 15 g/m^2, but only machine settings that are common for manufacturing filter papers were used.

[0144] Three samples in the cross direction were taken from the filter material of comparative example Z and the force-elongation-diagram was recorded in a tensile test in accordance with ISO 1924-2:2008. The evaluation of the force-elongation-diagrams was carried out analogously to the embodiments A to C. The results of the three measurements are shown in Table 4.

TABLE 4

Ex.	ε_b [%]	F(ε_b/2) [N]	E	E_{lin}	E_{nl}	E_{nl}/E [%]
Z	3.21	8.38	7.22	6.71	0.52	7.17
Z	3.23	7.42	6.40	5.97	0.42	6.64
Z	3.15	7.10	5.89	5.58	0.32	5.38

[0145] The force-elongation-curves of comparative example Z are shown in FIG. **5**. Even without a quantitative analysis, it is already clear that the behavior is substantially closer to a linear elastic behavior, so that deformations upon removal of the load are essentially reversed and much higher elongations and forces are required to achieve permanent deformations. This means that the tensile strength or the elongation at break in the cross direction can easily be exceeded.

Manufacture of Segments and Smoking Articles

[0146] Filter rods wrapped with paper with a length of 100 mm and a diameter of 7.85 mm were manufactured from each filter material of exemplary embodiments A to E and the comparative example Z. The width of the filter material and the machine settings during filter manufacture were selected such that a draw resistance of 450±10 mmWG resulted.

[0147] Filter rods could be manufactured from the filter materials of exemplary embodiments A to E and the comparative example Z. But during manufacture, it was found that for the filter materials of exemplary embodiments A to E, the process of crimping reacted substantially less sensitively to changes in the machine settings and in particular to the setting of the distance between the rolls during crimping than for comparative example Z.

[0148] Filter cigarettes were manufactured from the segments of the embodiments A to E and the comparative example Z using a common process from the prior art. This manufacturing process was without any problems.

[0149] Thus, it can be seen that segments and smoking articles can be manufactured from the filter material according to the invention more reliably and more easily than from common hydroentangled nonwovens or papers, and that better results can be achieved during crimping due to the advantageous plastic elongation behavior.

1. Filter material for manufacturing a segment for a smoking article, wherein the filter material is web-shaped and contains at least 50% and at most 100% cellulose fibers, each with respect to the mass of the filter material,

wherein the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011, is at least 25 μm and at most 1000 μm, wherein the filter material has a machine direction and a cross direction orthogonal thereto and lying in the plane of the web of the filter material, and wherein the filter material has a characteristic plastic deformability in the cross direction which is characterized in that in a tensile test in the cross direction in accordance with ISO 1924-2:2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break.

2. Filter material according to claim **1**, in which the filter material is a hydroentangled nonwoven or a paper.

3. Filter material according to claim **1**, in which the proportion of cellulose fibers in the filter material is at least 70% and at most 95%, each with respect to the mass of the filter material.

4. Filter material according to claim **1**, in which the cellulose fibers are formed by pulp fibers or fibers from regenerated cellulose or mixtures thereof.

5. (canceled)

6. Filter material according to claim **4**, in which the proportion of fibers produced from regenerated cellulose is at least 5% and at most 50% with respect to the mass of the filter material.

7. (canceled)

8. Filter material according to claim **1**, with a basis weight of at least 20 g/m^2 and at most 50 g/m^2.

9. Filter material according to claim **1**, wherein the filter material has a characteristic plastic deformability in the cross direction which is characterized in that in said tensile test in the cross direction in accordance with ISO 1924-2: 2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 18% and at most 32% of the total deformation energy absorbed by the filter material up to half the elongation at break.

10. (canceled)

11. (canceled)

12. Filter material according to claim **1**, which contains at least one substance selected from the group consisting of triacetin, propylene glycol, sorbitol, glycerol, polyethylene glycol, polypropylene glycol, polyvinyl alcohol and triethyl citrate, or a mixture of two or more of the at least one substances.

13. Filter material according to claim **1**, in which at least a portion of the cellulose fibers is loaded with a filler, wherein the filler is formed by calcium carbonate particles.

14. Filter material according to claim **1**, in which the thickness of one layer of the filter material, measured in accordance with ISO 534:2011, is least 35 μm and at most 600 μm.

15. (canceled)

16. (canceled)

17. Segment for a smoking article, comprising a filter material gathered in the cross direction, wherein the filter material contains at least 50% and at most 100% cellulose fibers, each with respect to the mass of the filter material,

wherein the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011, is at least 25 μm and at most 1000 μm, wherein the filter material has a cross direction, in which the filter material is gathered, and wherein the filter material in the non-gathered state has a characteristic plastic deformability in the cross direction which is characterized in that in a tensile test in the cross direction in accordance with ISO 1924-2:2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break.

18. Segment according to claim **17**, in which the filter material has one or more of the features that are defined in claim **2**.

19. Segment according to claim **17**, wherein the segment is cylindrical with a diameter of at least 4 mm and at most 9 mm, and/or wherein the segment has a length of at least 6 mm and at most 35 mm.

20. Segment according to claim **17**, wherein the draw resistance of the segment in accordance with ISO 6565:2015 per unit length of the segment is at least 1 mmWG/mm and at most 12 mmWG/mm.

21. (canceled)

22. Segment according to claim **17**, wherein the wrapper material has a basis weight in accordance with ISO 536: 2019 of at least 30 g/m^2 and at most 130 g/m^2.

23. Process for manufacturing a segment according to claim **17**, in which the filter material according to claim **1** is crimped or pleated, a continuous tow of crimped or pleated filter material is formed and the tow of crimped or pleated filter material is wrapped with a wrapper material and the wrapped tow is cut into individual rods of a defined length.

24. Smoking article, comprising a segment, which contains an aerosol-forming material, and a segment according to claim **17**.

25. Smoking article according to claim **24**, wherein the smoking article is a filter cigarette, and the aerosol-forming material is or contains tobacco.

26. Smoking article according to claim **24**, wherein the smoking article is a smoking article in which, during its intended use, the aerosol-forming material is only heated but not burned, wherein the aerosol-forming material comprises a material which is selected from the group consisting of tobacco, reconstituted tobacco, nicotine, glycerol, propylene glycol or mixtures thereof.

27. Smoking article according to claim **26**, in which the aerosol-forming material is present in liquid form and located in a corresponding container in the smoking article.

28. Process for manufacturing a filter material, wherein the process comprises the following steps:

A1—providing a fiber web comprising cellulose fibers, which has a machine direction and a cross direction orthogonal thereto and lying in the web plane,

A2—hydroentangling the fiber web by water jets directed onto the fiber web to produce a hydroentangled fiber web, A3—drying the hydroentangled fiber web,

wherein in step A1, the amount or the proportion of cellulose fibers in the fiber web is selected such that after drying in step A3, the filter material contains at least 50% and at most 100% cellulose fibers, with respect to the mass of the filter material, and wherein in step A2, the number, pressure and/or arrangement of the water jets is selected such that the filter material is provided with a characteristic plastic deformability in the cross direction, which is characterized in that in a tensile test carried out on the filter material after drying in step A3 in the cross direction in accordance with ISO 1924-2:2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break,

wherein, after drying in step A3, the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, and wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011, after drying in step A3, is at least 25 μm and at most 1000 μm.

29. (canceled)

30. Process according to claim **28**, in which the hydroentangling in step A2 is carried out by at least two rows of water jets directed onto the fiber web, wherein the water jets act on each of the two sides of the fiber web.

31. Process for manufacturing a filter material, which comprises the following steps B1 to B4:

B1—producing an aqueous suspension comprising cellulose fibers,

B2—applying the suspension from step B1 to a running wire,

B3—de-watering the suspension through the running wire to form a fiber web,

B4—drying the fiber web from step B3,

wherein in step B1, the amount or the proportion of cellulose fibers is selected such that after drying in step B4, the filter material contains at least 50% and at most 100% cellulose fibers, with respect to the mass of the filter material, wherein a machine direction of the fiber web is defined by the running direction of the wire in step B3 and a cross direction is defined by a direction orthogonal thereto and lying in the plane of the fiber web, and

wherein in step B2, the suspension is applied to the running wire with a speed which is lower than the speed of the running wire and the difference between these speeds is selected such that the filter material is provided with a characteristic plastic deformability in the cross direction, which is characterized in that in a tensile test carried out on after drying in step B4, the filter material in the cross direction in accordance with ISO 1924-2:2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break,

wherein, after drying in step B4, the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, and wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011, after drying in step B4, is at least 25 μm and at most 1000 μm.

32. Process for manufacturing a filter material, which comprises the following steps C1 to C6:

C1—producing an aqueous suspension comprising cellulose fibers,

C2—applying the suspension from step C1 to a running wire,

C3—de-watering the suspension through the running wire, to form a fiber web,

C4—transferring the fiber web from step C3 to a support wire,

C5—hydroentangling the fiber web by water jets directed onto the fiber web to form a hydroentangled fiber web,

C6—drying the hydroentangled fiber web,

wherein, in step C1, the amount or the proportion of cellulose fibers is selected such that after drying in step C6, the filter material contains at least 50% and at most 100% cellulose fibers, with respect to the mass of the filter material, and wherein in step C3, a machine direction of the fiber web is defined by the running direction of the wire and a cross direction is defined by a direction orthogonal thereto and lying in the plane of the fiber web,

wherein, after drying in step C6, the filter material has a basis weight of at least 15 g/m^2 and at most 60 g/m^2, and wherein the thickness of one layer of the filter material, measured in accordance with ISO 534:2011, after drying in step C6, is at least 25 μm and at most 1000 μm,

wherein in step C2, the suspension is applied to the running wire with a speed which is lower than the speed of the running wire and the difference between these speeds in step C2 and the number, pressure and/or arrangement of the water jets in step C5 are selected such that the filter material is provided with a characteristic plastic deformability in the cross direction, which is characterized in that in a tensile test carried out on after drying in step C6, the filter material in the cross direction in accordance with ISO 1924-2:2008, the nonlinear portion of the deformation energy absorbed by the filter material up to half the elongation at break is at least 10% and at most 50% of the total deformation energy absorbed by the filter material up to half the elongation at break.

33. Process according to claim **31**, in which the aqueous suspension in step B1 or C1, respectively, has a solids content of at most 0.2%.

34. (canceled)

35. (canceled)

36. (canceled)

37. Process according to claim **28**, wherein the filter material manufactured according to this process is a filter material according to claim **1**.

38. Process according to claim **28**, which comprises a further step, in which one or more additives are applied onto the fiber web, wherein the one or more additives is or are selected from the group consisting of alkyl ketene dimers (AKD), acid anhydrides, alkenyl succinic acid anhydride (ASA), polyvinyl alcohol, waxes, fatty acids, starch, starch derivatives, carboxy methyl cellulose, alginates, chitosan, wet strength agents or substances to adjust the pH, organic or inorganic acids or bases, and mixtures thereof.

39. (canceled)

40. Process according to claim **38**, in which the one or more additives is or are applied

between the steps A2 and A3, or

between the steps B3 and B4, or

between the steps C3 and C4 or C4 and C5 or C5 and C6, or

wherein the one or more additives are applied

after the step A3, or

after the step B4, or

after the step C6,

followed by a further step of drying the fiber web.

41. Smoking article according to claim **24**, wherein said segment according to claim **17** is the segment of the smoking article located closest to the mouth end.

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