

TISSUE PAPER MATERIAL AND TISSUE PAPER PRODUCT

TECHNICAL FIELD

The present disclosure relates to a single-ply tissue paper material, to a single-ply tissue
5 paper product, and to a multi-ply tissue paper product, comprising at least one non-wood
tissue ply comprising non-wood cellulose pulp fibres.

BACKGROUND

Tissue paper materials find extensive use in modern society. Toilet paper, and paper
10 towels such as hand towels or household (kitchen) towels, facial tissues, tissue
handkerchiefs, napkins, and industrial wipes are staple items of commerce. These
products are typically made from papermaking pulp comprising wood fibres, such as
hardwood and softwood fibres.

15 In the following, a "tissue paper product" relates to an absorbent paper product based on
cellulose wadding which is also called tissue paper material or tissue paper base-sheet in
this field of technology.

Tissue paper material is defined as a soft absorbent paper material having a low basis
weight, of for example 8 to 45 g/m², preferably 10 to 35 g/m² per ply. The total basis
20 weight of multi-ply tissue paper products may preferably be up to a maximum of 110 g/m²,
more preferably to a maximum of 80 g/m². Its density is typically below 0.6 g/cm³,
preferably below 0.30 g/cm³ and more preferably in the range of 0.02 g/cm³ and 0.20
g/cm³. The production of tissue paper material is distinguished from conventional paper
production, e.g. printing paper production, by its relatively low basis weight and relatively
25 high tensile energy absorption index (see ISO 12625-4). Conventional paper and tissue
paper also differ in general with regard to the modulus of elasticity that characterises the
stress/strain properties of these generally planar products as a material parameter.

The fibres contained in the tissue paper are mainly cellulosic fibres, such as pulp fibres
from chemical pulp (e.g. Kraft or sulphite), or mechanical pulp (e.g. ground wood, thermo
30 mechanical pulp, chemo-mechanical pulp and/or chemo- thermo-mechanical pulp
/CTMP). Pulps derived from both deciduous (hardwood) and coniferous (softwood) can be
used. Fibres may also come from non-wood plants e.g. cereal, bamboo, jute, or sisal. The

fibres or a portion of the fibres may be recycled fibres, which may belong to any or all of the above categories. The fibres can be treated with additives, e.g. fillers, softeners, such as, but not limited to, quaternary ammonium compounds and binders, conventional dry-strength agents, temporary wet strength agents or wet-strength agents, in order to
5 facilitate the original paper making or to adjust the properties thereof.

Tissue paper products in particular for use as hygiene- or wiping products primarily include all kinds of tissue paper materials including dry-creped tissue paper material, wet-creped tissue paper material, NTT (flat), TAD-paper material (Through Air Drying), tissue paper material based on structured or textured technologies such as ATMOS, NTT
10 (textured), UCTAD, eTAD, QRT, PrimeLineTEX etc. and cellulose or pulp-wadding, or combinations, laminates or mixtures thereof. Typical properties of these hygiene- and wiping products include the ability to absorb tensile stress energy, their drapability, good textile-like flexibility, properties which are frequently referred to as bulk softness, a high surface softness and a high specific volume with a perceptible thickness. A liquid
15 absorbency as high as possible and, depending on the application, a suitable wet and dry strength as well as an appealing visual appearance of the outer product's surfaces are desired. These properties, among others, allow these hygiene and wiping products to be used, for example, as cleaning wipes such as windscreen cleaning wipes, industrial wipes, kitchen paper or the like; as sanitary products such as for example bathroom
20 tissue, handkerchiefs, household towels, towels and the like; as cosmetic wipes such as for example facials and as serviettes or napkins, just to mention some of the products that can be used. Furthermore, the hygiene- and wiping products can be dry, moist, wet, printed or pre-treated in any manner. In addition, the hygiene- and wiping products may be folded, interleaved or individually placed, stacked or rolled, connected or not, in any
25 suitable manner.

The products described above can be used for personal and household use as well as commercial and industrial use. They are adapted to absorb fluids, remove dust, and for other cleaning purposes.

If tissue paper material is to be made out of pulp, the process essentially comprises a
30 forming step that includes a headbox- and a forming wire section, and a drying section, e.g. including through air drying or conventional drying on a Yankee cylinder. The production process can also include a crepe process for tissue paper and, finally, typically a monitoring and winding area.

Tissue paper material can be formed by placing the fibres, in an oriented or random manner, on one or between two endless continuously rotating wires or felts of a paper making machine while simultaneously removing water.

Further dewatering and drying the formed primary fibrous web occur in one or more steps
5 by mechanical and thermal means until a final dry-solid content of usually about 90 to 99% has been reached.

In case of creped tissue paper material making, this stage is followed by the crepe process which influences the properties of the finished tissue paper product in conventional processes. The conventional dry crepe process involves creping on a
10 usually 3.0 to 6.5 m diameter drying cylinder, the so-called Yankee cylinder, by means of a crepe doctor blade with the aforementioned final dry-solids content of the raw tissue paper. Wet creping can be used as well, if lower demands are made of the tissue quality. The creped, finally dry raw tissue paper material, the so-called base tissue, is then available for further processing into the tissue paper product.

15 Instead of the conventional tissue making process described above, the use of a modified technique is possible in which an improvement in specific volume is achieved by a special kind of drying which leads to an improvement in the e.g. caliper, bulk, softness, etc. of the tissue paper material. This process, which exists in a variety of subtypes, is herein generally termed the structured tissue technique. Examples of structured tissue
20 techniques are TAD ATMOS®, NTT(textured), UCTAD, eTAD, QRT, PrimeLineTex etc.

The processing step from the tissue paper material to the finished tissue paper product occurs in processing machines (converting machines) which include operations such as unwinding the tissue paper material (base tissue), calendering of the tissue, laminating, printing or embossing.

25 Several plies may be combined together by a combining operation of a chemical nature (e.g. by adhesive bonding), or of a mechanical nature (e.g. by knurling or so-called edge-embossing), or a combination of both. Examples of such process steps for combining plies together will be described in more detail in the below.

Further, the processing to finished tissue paper product may involve e.g. longitudinal cut,
30 folding, cross cut etc. Moreover, individual tissue paper products may be positioned and brought together to form stacks, which may be individually packaged. Such processing

steps may also include application of substances like scents, lotions, softeners or other chemical additives.

When several plies are combined together using adhesive bonding, a film of adhesive is deposited over some or all of the surface of at least one of the plies, then the adhesive-
5 treated surface is placed in contact with the surface of at least one other ply.

When several plies are combined together using mechanical bonding, the plies may be combined by knurling, by compression, by edge-embossing, union embossing and/or ultrasonic.

Mechanical and adhesive bonding may also be combined to combine several plies
10 together to form a multi-ply product.

Embossing is to change the shape of a sheet from flat to shaped, so that there are areas that are raised and/or recessed from the rest of the surface. It therefore constitutes a deformation of the previously relatively flat sheet, and results in a ply having a particular relief. The thickness of the ply or of the multiple plies is in most cases increased after
15 embossing compared with its initial thickness.

An embossing process is carried out between an embossing roll and an anvil roll. The embossing roll can have protrusions or depressions on its circumferential surface leading to embossed protrusions/depressions in the paper web. Anvil rolls may be softer than the corresponding embossing roll and may consist of rubber, such as natural rubber, or
20 plastic materials, paper or steel. If the anvil roll is made of a softer material like rubber, a contact area/nip can be formed between the embossing roll (e.g. steel roll) and the anvil roll by the deformation of the softer roll.

By embossing, a pattern can be applied to a tissue paper fulfilling a decorative and/or functional purpose.

25 A functional purpose may be to improve the properties of the hygiene paper product, that is, the embossment may improve the product thickness, absorbency, bulk, softness etc.

A functional purpose may also be to provide a joint to another ply in a multi-ply product.

Tissue paper products display a number of physical properties which are of importance for their use for example as toilet paper, hand towels, kitchen towels, facial tissues,
30 handkerchiefs, napkins, wipe or the like. Examples of such properties are their strength, softness, and absorbency (primarily for aqueous systems). These physical properties are

generally tuned for addressing common consumer demand in view of the intended use of the tissue paper product.

For example, tissue paper products need to retain their strength at least for a time period
5 of use e.g. for wiping liquids or moisture.

At the same time, there are requirements regarding tactile properties such as softness as tissue paper products may be intended to come in intimate contact with the body and skin. Accordingly, it is desired that tissue paper products shall exhibit sufficient softness in
10 order to ensure consumer's comfort.

However, some of the desired physical properties of tissue paper products are generally conflicting properties. One example is strength and softness. Often, as strength in a tissue paper product rises, the softness declines.

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Hence, it is desired to provide a tissue paper product providing a good balance between required properties. For example, it is desired to provide a tissue paper product achieving a satisfactory balance between softness and strength.

20 Further, there is a desire to reduce the consumption of wood fibre to produce tissue paper products. This desire is advocated by e.g. rising costs for wood fibre, concerns involving sustainable forest management, and other environmental reasons such as carbon foot print.

25 To this end, attempts have been made to replace some or all of the wood fibre in tissue paper products with for example recycled fibres and/or with non-wood fibres. However, since the fibre content in the pulp will naturally impact the above-mentioned physical properties of the resulting tissue paper material, the replacement of virgin wood fibres with other fibres in the pulp is not uncomplicated.

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Thus, there is a need for improvement and/or alternatives for tissue paper products in view of one or more of the above-mentioned desires.

SUMMARY

An object of the present invention is to fulfill said need for improvement and/or alternatives.

- 5 To this end, it is proposed herein to use non-wood cellulose pulp fibres in tissue paper materials and tissue paper products.

The non-wood cellulose pulp fibres may be chemical pulp fibres.

- 10 Optionally, the non-wood cellulose pulp fibres may be never-dried fibres. "Never-dried" means herein that the fibres have not been subject to drying before use in the tissue making process. It is believed that the non-wood cellulose pulp fibres being never-dried may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

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Optionally, the non-wood cellulose pulp fibres contain at least 15% hemicellulose. It is believed that such a hemicellulose content may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

- 20 Optionally, the non-wood cellulose pulp fibres contain no more than 15 % lignin. For example, the non-wood cellulose pulp fibres may contain no more than 12 % lignin. In yet another example, the non-wood cellulose pulp fibres may contain no more than 10% lignin. It is believed that such a lignin content may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

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For example, the non-wood cellulose pulp fibres may contain at least 15% hemicellulose and no more than 15 % lignin, such as no more than 12 % lignin or no more than 10% lignin.

- 30 Optionally, the non-wood cellulose pulp fibres are pre-treated, to obtain the desired amounts of lignin and/or hemicellulose.

Further, the non-wood cellulose pulp fibres may have a relatively low average fibre length.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1700 μm .

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than
5 1200 μm .

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1000 μm .

10 Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 900 μm .

Further, it is believed that the non-wood cellulose pulp fibres having a relatively high breaking length, may contribute to the non-wood cellulose pulp fibres being suitable for
15 use in tissue paper materials and tissue paper products. The breaking length is the initial breaking length of the non-wood cellulose pulp fibres as measured on the non-wood cellulose pulp fibres after the pulping process.

Optionally, the non-wood cellulose fibres have a breaking length of more than 3000 m.
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For example, the non-wood cellulose fibres may have a breaking length of more than 3000 m and an average fibre length of less than 1700 μm , such as less than 1200 μm or less than 900 μm .

25 Also, it is believed that the non-wood cellulose pulp fibres having a relatively high ratio between breaking length, and average fibre length may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

30 Optionally, the non-wood cellulose fibres have a breaking length/average fibre length of more than 3.7.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.

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Optionally, the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 5, such as more than 5.5.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 3.7 such as more than 4 and an average fibre length of less than 1700 μm , such as less than 1200 μm , less than 1000 μm , or less than 900 μm .

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For comparison, it may be mentioned that different types of conventional hardwood and softwood pulps display lower breaking length/average fibre length ratios, than those suggested in the above for the non-wood cellulose fibres. This applies also to examples of never-dried hardwood and softwood pulps. Average ratios as calculated for different types

15 of hardwood and softwood pulps are indicated in the table in the below.

Type of pulps	Average ratio
BEK	2.4
BHK	2.0
BSK	1.0
BSS	0.6
NBHK	2.3
NBSK	1.2
Never-dried HW	0.9
Never-dried SW	1.0

(BEK – Bleached Eucalyptus Pulp, BHK – Bleached Hardwood Kraft, BSK – Bleached Softwood Kraft, BSS – Bleached Softwood Sulfite, Northern Bleached Hardwood Kraft, 20 Northern Bleached Softwood Kraft. The never-dried Hardwood (HW) and Softwood (SW) are sulfite.)

Also, several types of previously used non-wood cellulose pulp fibres have been found to display lower breaking length/average fibre length ratio than what is proposed in the 25 above. For example, tested samples of dried bagasse fibre pulp was found to have an average ratio of 2.6, dried bamboo fibre pulp an average ratio of 1.2 and dried wheat fibre pulp an average ratio of 3.5.

For example, the non-wood cellulose fibres may be never-dried non-wood cellulose pulp fibres and the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 3.7, such as more than 4.0 or more than 4.5.

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The non-wood cellulose pulp fibres as proposed herein may be used together with hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

As mentioned in the above, optionally, a portion of or all non-wood cellulose pulp fibres
10 are never-dried non-wood cellulose pulp fibres.

Optionally, the non-wood cellulose fibres are used with softwood cellulose pulp fibres. In this case, a portion of or all softwood cellulose fibres may be never-dried softwood cellulose pulp fibres.

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For example, the softwood cellulose pulp fibres may comprise never-dried hardwood cellulose pulp fibres and/or dried softwood cellulose pulp fibres.

Optionally, the non-wood cellulose fibres are used with hardwood cellulose pulp fibres. In
20 this case, a portion of or all hardwood cellulose fibres may be never-dried hardwood cellulose pulp fibres.

For example, the hardwood cellulose pulp fibres may comprise never-dried hardwood cellulose pulp fibres and/or dried hardwood cellulose pulp fibres.

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Optionally, the non-wood cellulose pulp fibres as proposed herein may be achieved by treatment by a non-pressurised process.

Optionally, the non-wood cellulose pulp fibres as proposed herein may be achieved by
30 treatment by a process with no use of sulfur.

For example, the non-wood cellulose pulp fibres may be achieved by treatment using methods similar to the methods described EP 2 048281 A1, EP 2 247781 B1, US20130129573 A1, EP 2 034 090 A1, US20110281298 A1, and/or US20130129573 A1.

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Additionally or alternatively, the non-wood cellulose pulp fibres may be achieved by treatment using methods similar to the methods described in WO2020264311 A1, WO2020264322 A1, US20190091643 A1, US2592983.

- 5 For example, the non-wood cellulose pulp fibres may be achieved by the Phoenix Process TM, of Sustainable Fiber Technologies Inc.

It will be understood that the features as discussed in the above as being contributing to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and
10 tissue paper products may be used separately or in different combinations.

Optionally, the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct.

- 15 Optionally, the non-wood cellulose pulp fibres are derived from a member of the Poaceae family. For example, the non-wood cellulose pulp fibres may be derived from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, and/or sorghum. Another example of a member of the Poaceae family is sugar cane, from which non-wood cellulose pulp fibres may be derived, for
20 example from sugar cane bagasse.

Optionally, the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family. For example, the non-wood cellulose pulp fibres may be derived from hemp and/or hop.

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- Optionally, the non-wood cellulose pulp fibres are derived from agricultural waste or byproducts. For example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts of the members of the Poaceae family and/or Cannabaceae family such as exemplified in the above, i.e. including agricultural waste or
30 byproducts from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop. In another example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts such as banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.

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Optionally, the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae), switchgrass, succulents, alfalfa (belongs to the family Fabaceae.), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).

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Optionally, the non-wood cellulose pulp fibres are derived from one or more of wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, sorghum, banana harvest residue, pineapple residue, nut shell waste, sugar-cane bagasse, industrial hemp, and/or members of the Cannabaceae family,
10 kenaf, switchgrass, succulents, alfalfa, corn stover, and flax straw.

Optionally, the non-wood cellulose pulp fibres are derived from wheat straw, oat straw, barley straw, and/or rye grass. For example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts of wheat straw, oat straw, barley straw,
15 and/or rye grass.

For example, the non-wood cellulose pulp fibres may be derived from wheat straw, such as from agricultural waste or byproducts of wheat.

20 Optionally, the non-wood cellulose pulp fibres are derived from residues from sugar production. For example, the non-wood cellulose pulp fibres may be residues from beet.

Optionally, the non-wood cellulose pulp fibres are derived from sugarcane bagasse.

25 Optionally, the non-wood cellulose pulp fibres are derived from agave. For example, the non-wood cellulose pulp fibres may be derived from residues from agave syrup production or derived from agave bagasse.

Although the present disclosure relates primarily to tissue paper made of non-wood fibres,
30 it is understood that the non-wood cellulose pulp fibres as described herein may also find use in other applications e.g. in wound care, in absorbent articles, for example diapers, sanitary napkins, and incontinence articles, in beauty care, and/or in nonwoven materials and products.

Herein, the non-wood cellulose pulp fibres as described in the above are proposed to be used to form a non-wood tissue ply, comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the non-wood tissue ply.

- 5 Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the non-wood tissue ply.

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Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 30% by dry weight of the non-wood tissue ply.

- 15 Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount from 20 to 50% by dry weight of the non-wood tissue ply.

- 20 Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount from 25 to 35% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight of the non-wood tissue ply.

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Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight of the non-wood tissue ply.

- 30 Optionally, the non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

Optionally, the non-wood tissue ply further comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the tissue paper ply.

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Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 95/5.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the
5 non-wood tissue ply is less than 90/10.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 80/20.

- 10 Optionally, said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply. In other words, at least some non-wood cellulose pulp fibres may be found in all parts of the ply, e.g. in all layers of the ply. The non-wood cellulose pulp fibres need not be uniformly distributed, but may be a result of e.g. stratified distribution of the non-wood cellulose pulp fibres. For example, the non-wood cellulose pulp fibres may be
15 homogenously distributed in the ply. In another example, the non-wood cellulose pulp fibres may be heterogeneously distributed in the ply.

Optionally, when said non-wood tissue ply comprises two or more layers, at least one layer of the non-wood tissue ply comprises non-wood fibres. For example, said at least
20 one layer maybe an outer layer of the non-wood tissue ply.

Optionally, when said non-wood tissue ply comprises two or more layers, each out of said two or more layers may comprise non-wood fibres.

- 25 Optionally, the non-wood tissue ply is produced by conventional wet press technology (CWP). By "is produced" means that the tissue paper material has been manufactured using conventional wet press technology, i.e. the tissue paper material is a CWP tissue paper material. For example, the tissue paper material may be a dry crepe tissue paper material.

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Optionally, the non-wood tissue ply is produced by structured tissue technology. By "is produced" means that the tissue paper material has been manufactured using structured tissue technology, i.e. the tissue paper material is a structured tissue paper material.

- 35 Optionally, the non-wood tissue ply is produced by TAD (Through Air Drying) technology.

Optionally, the non-wood tissue ply is produced by ATMOS technology.

Optionally, the non-wood tissue ply is produced by UCTAD technology.

Optionally, the non-wood tissue ply is produced by textured NTT technology.

Optionally, the non-wood tissue ply is produced by eTAD technology, such as Advantage
5 eTAD technology from Valmet.

Optionally, the non-wood tissue ply is produced by QRT technology.

Optionally, the non-wood tissue ply is produced by PrimeLine TEX technology.

In accordance with the invention, there is provided tissue paper materials and tissue
10 paper products including the non-wood tissue ply as described in the above with the non-
wood cellulose pulp fibres as described in the above.

Thus, in a first aspect, there is provided a single-ply tissue paper material according to
claim 1.

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Thus, there is provided a single-ply tissue paper material having a basis weight less than
40 gsm and a GMT tensile strength of at least 60 N/m, the tissue paper material
comprising a non-wood tissue ply. The non-wood tissue ply comprises non-wood cellulose
pulp fibres being present in an amount of at least 10% by dry weight of the tissue paper
20 material.

Optionally, the tissue paper material has a GMT tensile strength of at least 70 N/m.

Optionally, the tissue paper material has a GMT tensile strength of at least 80 N/m.

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Optionally, the tissue paper material has a basis weight of less than 30 gsm.

Optionally, the tissue paper material has a basis weight of less than 25 gsm.

30 Optionally, the tissue paper material has a basis weight greater than 10 gsm.

Optionally, the tissue paper material has a basis weight in the range from 14 gsm to 25
gsm.

In a second aspect, there is provided a single-ply tissue paper product comprising a single-ply tissue paper material according to the first aspect. This implies that the single-ply tissue paper product may consist of the single-ply tissue paper material.

- 5 In a third aspect, there is provided a multi-ply tissue paper product in accordance with claim 7. Thus there is provided a multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 g/m², and the multi-ply tissue paper product having a GMT tensile strength of at least 100 N/m, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose
10 pulp fibres, said non-cellulose pulp fibres being present in an amount of at least 10% by dry weight of the non-wood tissue ply.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m, such as at least 150 N/m.

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Optionally, the multi-ply tissue paper product according to the second aspect or the single-ply tissue paper product according to the first aspect, has an absorbency of at least 7 g/g.

- 20 Optionally, the multi-ply tissue paper product according to the second aspect or the single-ply tissue paper product according to the first aspect, has an absorbency of at least 8 g/g.

- Optionally, the multi-ply tissue paper product according to the second aspect or the
25 single-ply tissue paper product according to the first aspect, has an absorbency of less than 20 g/g, such as less than 18 g/g.

Optionally, the multi-ply tissue paper product or the single ply tissue paper product has an absorbency of 7 to 20 g/g.

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Optionally, the multi-ply tissue paper product or the single ply tissue paper product has an absorbency of 8 to 15 g/g.

- Optionally, a majority of the plies of the multi-ply tissue paper material are non-wood
35 tissue plies.

Optionally, all of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
5 an amount of at least 10% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
an amount of at least 15% by dry weight of the multi-ply tissue paper product.

10 Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
an amount of at least 20% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
an amount of at least 30% by dry weight of the multi-ply tissue paper product.

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Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
an amount of at least 40% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
20 an amount of no more than 70% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
an amount of no more than 60% by dry weight of the multi-ply tissue paper product.

25 Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
an amount in a range from 15 % to 50% by dry weight of the multi-ply tissue paper
product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
30 an amount in a range from 15 % to 40% by dry weight of the multi-ply tissue paper
product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
an amount in a range from 25 % to 35% by dry weight of the multi-ply tissue paper
35 product.

Optionally, the multi-ply tissue paper product comprises two to five plies.

Optionally, each of the plies of the multi-ply tissue paper product comprises the same
5 amount of non-wood cellulose pulp fibres.

Optionally, at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres.

10 Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 5% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 10% dry weight.

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Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 20% dry weight.

Optionally, the multi-ply tissue paper product comprises one or more plies with no non-
20 wood cellulose pulp fibres.

Optionally, said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper product.

25 Optionally, the multi-ply tissue paper product comprises at least two non-wood tissue plies, wherein the non-wood tissue plies form a first and a second outer ply of the multi-ply tissue paper product.

Optionally, for each of the alternatives relating to a multi-ply tissue paper product in the
30 above, the non-wood ply may be such as defined in the above in any one of the options relating to the first aspect.

Optionally, the at least one non-wood tissue ply of the multi-ply tissue paper product comprises a single-ply tissue paper material in accordance with the first aspect as
35 described in the above.

The single-ply tissue paper product and the multi-ply tissue paper product as disclosed herein may for example be a tissue paper product for personal hygiene.

- 5 Optionally, the single-ply tissue paper product and the multi-ply tissue paper product disclosed herein may for example be toilet paper, hand wipes, paper napkins, facial tissue, handkerchiefs, or a kitchen towel or an industrial wipe.

The single-ply tissue paper product and the multi-ply tissue paper product may be
10 embossed and/or calendared as is known in the art.

Optionally, the plies of the multi-ply product may be joined by ply bonding, such as for example embossing or knurling. For example, the multi-ply product may be joined by nesting.

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Optionally, the plies of the multi-ply product may be joined by Goffra-Incolla technology.

Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

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BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

25

In the drawings:

Fig. 1 is a diagram illustrating softness and GMT tensile strength for a number of base sheet samples including various amounts of non-wood fibre;

- 30 Fig. 2 is a diagram illustrating softness versus GMT tensile strengths for the base sheet samples of Fig. 1 comprising 0% non-wood fibre and 30% non-wood fibre;

Fig. 3 is a diagram illustrating softness and GMT tensile strength for a number of multiply tissue samples including various amounts of non-wood fibre;

Fig. 4 is a diagram illustrating the absorption for the tissue samples of Fig. 3; and

- 35 Fig. 5 is a diagram illustrating the thickness for the tissue samples of Fig. 3.

DETAILED DESCRIPTION

The description in the below relates to examples of tissue paper materials and tissue paper products as obtained using the non-wood cellulose pulp fibres as proposed herein.

5

Single-ply tissue paper materials (base sheets)

Five different tissue paper materials were prepared.

The five different tissue paper materials are base sheets and suitable for forming
10 bathroom tissue.

The samples were prepared using CWP technology to provide a dry creped tissue.

Two different grades of tissue were targeted:

15 Grade 1 (G1): soft bathroom tissue

Grade 2 (G2): standard bathroom tissue

The original fibre recipe for the two grades, without any non-wood fibre content is:

Trial ref	Reference furnish
Grade G1	50% softwood (never-dried pulp) – 50% hardwood (Eucalyptus – dried pulp)
Grade G2	70% softwood (never-dried pulp) – 30% hardwood (never-dried pulp)

20

The trial aimed at introducing different levels of non-wood fibrous pulp instead of standard wood pulp to assess base paper properties and consequently finished product quality.

The tissue machine is a Crescent former with suction press roll configuration, with a 2
25 layers Headbox: 50% Top Layer, 50% Bottom Layer.

The G1 grade was run in a stratified mode (different recipes on the 2 layers of the base paper), the G2 grade was run in homogenous mode (same recipe on both layers of the base paper), with target specifications as in the below:

30

G1:

Headbox: 2 layers

Blade: 20° ceramic

Basis weight: 16.5 g/m²

5 Thickness (10p): 0.97 mm/10 plies

MD dry tensile/ ply: 140 N/m

CD dry tensile/ply: 50 N/m

MD stretch: 18%

10 **G2:**

Headbox: 1 layer

Blade: 10° ceramic

Basis weight: 16 g/m²

Thickness (10p): 1.15 mm/10 plies

15 MD dry tensile/ ply: 150 N/m

CD dry tensile/ply: 60 N/m

MD stretch: 16%

The amount of non-wood fibres introduced ranged from 0 to 50% of the total blend. The compositions of the various base sheets are indicated in the table in the below:

Grade	Grade	Grade 1		Grade 2			
Trial	Trial	G 1A	G1B	G 2A	G2B	G2D	G2E
Overall furnish	hardwood (dried pulp)	50%	50%				
	softwood (never-dried pulp)	50%	30%	70%	50%	40%	30%
	hardwood (never-dried pulp)			30%	30%	30%	20%
	non-wood fibre (never-dried pulp)	0%	20%	0%	20%	30%	50%

25 The non-wood cellulose fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp had a lignin content of 12.8% and a hemicellulose content of 18.0%.

The conventional short fibre content was made out of Hardwood dried pulp being a Eucalyptus dried pulp, and Hardwood never-dried pulp being a hardwood never-dried sulfite pulp.

- 5 The conventional long fibre content was made out of Softwood. In this example, the Softwood fibre pulp was also never-dried sulfite pulp. The breaking length, average fibre length, and ratio breaking length/average fibre length of the hardwood never-dried pulp, softwood never-dried pulp and hardwood dried pulp (eucalyptus) were as indicated in the table below:

10

	Non-wood	Hardwood (dried)	Softwood (never-dried)	Hardwood (never-dried)
Breaking length (m)	3775	1724	1755	882
Average fibre length (μm)	748	714	2165	929
Ratio breaking length/fibre length (- /micro)	5.05	2.41	0.81	0.95

The non-wood cellulose pulp fibres substituted mostly conventional long fibre both for its intrinsic strength properties and the tensile developed after refining. Despite this,

- 15 additional strength generated needed a decrease on the long fibre refining line.

Grade	Grade	Grade 1		Grade 2			
Trial	Trial	G 1A	G1B	G 2A	G2B	G2D	G2E
Long fibre line	softwood (never-dried pulp)	100%	100%	100%	100%	80%	60%
	non-wood fibre					20%	40%
	Refining kwh/T	60	50	70	32	32	37
Short fibre line	hardwood (dried pulp)	100%	70%				

	hardwood (never-dried pulp)			100%	60%	60%	40%
	non-wood fibre		30%		40%	40%	60%
	Refining		none	none	15	18	48
Headbox	Configuration	Stratified	Stratified	Homogeneous	Homogeneous	Homogeneous	Homogeneous
	Yankee layer	100% SF	100% SF	30% SF + 70% LF	50% SF + 50% LF	50% SF + 50% LF	50% SF + 50% LF
	Hood layer	100% LF	40% SF + 60% LF	30% SF + 70% LF	50% SF + 50% LF	50% SF + 50% LF	50% SF + 50% LF

The content of non-wood fibres, conventional long fibres, and conventional short fibres in each of the tissue paper materials is indicated in the table in the below:

5

Grade	Trial reference	Non wood fibre content	Long fibre content %	Short fibre content %	Long fibre line refining kwh/T	Short fibre line refining kwh/T
Grade 1 (soft grade)	G1-A	0%	50%	50%	60	0
	G1-B	20%	30%	50%	50	0
Grade 2 (standard grade)	G2-A	0%	70%	30%	70	0
	G2-B	20%	50%	30%	32	15
	G2-D	30%	40%	30%	32	18
	G2-E	50%	30%	20%	37	48

Dry tensile strength in CD and MD directions and panel softness, were measured for the various samples, with the results as indicated in the table in the below and in Figs. 1 and

10 2.

	Basis weight	MD dry tensile	CD dry tensile	GMT dry tensile	MD stretch	Panel
	g/m ²	N/m - 1 ply	N/m - 1 ply	N/m - 1 ply	%	
G1 - A	16.8	145	51	86	20.1	2.7
G1 - B	17.2	151	56	92	18.6	2.7
G2 - A	16.1	130	54	83	19.2	2.5
G2 - B	16.2	156	64	100	18.2	2.6
G2 - E	16.5	192	81	125	18.8	2.1

Fig. 1 is a combined bar chart and linear chart, where the bars represent the softness values and the line indicates the GMT tensile strength of the tissue paper materials G1-A, G1-B, G2-A, G2-B, and G2- E of Table 1.

5

The samples of the different Grades denoted A, are all samples with no non-wood fibre content, whereas the samples of the different Grades denoted with other letters comprise increasing amounts of non-wood fibre content (in alphabetical order).

10 No general trend for the relationship between the GMT strength and the softness in view of the non-wood cellulose fibre content may be seen which is valid for all of the different Grades. For the grade G1 being the softer grade, the softness values with or without non-wood fibres are similar. For the grade G2 being the standard grade, the softness values deviate more, but the GMT strength is increasing with increasing non-wood content.

15

Surprisingly the GMT strength is seen to increase with increasing content of non-wood fibre in the two different grades. Turning to Fig. 2, the basesheet softness and strength are again visualized, this time for samples including 0% non-wood versus samples including 30% non-wood. The samples with 30% non-wood display advantageous

20 softness and GMT tensile strength.

Further, another surprising result is that all of the Grades display a GMT strength and a softness which is within limits rendering them useful for tissue paper products.

25 Multi-ply products

Three different types of multi-ply products, MP1, MP2 and MP3 were prepared. For each type of multi-ply product, samples were made with different overall non-wood fibre content, using the base sheets of different grades and non-wood fibre content as

30 described in the above.

The plies of the multi-ply products were assembled by means of Goffra-Incolla technology. All converting parameters were the same for the different non-wood content of each of the products MP1, MP2, MP3.

35

MP1:

4-ply product

	Embossing top ply	Basesheet Top ply	Basesheet Middle ply	Basesheet Middle ply 2	Basesheet Bottom ply
MP1 0%	Feather (RT 20D)	Grade 1 A	Grade 2 A	Grade 2 A	Grade 1 A
MP1 32%	Feather (RT 20D)	Grade 1 B	Grade 2 E	Grade 2 E	Grade 1 B

5

MP2:

4-ply product

	Embossing top ply	Basesheet Top ply	Basesheet Middle ply	Basesheet Middle ply 2	Basesheet Bottom ply
MP2 0%	Ornament (RT71D)	Grade 1 A	Grade 2 A	Grade 2 A	Grade 1 A
MP2 20%	Ornament (RT71D)	Grade 1 B	Grade 2 B	Grade 2 B	Grade 1 B
MP2 30%	Ornament (RT71D)	Grade 1 B	Grade 2 E	Grade 2 E	Grade 1 B

10 **MP3:**

3-ply product

	Embossing top ply	Basesheet Top ply	Basesheet Middle ply	Basesheet Middle ply 2	Basesheet Bottom ply
MP3 0%	Seven (RT305)	Grade 1 A	Grade 2 A	-	Grade 1 A
MP3 20%	Seven (RT305)	Grade 1 B	Grade 2 B	-	Grade 1 B
MP3 30%	Seven (RT305)	Grade 1 B	Grade 2 E	-	Grade 1 B

The resulting multi-ply tissues were tested for various parameters, and the results are displayed in the below table.

	Number of	Non-wood	Firmness	Basis	Thickness	GMT	Softness	Absorption	5
	plies	%		(g/m ²)	(1 sheet) mm	N/m	Panel	g/g	
MP1 0%	4	0	61	63,8	0,58	267	1,7	9,0	
MP1 32%	4	32	60	64,8	0,57	335	1,7	8,6	10
MP2 0%	4	0	59	63,0	0,53	255	1,7	9,3	
MP2 20%	4	20	55	65,8	0,55	309	1,6	8,8	
MP2 30%	4	30	54	65,9	0,55	329	1,5	9,0	
MP3 0%	3	0	54	46,3	0,43	167	1,6	9,6	15
MP3 20%	3	20	47	48,2	0,44	200	1,6	9,0	
MP3 30%	3	30	48	48,2	0,44	206	1,6	9,3	

The results will be further discussed in the below with reference to Figs. 3 to 6.

- 20 Fig. 3 is a combined bar chart and linear chart, where the bars represent the softness values of the samples and the line indicates the GMT tensile strength.

In Fig. 3, as well as in the following Figs 4 to 6, for each type of multiply tissue paper material MP1, MP2, MP3, the samples are presented from left to right and with the sample having 0 percentage non-wood content to the left, and in increasing order of non-wood content towards the right in the figures.

As demonstrated by Fig. 3, the softness values for each type of multiply tissue paper material MP1, MP2, and MP3 is relatively constant or decreases only insignificantly with increasing amount of non-wood content. (A significant difference in the softness values (panel softness) would be about 0.2 points.) Thus, the results indicate that the softness is

not significantly affected in the samples comprising various amounts of non-wood as compared to the samples comprising no non-wood.

Further, for each of the types MP1, MP2, and MP3, the GMT tensile strength increases
5 with increasing amount of non-wood content. The increase in GMT tensile strength is significant, which was surprising. Thus, the results indicate that the GMT tensile strength is significantly increased in the samples comprising various amounts of non-wood as compared to the samples comprising no non-wood.

10 Thus, the results indicate that the balance between the softness and GMT strength in the samples comprising various amounts of non-wood, is better than for the samples with no non-wood content, i.e. increased GMT strength is achieved at about the same softness.

A satisfactory result for a tissue paper product comprising non-wood would be a balance
15 being about the same as for a tissue paper product with no non-wood content. Based on the tests performed, it may therefore be assumed that the non-wood cellulose pulp fibres used herein are useful for replacing wood fibres in numerous different multi-ply and single ply tissue paper products while achieving at least satisfactory results in terms of softness and strength.

20

Turning to absorption, Fig. 4 is a bar chart illustrating the absorption g/g of the different samples of the three types of tissue paper material MP1, MP2, and MP3. As seen in the results, for each of the types MP1, MP2, and MP3, the highest value for absorption is
25 the impact of increasing non-wood amount on the absorption values may be seen.

Further, the variations in the measured absorption values are mainly insignificant, as a significant difference for absorption is about 0,5 g/g.

Thus, the results indicate that the absorption is not significantly affected in the samples
30 comprising various amounts of non-wood, and instead the absorption is as good in the samples with various amounts of non-wood content as in the sample comprising no non-wood.

Turning to thickness, Fig. 5 is a bar chart illustrating the thickness (mm) of the different
35 samples of the three types of tissue paper material MP1, MP2, and MP3. The results

indicate that the thickness is not significantly affected in the samples comprising various amounts of non-wood as compared to the samples comprising no non-wood.

Thus, in summary, the results indicate that introduction of various amounts of the non-wood cellulose fibres into different tissue paper materials results in acceptable or insignificant changes in parameters relevant for the function of the tissue paper material, such as the GMT strength, the softness, the absorption and/or the thickness, as compared to the same tissue paper material without non-wood fibre content.

The advantageous results are believed to be at least partially due to the use of the non-wood fibres, and in particular the various features which may be contributing to the advantageous properties of tissue paper materials and products including the non-wood fibres as set out in the above.

For example, as in the samples in the above, the non-wood cellulose pulp fibre may have a breaking length/average fibre length ratio greater than 4. Also, the non-wood pulp fibres may be never-dried. Further, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts such as one out of wheat straw, oat straw, barley straw, and/or rye grass, for example wheat.

20

However, other combinations of features as described in the above for the non-wood cellulose fibres may be made by a person skilled in the art to provide the tissue materials and tissue products as proposed herein.

Hence, the results, although relating to specific examples of tissue paper materials and tissue paper products are believed to indicate that the non-wood fibres as such may be used to provide advantageous results in for a wider range of tissue paper materials and tissue paper products.

30 DEFINITIONS

Tissue paper material: The term "tissue paper material" as used herein refers to the one-ply base tissue as obtained from a tissue machine.

Layer: The tissue paper material may comprise one or more layers, i.e. it may be a single-layered or a multi-layered web. The term "layer" refers to a stratum within the web having a defined fibre composition. The one or more layers is/are formed by depositing one or more streams of pulp furnishes onto a wire with a pressurized single-or multi-layered
5 headbox.

Ply: The term "ply" as used herein refers to the one or more plies of tissue paper material in the final tissue paper product as are obtained after processes, i.e. converting, one or more base tissue webs. Each individual ply consists of a tissue paper material comprising
10 one or more layers, e.g. one, two, or three layers.

Hardwood: As hardwood we understand herein fibrous pulp derived from the woody substance of deciduous trees (angiosperms). For example, hardwood includes eucalyptus. Typically, hardwood fibres are relatively short fibres. For example, the
15 hardwood fibres may have an average fibre length less than 1700 μm . The hardwood fibres may for example have a diameter of 15 to 40 μm and a wall thickness of 3 to 5 μm .

Softwood: as softwood we understand fibrous pulp derived from the woody substance of coniferous trees (Gymnosperms). Typically, softwood fibres are relatively long fibres. For
20 example, the softwood fibres may have an average fibre length above 1700 μm , such as above 1950 micron, for example the soft wood fibres may have an average fibre length in a range from 1700 to 2500. μm . The softwood fibres may for example have a diameter of from 30 to 80 μm , and a wall thickness of from 2 to 8 μm .

25 Conventional short fibres: As conventional short fibres we understand herein hardwood fibres as described in the above. Generally, the conventional short fibres may have an average fibre length less than 1700 μm .

Conventional long fibres: As conventional long fibres we understand herein softwood
30 fibres as described in the above. Generally, the conventional long fibres may have an average fibre length greater than 1700 μm .

CWP & structured tissue technology:

As described in the above, paper tissue webs can be produced in several ways. Conventional paper machines have been used for many years for that purpose, to produce such conventional webs at a relatively low cost.

An example of a conventional paper tissue web process is the dry crepe process which involves creping on a drying cylinder, the so-called yankee cylinder, by means of a crepe doctor. Wet creping can be used as well, if there are lower demands on the tissue quality. The creped, finally dry raw tissue paper, the so-called base tissue, is then available for further processing into the paper product for a tissue paper product.

Recently, more advanced methods have been developed, such as e.g. Through Air Drying (TAD), Advanced Tissue Molding System (ATMOS) and similar methods for producing structured tissue webs. A common feature for these latter methods is that they result in a more structured web with a lower density than a web produced on a conventional paper machine.

As used herein the term CWP technology (Conventional Wet Pressed technology) refers to conventional paper web processes, in which the tissue is formed on a forming fabric and dewatered by pressing with one or more pressure roll nips. The process may involve transfer of the sheet to a Yankee dryer and removing the sheet from the Yankee surface by a doctor blade in a creping process. CWP technology as used herein includes for example dry crepe technology, wet crepe technology, and flat NTT (New Tissue Technology).

As used herein, the term structured tissue technology relates to the newer technologies for producing a structured tissue web. Such methods will not employ the high pressure used to dewater the web in the CWP process. Therefore, structured tissue technology is sometimes referred to as non-compressing de-watering technology. The structured tissue technology may for example be TAD (Thru-Air-Dried), UCTAD (Uncreped-Through-Air-Dried) or ATMOS (Advanced-Tissue- Molding-System), textured NTT, QRT, PrimeLineTEX technology and eTAD technology.

The structured tissue technology methods are known from prior art, for example TAD is known from US5853547; and ATMOS from US 7744726, US7550061 and US7527709; and UCTAD from EP 1 156925 and WO 02/40774.

TAD technology has been developed since the 1960's and is well known to a person skilled in the art. It generally involves developing functional properties of the tissue by moulding the fibre mat on a structured fabric. This results in the fibre mat forming a structured tissue which may acquire high bulk and absorption due to air passing through the web while drying the web when still on the structured fabric.

ATMOS technology is a production method developed by Voith and which is also well known to a person skilled in the art.

Another example is textured NTT (New Tissue Technology). Textured NTT was designed to overcome some of the limitations of ATMOS by pressing at even higher pressures before transferring to the Yankee. A shoe press is used in the first pressing section between the former felt and a belt with cells designed to provide absorptive capacity and increase strength. The NTT technology may reduce the Yankee Hood drying load as compared to ATMOS.

Yet other examples are Prime Line Tex technology as rendered available by Andritz for production of textured tissue, and eTAD technology as rendered available by Valmet.

METHODS

Lignin content:

The measurement of residual lignin content in the pulp fibres has been carried out according to the draft standard ISO/DIS 21436: Pulps-Determination of lignin content – Method of acid hydrolysis 1), which includes:

- i) the gravimetric measurement of the residue after acid hydrolysis (AIL : Acid Insoluble Lignin or Klason Lignin), also described in the Tappi T222 om-02 method 2 ; and
- ii) the measurement of soluble lignin (ASL : Acid Soluble Lignin), also described in the technical note Tappi UM2503 .

3.1) Sample preparation: The samples were disintegrated with a grinder/mixer. Their dry matter contents were determined before analysis, by drying in an oven of an aliquot of 2-3 g at 105°C, according to the ISO 638 standard 4 .

3.2) Measurement of acid insoluble lignin (AIL or Klason lignin) after acid hydrolysis An aliquot of ~1 g was hydrolysed with a solution of sulfuric acid, firstly at ambient temperature (2 h) and then under reflux during 4 h (Procedure B of the future standard).

- 5 After cooling, the suspension was filtered and washed and the solid residue was collected, dried and weighted. The acid insoluble lignin content in the sample was determined by difference between the dry hydrolysis residue weight and the ash weight, reported to the dry mass content of the initial sample. Note 1 : Detection limit (DL) ~0.1% ; Quantification limit (QL) ~0.5%.

10

3.3) Measurement of acid soluble lignin. The absorbance at 205 nm of the hydrolysate (i.e. the filtrate collected during the filtration of the suspension, cf 3.2), were measured. The acid soluble lignin content (ASL) was determined according to the predefined extinction coefficient of the lignin (i.e. 110 L/g.cm). Note 2 : : Detection limit (DL) ~0.1% ; Quantification Limit (QL) ~0.5% Remark: This quantification method is sensitive to the contaminants being present into the sample. Each compound other than hemicelluloses and cellulose and the acid insoluble minerals are susceptible to interfere with the measurement of the hydrolysis residue and with the acid soluble lignin.

20 Hemicellulose

- The determination of the contents of the main polysaccharides in the pulp (arabinane, galactane, glucane, xylene, and mannane) has been made by using high performance anion exchange chromatography with a pulsed amperometric detector, HPAE/PAD-Dionex® analysis of free monosaccharides (arabinose, galactose, glucose, xylose and mannose) after sulphuric acid hydrolysis of the sample pulp. The cellulose and the hemicellulose content in the pulp sample is determined according to standard method ISO / DIS21437 – Pulps: Determination of carbohydrate (under publication) after calibration. The samples studied are chemical pulp which has not required extraction of acetone beforehand. In contrast, the samples have been dried. However, considering the pulp state (wet lap sheets), samples were grinded before analysis. Dry content of the grinded samples was measured according to NF EN ISO 638:2008.
- 25
30

Basically the method is quantifying the amounts of sugars (monosaccharides) after hydrolysis of cellulose and hemicellulose using the ISO / DIS 21437 – Pulps: Determination of

carbohydrate. Then, calculation is made backwards to estimate level of hemicelluloses (knowing proportion of sugars in hemi and cellulose)

Basis weight

- 5 Basis weight is determined in accordance with ISO 12625-6: 2016.

The basis weight is determined in g/m².

Thickness per sheet:

Thickness is determined in accordance with ISO 12625-3.

GMT strength:

- 10 GMT strength (Geometric Mean Tensile strength) refers to the square root of the product of the machine direction dry tensile strength and the cross-direction dry tensile strength of a tissue web/product.

The GMT strength is determined in accordance with ISO 12625-4.

A load cell of 100N was used.

- 15 Absorption:

Absorption is herein the water absorption capacity of the tissue paper. Water absorption capacity is the amount of water the sample is able to absorb, reported in g/g (i.e. g water / g material in sample).

Absorption was measured according to ISO12625-8:2011.

- 20 The water is deionized water, conductivity ≤ 0.25 mS/m at 25°C, in accordance with ISO14487.

Softness panel:

Panel softness is determined by evaluation made by panel members. The panelists rank products in terms of softness. The Softness Panel values are therefore comparative

- 25 values enabling a comparison between the samples tested, rather than an absolute parameter.

The softer the product/tissue base sheet is rated the higher the value will be.

Softness values of tissue paper products (finished goods) and tissue base sheets are not directly comparable as there are different scales/reference products.

Each sample is composed of one product, i.e. a multi-ply tissue paper product.

The dimensions of the samples are therefore the dimensions of the finished products.

5 Samples are placed in MD before the panelists.

Samples are conditioned for minimum 2 hours in a controlled area at 23°C and 50% relative humidity.

The different samples are comfort rated by ten panelists, and an average comfort rating for each product is determined over the panelists.

10 Hence, softness panel values are comparative values within a test and indicate the perceived softness of a product.

For the purpose of this application, softness panel values given in one and the same table are comparable and indicate the perceived relative softness of the products tested. The higher the value of the rating, the more comfortable is the product.

15

Average fibre length measurement:

Fibre length measurement was made using the standard for fibre analyser: ISO 16065-2:2014: Pulps – Determination of fibre length by automated optical analysis – Part 1: Unpolarized light method.

20

Length-weighted mean length was used and the average of the length – weighted fibre-length distribution.

Breaking length measurement

25 The breaking length is the calculated upper limit of length of a uniform paper strip that would support its own weight if it were suspended at one end. Breaking length (m) = $102 \times T/R$, where T = Tensile strength, N/m, and R = basis weight, g/m².

The breaking length is a pulp characteristic obtained by tensile strength and basis weight

30 measurements as measured on lab handsheets produced in accordance with EN ISO 5269-2. (Tensile strength: ISO 12625-4; basis weight: ISO 12625-6: 2016)

Ratio of breaking length measurement/average fibre length measurement

The ratio of breaking length/average fibre length is herein using the values of the fibre
5 length measurement and the breaking length measurements as achieved according to the
methods in the above, the average fibre length measurement being reported in μm , and
the breaking length being reported in m.

It may be noted that the breaking length, as well as the average fibre length, are pulp
10 characteristics. Accordingly, the measurements of these properties are to be performed
on the pulp as received from the pulping process, before reaching the papermaking
process, such as before entering the stock preparation in a paper machine. Thus, the
measurements are done prior to any mechanical and/or chemical and/or enzymatic
treatment for strength adjustment which may occur during the paper making process.

15

CLAIMS

1. A single-ply tissue paper material having a basis weight less than 40 gsm and a GMT tensile strength of at least 60 N/m, comprising a non-wood tissue ply, said
5 non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
2. A single-ply tissue paper material according claim 1, wherein the tissue paper
10 material has a GMT tensile strength of at least 70 N/m.
3. A single-ply tissue paper material according claim 1 or 2, wherein the tissue paper material has a GMT tensile strength of at least 80 N/m.
- 15 4. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of less than 30 gsm.
5. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of less than 25 gsm.
- 20 6. A single-ply tissue paper product consisting of a single-ply tissue paper material according to any one of the claims 1 to 5.
7. A multi-ply tissue paper product comprising two or more plies, wherein an
25 average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having a GMT tensile strength of at least 100 N/m, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 30 8. A multi-ply tissue paper product according to claim 7, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.

9. A multi-ply tissue paper product according to claim 7 or 8, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.
- 5 10. A multi-ply tissue paper product according to any one of the claims 7 to 9, wherein at least 50 % of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 10 11. A multi-ply tissue paper product according to any one of the claims 7 to 10, wherein all of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 15 12. A multi-ply tissue paper product according to any one of the claims 7 to 11, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.
- 20 13. A multi-ply tissue paper product according to any one of the claims 7 to 12, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.
- 25 14. A multi-ply tissue paper product according to any one of the claims 7 to 13, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.
- 30 15. A multi-ply tissue paper product according to any one of the claims 7 to 14, wherein said multi-ply tissue paper material or product comprises two to five plies.
- 35 16. A multi-ply tissue paper product according to any one of the claims 7 to 15, wherein each ply of the multi-ply product comprises the same amount of non-wood cellulose pulp fibres.

17. A multi-ply tissue paper product according to any one of the claims 7 to 15,
wherein at least two plies comprise different amounts of non-wood cellulose pulp
fibres.
- 5 18. A multi-ply tissue paper product according to any one of the claims 7 to 17,
wherein said at least one non-wood tissue ply is an outer ply of said multi-ply
tissue paper material.
- 10 19. A multi-ply tissue paper product according to claim 18, wherein the multi-ply
tissue paper material comprises at least two non-wood tissue plies, the non-
wood tissue plies forming a first and a second outer ply of the multi-ply tissue
paper product.
- 15 20. A multi-ply tissue paper product according to any one of the claims 7 to 19,
wherein said non-wood tissue ply is formed by a single-ply tissue paper material
in accordance with any one of claims 1 to 5.
- 20 21. A single-ply tissue paper product or a multi-ply tissue paper product according to
any one of the claims 6 to 20, wherein the tissue paper product has an
absorbency of at least 7 g/g.
- 25 22. A single-ply tissue paper product or a multi-ply tissue paper product according
to any one of the claims 6 to 21, wherein the tissue paper product has an
absorbency of at least 8 g/g.
- 30 23. A single-ply tissue paper material, a single-ply tissue paper product or a multi-
ply tissue paper product according to any one of the preceding claims, wherein
the non-wood cellulose pulp fibres contains at least 15% hemicellulose.
- 35 24. A single-ply tissue paper material, a single-ply tissue paper product or a multi-
ply tissue paper product according to any one of the preceding claims, wherein
the non-wood cellulose pulp fibres contains no more than 15 % lignin.
25. A single-ply tissue paper material, a single-ply tissue paper product or a multi-
ply tissue paper product according to any one of the preceding claims, wherein

the non-wood cellulose pulp fibres have an average fibre length of less than 1700 μm .

- 5 26. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1200 μm .
- 10 27. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 900 μm .
- 15 28. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length of more than 3000 m.
- 20 29. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 3.7.
- 25 30. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.
- 30 31. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5.
- 35 32. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from a member of the Poaceae family, such as from wheat straw, rice straw, barley straw, oat straw, rye grass,

costal Bermuda grass, Arundo donax, miscanthus, bamboo, sugar cane bagasse and/or sorghum.

- 5 33. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family, such as from hemp and/or hop.
- 10 34. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are agricultural waste or byproduct, such as derived from agricultural waste or byproduct of the Poaceae family and/or Cannabaceae family such as exemplified in the above, including agricultural waste or byproduct from wheat straw, rice straw, barley straw, oat straw, rye
- 15 grass, sugar cane bagasse, hemp or hop and/or wherein the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct such as banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.
- 20 35. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae), switchgrass, succulents, alfalfa (belongs to the family Fabaceae.), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).
- 25 36. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 15%.
- 30 37. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 20% by dry weight.
- 35

- 5 38. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight.
- 10 39. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight.
- 15 40. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.
- 20 41. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to claim 40, wherein said non-wood tissue ply comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the non-wood tissue ply.
- 25 42. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to claim 40 or 41, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 95/5.
- 30 43. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 40 to 42, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 90/10.
- 35 44. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 40 to 43, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 80/20.

- 5 45. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply or plies.
- 10 46. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises two or more layers, and at least one layer comprises non-wood fibres.
- 15 47. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, said non-wood tissue ply or plies being produced by conventional wet press technology (CWP).
- 20 48. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, said non-wood tissue ply or plies being produced by structured tissue technology, for example TAD (Through Air Drying), ATMOS, NTT(textured), UCTAD, QRT, eTAD or PrimeLineTEX.
- 25 49. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein a portion of or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibre.
- 30 50. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, comprising softwood cellulose pulp fibres and wherein a portion of or all softwood cellulose fibres are never-dried softwood cellulose pulp fibre.
- 35 51. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, comprising hardwood cellulose pulp fibres and wherein a portion of or all hardwood cellulose fibres are never-dried hardwood cellulose pulp fibre.

52. Single-ply tissue paper product or multi-ply tissue paper product according to any one of the claims 6 to 51, the tissue paper product being for personal hygiene, such as toilet paper, hand wipes, paper napkins, facial wipes, handkerchiefs or the tissue paper product being a kitchen towel or industrial wipe.