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(57) Abstract:

The present invention relates to a refined cellulose fiber composition useful as a strength enhancing agent for paper and paperboard, wherein the refined cellulose fiber composition has a Schopper-Riegler (SR) number in the range of 80-98 as determined by standard ISO 5267-1, and wherein the refined cellulose fiber composition has a content of fibers having a length >0.2 mm of at least 12 million fibers per gram based on dry weight. The invention further relates to a method for preparing the refined cellulose fiber composition and to pulp paper and paperboard comprising the refined cellulose fiber composition.

ABSTRACT

The present invention relates to a refined cellulose fiber composition useful as a strength enhancing agent for paper and paperboard, wherein the refined cellulose fiber composition has a Schopper-Riegler (SR) number in the range of 80-98 as
5 determined by standard ISO 5267-1, and wherein the refined cellulose fiber composition has a content of fibers having a length >0.2 mm of at least 12 million fibers per gram based on dry weight. The invention further relates to a method for preparing the refined cellulose fiber composition and to pulp paper and paperboard comprising the refined cellulose fiber composition.

REFINED CELLULOSE FIBER COMPOSITION

Technical field

The present disclosure relates to strength enhancement agents for improving paper or paperboard strength properties, especially for improving Z-strength and/or tensile strength. The present disclosure further relates to the manufacture of such strength enhancement agents and to paper or paperboard comprising such strength enhancement agents.

10 Background

Paperboard comprises a plurality of layers, also known as plies, of pulp and optional additives. The layers are selected and arranged to achieve the desired properties of the paperboard as such. An essential property of the paperboard is the bending stiffness. The bending stiffness in paperboard is usually built up by having outer plies with high tensile stiffness and one or several bulky plies in between, so that the outer plies are placed at a desired distance from each other. The bulky ply/plies is/are often a middle layer/middle layers.

The middle layer in paperboard may comprise a mechanical pulp, such as thermomechanical pulp (TMP) or chemi-thermomechanical pulp (CTMP). TMP and CTMP generally have a high bulk, thereby enabling constructing paperboard with the desired high stiffness at low grammage, compared to for example chemical pulps.

25 In the CTMP process, wood chips are impregnated with a lignin softening chemical prior to pressurized refining. This results in softening of lignin and the fiber rupture during refining will therefore be concentrated to the lignin rich middle lamella. This results in stiff fibers and a lower amount of fines and shives at a certain energy input compared to TMP. A high concentration of long fibers is important for all products where high bulk is desired. Therefore, CTMP is more advantageous than TMP in paperboard.

The strength of paper is measured in three dimensions: the grain direction, also known as the X- direction; the cross-grain direction, also known as Y-direction;

and the direction perpendicular to the paper surface plane, also known as the Z-direction. The force needed to delaminate a sample of a paper is recorded as its internal bond strength, or Z-directional tensile strength. A high Z-strength in the middle layer of paperboard is desired in order to avoid delamination of the middle
 5 layer and hence delamination of the paperboard as such. Such a Z-strength must however be achieved without deteriorating the bending stiffness, that is without having to increase the paper web density.

Z-strength and density of a paperboard layer is usually optimized by altering the
 10 raw materials, by choosing different operation conditions in stock preparation and on the board machine and by addition of paper chemicals. Like many other strength properties, strength in Z-direction increases with increased density and the effect comes from increase of bonded area between the fibers. The relationship between density and out-of-plane strength may vary depending on
 15 pulp type and densification method. Refining increases strength more than wet pressing. The main purpose of refining is to improve the bonding properties of the fibers. Changes that improve fiber-to-fiber bonding are internal and external fibrillation together with fines creation. All three changes result in an increase of the water-holding capacity of the pulp, its density and strength properties such as
 20 tensile strength and stiffness, burst and compression strength, and also strength in Z-direction.

While CTMP provides a high bulk, the Z-strength of CTMP is comparatively low.

25 It is not only paperboard which requires high delamination resistance and bending stiffness. These properties are important in for example printing, in converting and in end-use situations. This means that producing paper and board with high strength in Z-direction is very important for many paper products.

30 Strength in fiber and paperboard products can be increased by enhancing fiber-fiber contact, such as by surface fibrillation, by using modified fibers, or by using natural or synthetic strength enhancing chemicals such as polysaccharides. One of the recent development trends is to use nanocellulose as a strength enhancing agent. While nanocellulose is very useful as a strength enhancement agent,

nanocellulose manufacturing concepts are usually very energy intensive. In order to reduce energy costs, the use of enzymatic pretreatment or chemical pretreatment, such as derivatization, or fiber swelling has been proposed.

However, biological, chemical or physico-chemical treatment all requires separate
5 treatment steps or additional process solutions or investments if adopting to pulp mill integration/environment.

Thus, there remains a need for improved solutions to improve the tensile strength and Z-strength strength of paper or paperboard.

10

Description of the invention

A specific object of the invention is to provide a new type of strength enhancement agent that gives paper or paperboard better strength properties, especially a better
15 tensile strength and a better Z-strength.

A further object of the invention is to provide a cellulose based strength enhancement agent, the manufacture of which requires less energy than the manufacture of previous cellulose-based strength enhancement agents.

20

A further object of the invention is to provide a method for manufacturing a strength enhancement agent for paper or paperboard, which requires less energy than the manufacture of previous cellulose-based strength enhancement agents.

25 Yet a further object of the invention is to provide a method for manufacturing a strength enhancement agent for paper or paperboard, which can be integrated in a pulp mill without the need for investments in special equipment such as fluidizers or homogenizers.

30 The above-mentioned objects, as well as other objects as will be realized by the skilled person in the light of the present disclosure, are achieved by the various aspects of the present disclosure.

According to a first aspect illustrated herein, there is provided a refined cellulose fiber composition,

wherein the refined cellulose fiber composition has a Schopper-Riegler (SR) number in the range of 80-98 as determined by standard ISO 5267-1, and

- 5 wherein the refined cellulose fiber composition has a content of fibers having a length >0.2 mm, according to standard ISO 16065-2, of at least 15 million fibers per gram based on dry weight. The content of fibers having a length >0.2 mm may for example be determined using the L&W Fiber tester Plus instrument (L&W/ABB).

10

The inventive refined cellulose fiber composition having both a high SR value and a high content of fibers having a length >0.2 mm has been found to be very efficient as a strength enhancing agent when mixed in CTMP sheets, and may prove a sustainable alternative as source reduction agent for paper and

- 15 paperboard production.

The inventive composition is a refined cellulose fiber composition. Refining, or beating, of cellulose pulps refers to mechanical treatment and modification of the cellulose fibers in order to provide them with desired properties.

20

In some embodiments, the refined cellulose fiber composition has a Schopper-Riegler (SR) number in the range of 85-98, preferably in the range of 90-98, as determined by standard ISO 5267-1. In some embodiments, the refined cellulose fiber composition has a Schopper-Riegler (SR) number in the range of 92-98,

- 25 preferably in the range of 94-98, as determined by standard ISO 5267-1.

In some embodiments, the refined cellulose fiber composition has a content of fibers having a length >0.2 mm of at least 17 million fibers per gram based on dry weight, and more preferably at least 20 million fibers per gram based on dry

- 30 weight. The content of fibers having a length >0.2 mm may be determined using the Fiber Tester Plus instrument.

In some embodiments, the refined cellulose fiber composition has a crill value of at least 1.7, preferably at least 1.8, more preferably at least 1.9. The crill value is determined using the Fiber Tester Plus instrument.

- 5 In some embodiments, the refined cellulose fiber composition has a mean fibril area of fibers having a length >0.2 mm of at least 17%, preferably at least 20%, more preferably at least 22%. The mean fibril area is determined using the Fiber Tester Plus instrument.
- 10 The refined cellulose fiber composition according to the invention can be produced from different raw materials, for example softwood pulp or hardwood pulp.

The benefit of reduced energy demand is demonstrated by selecting a fraction of softwood Kraft pulp. Thus, in some embodiments, the cellulose pulp is a softwood
15 pulp.

In some embodiments, the refined cellulose fiber composition is substantially free from lignin, preferably said cellulose pulp has a lignin content below 10% by weight, based on the total dry weight of the pulp.

20

In some embodiments, the refined cellulose fiber composition is obtained by subjecting a fine fiber fraction obtained by fractionation of a cellulose pulp to refining with a total refining energy in the range of 100-1500 kWh/t, preferably in the range of 500-1500 kWh/t, more preferably in the range of 750-1250 kWh/t.

25

The present invention further relates to a method for making a refined cellulose fiber composition according to the first aspect with reduced amount of energy.

Thus, according to a second aspect illustrated herein, there is provided a method
30 for manufacturing a refined cellulose fiber composition for use as a strength enhancement agent for paper or paperboard, comprising:

- a) providing a fine fiber fraction obtained by size fractionation of a cellulose pulp into a fine fiber fraction and a coarse fiber fraction;

b) subjecting said fine fiber fraction to refining at a consistency in the range of 0.5-30% by weight to a Schopper-Riegler (SR) number in the range of 80-98, as determined by standard ISO 5267-1, to obtain the refined cellulose fiber composition, wherein said refined cellulose fiber composition has a content of
5 cellulose fibers having a length >0.2 mm, according to standard ISO 16065-2, of at least 15 million fibers per gram on dry weight.

A problem when refining a non-fractionated pulp is that the energy consumption will be high. One option to reduce the energy consumption is to derivatize the pulp
10 or to use enzymes to enhance and facilitate the fibrillation as described e.g. in international patent application WO2007091942A1. However, the use of chemicals and additives have their own limitations, especially in an integrated pulping process. The chemicals increase costs and may also interfere with other chemicals.

15 The refining process is an energy intensive process that has a significant impact on the properties of many paper products and therefore it is very important to control this process. Today on-line measurements of the drainage resistance of the stock, for example the Schopper-Riegler value, and also sometimes the
20 geometrical dimensions of the fibers are mainly used to control the refining process. One very important variable left out is the potential of fibers to bond to each other. The fibrils that are partially or completely loosened from the fibers are called crill. Crill generated during the refining process significantly improves the bonding between fibers.

25 Experiments performed by the inventors show that unfractionated pulp can indeed be refined to high SR by increasing the refining energy, which is expected and in line with the prior art. However, the results also show that the content of fibers having a length >0.2 mm and crill value remain on relatively low values. When
30 using 5% by weight of the refined unfractionated pulp in CTMP sheets, both Z-strength and tensile index increase, but the increases are low or moderate.

On the other hand, when the pulp is fractionated into a fine fiber fraction and a coarse fiber fraction, and the refining is performed on a fine fiber fraction, the

experiments shows that independently of the softwood mixtures a high SR value can be reached but with a high content of fibers having a length >0.2 mm and a high crill value. This, despite refining being performed at low consistency.

- 5 The inventive refined cellulose fiber composition having both a high SR value and a high content of fibers having a length >0.2 mm has been found to be very efficient as a strength enhancing agent when mixed in CTMP sheets, and may prove a sustainable alternative as source reduction agent for paper and paperboard production.

10

The fine fiber fraction used as the starting material in the inventive method is obtained by size fractionation of a cellulose pulp starting material into a fine fiber fraction and a coarse fiber fraction. Compared to the starting material, the fine fiber fraction has a higher amount of shorter and thinner fibers. The fine fiber fraction
15 may for example be obtained by separating the cellulose pulp starting material in pressure screens to achieve a fraction with shorter and thinner fibers.

The fine fiber fraction typically has a mean fiber length of fibers having a length >0.2 mm below 1.7 mm (as determined according to ISO 16065-2) and a content
20 of fibers having a length >0.2 mm of at least 5 million fibers per gram based on dry weight.

The coarse fiber fraction also obtained from the fractionation, having a reduced amount of fines and fine fibers, may be used for example in the production of
25 tissue.

In some embodiments, the cellulose pulp in step a) is a softwood pulp.

In some embodiments, the cellulose pulp in step a) is a never dried pulp.
30

In some embodiments, the cellulose pulp in step a) is a non-beaten pulp.

In some embodiments, the cellulose pulp is substantially free from lignin, preferably said cellulose pulp has a lignin content below 10% by weight, based on the total dry weight of the pulp.

- 5 In some embodiments, the cellulose pulp has a hemicellulose content in the range of 10-30% by weight, based on the total dry weight of the pulp.

The fine fiber fraction may optionally be treated by oxidation or by addition of an auxiliary strength enhancing agent prior to the refining in step b). In some
10 embodiments, the fine fiber fraction is treated with an oxidant prior to the refining. In some embodiments, an auxiliary strength enhancing agent is added to the fine fiber fraction prior to the refining.

In some embodiments, the fine fiber fraction in step a) has a Schopper-Riegler
15 (SR) number of less than 70, preferably less than 50, as determined by standard ISO 5267-1.

In some embodiments, the fine fiber fraction in step a) has a content of fibers having a length >0.2 mm in the range of 1-10 million fibers per gram, preferably in
20 the range of 5-10 million fibers per gram.

In some embodiments, the fine fiber fraction in step a) has a mean fiber length in the range of 1-2, preferably in the range of 1-1.7.

- 25 In some embodiments, the fine fiber fraction is subjected to refining at a consistency in the range of 1-10% by weight.

In some embodiments, the fine fiber fraction is subjected to refining with a total refining energy in the range of 100-1500 kWh/t, preferably in the range of 500-
30 1500 kWh/t, more preferably in the range of 750-1250 kWh/t.

In some embodiments, the refined cellulose fiber composition in step b) has a Schopper-Riegler (SR) number in the range of 85-98, preferably in the range of 90-98, as determined by standard ISO 5267-1. In some embodiments, the refined

cellulose fiber composition has a Schopper-Riegler (SR) number in the range of 92-98, preferably in the range of 94-98, as determined by standard ISO 5267-1.

- 5 The refining of the fine fiber fraction results in a refined cellulose fiber composition having a high content of fibers having a length >0.2 mm that are highly fibrillated and have a high crill value.

- 10 The refined cellulose fiber composition has a content of fibers having a length >0.2 mm of at least 15 million fibers per gram based on dry weight, and more preferably at least 20 million fibers per gram based on dry weight.

In some embodiments, the refined cellulose fiber composition has a crill value of at least 1.7, preferably at least 1.8, more preferably at least 1.9.

- 15 In some embodiments, the refined cellulose fiber composition has a mean fibril area of fibers having a length >0.2 mm of at least 17%, preferably at least 20%, more preferably at least 22%. "mean fibril area" herein refers to length weighted mean fibril area.
- 20 Fiber mean length of fibers having a length >0.2 mm, fibril area of fibers having a length >0.2 mm, and crill value were determined using the L&W Fiber Tester Plus (L&W/ABB) instrument (also referred to herein as "Fiber Tester Plus" or "FT+") with definition of fibers as fibrous particles longer than 0.2 mm according to standard ISO 16065-2.

25

A known sample weight of 0.100 g was used for each sample and the content of fibers having a length >0.2 mm (million fibers per gram) was calculated using the following formula: *Million fibers per gram* = *(No. fibers in sample) / (Sample weight) / 1 000 000* = *(Property ID 3141) / property ID 3136) / 1 000 000*

30

The crill measurement method is based on utilizing the ability of particles to absorb and diverge light of different wavelengths depending on their diameter. By leading the pulp suspension through one UV and one IR light source with a detector on the opposite side it is possible to detect if small particles is present in the solution. The

more particles the more light is diverged or absorbed. Small particles such as crill will spread and absorb the light from the UV light source whereas the fiber will affect the light from the infrared light source. The crill content is obtained as a quota of UV/IR detected.

5

The inventive refined cellulose fiber composition may preferably be used as strength enhancing additive in a cellulose pulp (e.g. CTMP) to enhance the strength of paper or paperboard manufactured from the pulp. The refined cellulose fiber composition is typically added to the pulp to be reinforced at a concentration
 10 of at least 0.1 % by weight, preferably at least 1 % by weight. In some embodiments the refined cellulose fiber composition is added to the pulp to be reinforced at a concentration in the range of 1-25 %, preferably in the range of 1-15 % by weight, more preferably in the range of 1-10 % by weight, most preferably in the range of 2-7 % by weight, based on dry weight. In some embodiments the
 15 refined cellulose fiber composition is added to the pulp to be reinforced at a concentration in the range of 2-5 % by weight, based on dry weight.

According to a third aspect illustrated herein, there is provided a cellulose pulp for manufacturing paper or paperboard, comprising at least 0.1 % by weight,
 20 preferably in the range of 1-25 % by weight, more preferably in the range of 1-10 % by weight, most preferably in the range of 2-7 % by weight, of the refined cellulose fiber composition described herein with reference to the previous aspects, based on dry weight.

25 In some embodiments, the cellulose pulp is a chemi-thermomechanical pulp (CTMP).

Paper and paperboard comprising the inventive refined cellulose fiber composition exhibits significantly improved tensile strength and a better Z-strength as
 30 compared to corresponding paper and paperboard without the inventive refined cellulose fiber composition.

According to a fourth aspect illustrated herein, there is provided a paper or paperboard comprised of one or more plies, wherein at least one ply comprises at

least 0.1 % by weight, preferably in the range of 1-25 % by weight, more preferably in the range of 1-10 % by weight, most preferably in the range of 2-7 % by weight, of the refined cellulose fiber composition described herein with reference to the previous aspects, based on dry weight.

5

Paper generally refers to a material manufactured in thin sheets from the pulp of wood or other fibrous substances comprising cellulose fibers, used for writing, drawing, or printing on, or as packaging material, or as liner, or as fluting, or as hygienic articles e.g. tissues, or absorbents, or non-woven.

10

Paperboard generally refers to strong, thick paper or cardboard comprising cellulose fibers used for boxes and other types of packaging. Paperboard can either be bleached or unbleached, coated or uncoated, and produced in a variety of thicknesses, depending on the end use requirements.

15

According to a fifth aspect illustrated herein, there is provided the use of a refined cellulose fiber composition described herein with reference to the previous aspects for improving the Z-strength and/or tensile strength of a paper or paperboard.

20 The strength enhancement agent in the third, fourth and fifth aspects may be further defined as set out above with reference to the first and second aspect.

The term "% based on dry weight" as used herein (e.g. with reference to pulp compositions or pulp fractions) refers to weight percent based on the total dry

25 weight of the composition.

While the invention has been described with reference to various exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

35

EXAMPLES

Analysis

Fiber mean length of fibers having a length >0.2 mm, fibril area of fibers having a length >0.2 mm, and crill value were determined using the L&W Fiber Tester Plus (L&W/ABB) instrument (FT+) with definition of fibers as fibrous particles longer than 0.2 mm according to standard ISO 16065-2.

A known sample weight of 0.100 g was used for each sample and the content of fibers having a length >0.2 mm (million fibers per gram) was calculated using the following formula: *Million fibers per gram = (No. fibers in sample) / (Sample weight) / 1 000 000 = (Property ID 3141) / property ID 3136) / 1 000 000*

Drainage resistance (tap water), was determined according to Schopper-Riegler method ISO 5267-1.

15

Sheet properties were measured according to the following standards:

Tensile testing ISO 1924-3:2005

Z-strength testing ISO 15754:2009

20 Starting materials

Softwood pulp 1 (SW1) is softwood kraft pulp (spruce/pine mixture) with a mean fiber length (>0.2 mm) of 2.1 mm according to ISO 16065-2 and a content of fibers having a length >0.2 mm of 4.2 million fibers per gram based on the FT+.

25 Softwood pulp 2 (SW2) is softwood kraft pulp (pine) with a mean fiber length (>0.2 mm) of 2.1mm according to ISO 16065-2 and a content of fibers having a length >0.2 mm of 3.6 million fibers per gram based on the FT+.

Softwood pulp 3 (SW3) is softwood kraft pulp (spruce) with a mean fiber length (>0.2 mm) of 2.6 mm according to ISO 16065-2 and a content of fibers having a length >0.2 mm of 3.1 million fibers per gram based on the FT+.

30

Softwood pulp 4 (SW4) is softwood kraft pulp (spruce/pine mixture) with a mean fiber length (>0.2 mm) of 2.4 mm.

Fractionation

A fine fiber fraction was achieved by separating the pulp in pressure screens (equipped with screen basket with hole size 1.2 mm) with the aim to obtain a fraction with many short fibers. By a two-stage procedure 4-7 % of the pulp was separated from the Feed pulp stream. The two-stage procedure decreased the fiber length and increased the number of fibers per gram. In addition to the FT+ mean length measurements, mean length was also determined using a Valmet fiber image analyzer FS5 with definition of fibers as fibrous particles longer than 0.2 mm according to standard ISO 16065-2.

Material	Sample	ISO std 16065 FS5 Mean length (>0.2mm)	ISO std 16065 FT+ Mean length (>0.2mm)	FT+ Fibril area (>0.2mm)	FT+ Crill Quota UV/IR	FT+ Million fibres (>0.2mm) per gram
SW1	Feed pulp	2.00	2.10	0.9	0.98	4.2
SW1	Fine fibre fraction	1.47	1.57	1.2	1.05	6.6
SW2	Feed pulp	2.01	2.11	0.9	0.97	3.6
SW2	Fine fibre fraction	1.46	1.49	1.5	0.99	6.6
SW3	Feed pulp	2.52	2.62	1.4	0.99	3.1
SW3	Fine fibre fraction	1.63	1.57	1.8	1.07	7.5
SW4	Feed pulp	2.35				
SW4	Fine fibre fraction	1.58	1.48	1.7	1.06	9.6

15

Refining

Refining of the unfractionated and fine fiber fraction samples was done with a Voith Sulzer LR1 refiner with 2 mm disc refiner at ~4% consistency and 100 liter/min flow rate as follows.

20

Example 1 (unfractionated):

SW1 pulp was refined with conical refiner fillings with 3 mm bars and cutting angle 60 degrees, at edge load 1.0 Ws/m to a refining energy of 466 kWh/t.

Example 2 (unfractionated):

- 5 SW1 pulp was refined with conical refiner fillings with 3 mm bars and cutting angle 60 degrees, at edge load 1.0 Ws/m to a refining energy of 1032 kWh/t.

Example 3 (unfractionated):

- 10 SW3 pulp was refined with disc refiner fillings with 2 mm bars and cutting angle 40 degrees, at edge load 0.25 Ws/m to a refining energy of 750 kWh/t.

Example 4 (unfractionated):

- 15 SW2 pulp was refined with conical refiner fillings with 3 mm bars and cutting angle 60 degrees, at edge load 1.0 Ws/m to a refining energy of 950 kWh/t.

Example 5-9 Fine fibre fractions (fractionated):

- The fine fiber fractions were refined with disc refiner fillings with 2 mm bars and cutting angle 40 degrees, at edge load 0.25 Ws/m to a refining energy 1039-1550 kWh/t.

20

Sheet preparation

- 5% by weight of the refined sample was added to CTMP (Spruce CTMP with canadian standard freeness of 600 ml CSF) and sheets for strength testing were prepared with a Formette dynamic sheet former with pulp consistency 3 g/liter and
- 25 1 minute mixing at 1000 rpm before making the sheets with nozzle 2514, pressure 2.5 bar, rotational speed 1050 rpm, basis weight 100 g/m², dewatering time 2 minutes, couching with blotter papers, 1st roll pressing 1 bar between felts, replacing blotters and 2nd pressing at 5 bar between felts, replacing blotters and 3rd pressing without felts at 5 bar, drying in bow dryer at 95 °C, conditioning at 23
- 30 °C 50% RH. For efficient mixing of the pulp furnish, the Formette dynamic sheet former was equipped with a baffled mixing chest similar to an upscaled Britt Dynamic Drainage Jar. The Z-strength and tensile index of the sheets was then analyzed.

Table 1.

Ex.	Sample	Specific Refining Energy (kWh/t)	SR	FT+ Mean length (>0.2mm)	FT+ Fibril area (>0.2mm)	FT+ Crill Quota UV/IR	Crill increase 2)	Million fibers (>0.2mm) per gram	Z-strength (kPa)	Z-strength increase 1) (kPa)	Tensile index (Nm/g)	Tensile index increase 1) (Nm/g)
Unfractionated												
1	SW1	466	65.9	2.023	7.4	1.31	0.31	4.8	156	27	28.2	6.4
2	SW1	1032	89.7	1.64	16.2	1.58	0.58	7.7	179	50	29.6	7.8
3	SW3	750	91.6	1.386	22.2	1.74	0.74	8.9	150	10	27.8	2.9
4	SW2	950	87.6	1.696	14.6	1.52	0.52	6.4	170	50	30.1	8.6
Fine fiber fraction												
5	SW4	1039	95.7	0.684	22.3	1.9	0.9	24.8	228	99	33.2	11.4
	Fine fibre											
6	SW4	1550	90.9	0.379	23.3	2.24	1.24	23.0	236	107	33.7	11.9
	Fine fibre											
7	SW2	1050	96.3	0.53	23.1	1.98	0.98	24.4	226	106	34.2	11.6
	Fine fibre											
8	SW3	1050	96.4	0.719	23.9	1.92	0.92	21.3	230	90	34.8	9.9
	Fine fibre											
9	SW3	1050	96.5	0.633	25.2	1.97	0.97	24.0	243	103	35.2	10.3
	Fine fibre											

1) compared to 100% CTMP

2) compared to unrefined pulp

CLAIMS

1. A refined cellulose fiber composition,
- 5 wherein the refined cellulose fiber composition has a Schopper-Riegler (SR) number in the range of 80-98 as determined by standard ISO 5267-1,
- characterized in that the refined cellulose fiber composition has a content of cellulose fibers having a length >0.2 mm, according to standard ISO 16065-2, of at
- 10 least 15 million fibers per gram based on dry weight.
2. The refined cellulose fiber composition according to claim 1, wherein said refined cellulose fiber composition has a Schopper-Riegler (SR) number in the range of 85-98, preferably in the range of 90-98, as determined by standard ISO
- 15 5267-1.
3. The refined cellulose fiber composition according to any one of the preceding claims, wherein said refined cellulose fiber composition has a content of cellulose fibers having a length >0.2 mm of at least 20 million fibers per gram based on dry
- 20 weight.
4. The refined cellulose fiber composition according to any one of the preceding claims, wherein said refined cellulose fiber composition has a crill value of at least 1.7, preferably at least 1.8, more preferably at least 1.9.
- 25
5. The refined cellulose fiber composition according to any one of the preceding claims, wherein said refined cellulose fiber composition has a length weighted mean fibril area of fibers having a length >0.2 mm of at least 17%, preferably at least 20%, more preferably at least 22%, determined using the L&W Fiber Tester
- 30 Plus.
6. The refined cellulose fiber composition according to any one of the preceding claims, wherein said refined cellulose fibers are refined softwood cellulose fibers.

7. A method for manufacturing a refined cellulose fiber composition for use as a strength enhancement agent for paper or paperboard, comprising:
- a) providing a fine fiber fraction obtained by size fractionation of a cellulose pulp into a fine fiber fraction and a coarse fiber fraction;
- 5 b) subjecting said fine fiber fraction to refining at a consistency in the range of 0.5-30% by weight to a Schopper-Riegler (SR) number in the range of 80-98, as determined by standard ISO 5267-1, to obtain the refined cellulose fiber composition, characterized in that said refined cellulose fiber composition has a content of cellulose fibers having a length >0.2 mm, according to standard ISO
- 10 16065-2, of at least 15 million fibers per gram based on dry weight.
8. The method according to claim 7, wherein said cellulose pulp is a softwood pulp.
- 15 9. The method according to any one of claims 7-8, wherein said cellulose pulp is a never dried pulp.
10. The method according to any one of claims 7-9, wherein said cellulose pulp is a non-beaten pulp.
- 20 11. The method according to any one of claims 7-10, wherein said cellulose pulp is substantially free from lignin, preferably said cellulose pulp has a lignin content below 10% by weight, based on the total dry weight of the pulp.
- 25 12. The method according to any one of claims 7-11, wherein said cellulose pulp has a hemicellulose content in the range of 10-30% by weight, based on the total dry weight of the pulp.
13. The method according to any one of claims 7-12, wherein said fine fiber
- 30 fraction is treated with an oxidant prior to the refining.
14. The method according to any one of claims 7-13, wherein an auxiliary strength enhancing agent is added to the fine fiber fraction prior to the refining.

15. The method according to any one of claims 7-14, wherein the fine fiber fraction in step a) has a Schopper-Riegler (SR) number of less than 70, preferably less than 50, as determined by standard ISO 5267-1.

5 16. The method according to any one of claims 7-15, wherein said fine fiber fraction is subjected to refining at a consistency in the range of 1-10% by weight.

17. The method according to any one of claims 7-16, wherein said fine fiber fraction is subjected to refining with a total refining energy in the range of 100-
10 1500 kWh/t, preferably in the range of 500-1500 kWh/t, more preferably in the range of 750-1250 kWh/t.

18. The method according to any one of claims 7-17, wherein said refined cellulose fiber composition in step b) has a Schopper-Riegler (SR) number in the
15 range of 85-98, preferably in the range of 90-98, as determined by standard ISO 5267-1.

19. The method according to any one of claims 7-18, wherein said refined cellulose fiber composition has a content of cellulose fibers having a length >0.2
20 mm of at least 20 million fibers per gram based on dry weight.

20. The method according to any one of claims 7-19, wherein said refined cellulose fiber composition has a crill value of at least 1.7, preferably at least 1.8, more preferably at least 1.9.

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21. The method according to any one of claims 7-20, wherein said refined cellulose fiber composition has a length weighted mean fibril area of fibers having a length >0.2 mm of at least 17%, preferably at least 20%, more preferably at least 22%%, determined using the L&W Fiber Tester Plus.

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22. Cellulose pulp for manufacturing paper or paperboard, comprising at least 0.1 % by weight, preferably in the range of 1-25 % by weight, more preferably in the range of 1-10 % by weight, most preferably in the range of 2-7 % by weight, of

the refined cellulose fiber composition according to any one of claims 1-6 or obtained by the method according to any one of 7-21, based on dry weight.

23. Cellulose pulp for manufacturing paper or paperboard according to claim 22,
5 wherein the cellulose pulp is a chemi-thermomechanical pulp (CTMP).

24. Paper or paperboard comprised of one or more plies, wherein at least one
ply comprises at least 0.1 % by weight, preferably in the range of 1-25 % by
weight, more preferably in the range of 1-10 % by weight, most preferably in the
10 range of 2-7 % by weight, of the refined cellulose fiber composition according to
any one of claims 1-6 or obtained by the method according to any one of 7-21,
based on dry weight.

25. Use of a refined cellulose fiber composition according to any one of claims 1-
15 6 or obtained by the method according to any one of 7-21 for improving the Z-
strength and/or tensile strength of a paper or paperboard.

I följande bilaga finns en översättning av patentkraven till svenska. Observera att det är patentkravens lydelse på engelska som gäller.

A Swedish translation of the patent claims is enclosed. Please note that only the English claims have legal effect.

PATENTKRAV

1. Mald cellulosaiberkomposition,

- 5 varvid den malda cellulosaiberkompositionen har ett Schopper-Riegler-tal (SR-tal) inom området 80-98 bestämt enligt standard ISO 5267-1,

kännetecknad av att den malda cellulosaiberkompositionen har ett innehåll av cellulosaiber med en längd >0,2 mm, enligt standard ISO 16065-2, som är minst
10 15 miljoner fiber per gram baserat på torr vikt.

2. Mald cellulosaiberkomposition enligt patentkrav 1, varvid nämnda malda cellulosaiberkomposition har ett Schopper-Riegler-tal (SR-tal) inom området 85-98, företrädesvis inom området 90-98, bestämt enligt standard ISO 5267-1.

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3. Mald cellulosaiberkomposition enligt något av de föregående patentkraven, varvid nämnda malda cellulosaiberkomposition har ett innehåll av cellulosaiber med en längd >0,2 mm som är minst 20 miljoner fiber per gram baserat på torr vikt.

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4. Mald cellulosaiberkomposition enligt något av de föregående patentkraven, varvid nämnda malda cellulosaiberkomposition har ett kryllvärde som är minst 1,7, företrädesvis minst 1,8, mera föredraget minst 1,9.

25 5. . Mald cellulosaiberkomposition enligt något av de föregående patentkraven, varvid nämnda malda cellulosaiberkomposition har en längdviktad genomsnittlig fibrillytarea hos fiber med en längd >0,2 mm som är minst 17 %, företrädesvis minst 20 %, mera föredraget minst 22 %, bestämd med användning av L & W Fiber Tester Plus.

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6. Mald cellulosaiberkomposition enligt något av de föregående patentkraven, varvid nämnda malda cellulosaiber är malda cellulosaiber från barrved.

7. Förfarande för framställning av en mald cellulosaiberkomposition för användning som ett styrkeförbättringsmedel för papper eller kartong, som innefattar:

- a) att tillhandahålla en fin fiberfraktion erhållen genom storleksfraktionering av en cellulosaibassa i en fin fiberfraktion och en grov fiberfraktion,
- b) att utsätta nämnda fina fiberfraktion för malning vid en massakoncentration inom området 0,5-30 vikt-% till ett Schopper-Riegler-tal (SR-tal) inom området 80-98, bestämt enligt standard ISO 5267-1, för att erhålla den malda cellulosaiberkompositionen, **kännetecknat av** att nämnda malda cellulosaiberkomposition har ett innehåll av cellulosaiber med en längd >0,2 mm, enligt standard ISO 16065-2, som är minst 15 miljoner fiber per gram baserat på torr vikt.

8. Förfarande enligt patentkrav 7, varvid nämnda cellulosaibassa är en barrvedsibassa.

9. Förfarande enligt något av patentkraven 7-8, varvid nämnda cellulosaibassa är en aldrig torkad massa.

10. Förfarande enligt något av patentkraven 7-9, varvid nämnda cellulosaibassa är en omald massa.

11. Förfarande enligt något av patentkraven 7-10, varvid nämnda cellulosaibassa är väsentligen ligninfri, varvid nämnda cellulosaibassa företrädesvis har en ligninhalt under 10 vikt-%, baserat på den totala torrvikten hos massan.

12. Förfarande enligt något av patentkraven 7-11, varvid nämnda cellulosaibassa har en hemicellulosaibalt inom området 10-30 vikt-%, baserat på den totala torrvikten hos massan.

13. Förfarande enligt något av patentkraven 7-12, varvid nämnda fina fiberfraktion behandlas med ett oxidationsmedel före malningen.

14. Förfarande enligt något av patentkraven 7-13, varvid ett ytterligare styrkeförbättrande medel tillsätts till den fina fiberfraktionen före malningen.

15. Förfarande enligt något av patentkraven 7-14, varvid den fina fiberfraktionen
5 i steg a) har ett Schopper-Riegler-tal (SR-tal) som är mindre än 70, företrädesvis mindre än 50, bestämt enligt standard ISO 5267-1.

16. Förfarande enligt något av patentkraven 7-15, varvid nämnda fina fiberfraktion utsätts för malning vid en massakoncentration inom området 1-10
10 vikt-%.

17. Förfarande enligt något av patentkraven 7-16, varvid nämnda fina fiberfraktion utsätts för malning med en total malningsenergi inom området 100-1500 kWh/t, företrädesvis inom området 500-1500 kWh/t, mera föredraget inom
15 området 750-1250 kWh/t.

18. Förfarande enligt något av patentkraven 7-17, varvid nämnda malda cellulosafiberkomposition is steg b) har ett Schopper-Riegler-tal (SR-tal) inom området 85-98, företrädesvis inom området 90-98, bestämt enligt standard ISO
20 5267-1.

19. Förfarande enligt något av patentkraven 7-18, varvid nämnda malda cellulosafiberkomposition har ett innehåll av cellulosafibrer med en längd >0,2 mm som är minst 20 miljoner fibrer per gram baserat på torr vikt.
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20. Förfarande enligt något av patentkraven 7-19, varvid nämnda malda cellulosafiberkomposition har ett kryllvärde som är minst 1,7, företrädesvis minst 1,8, mera föredraget minst 1,9.

30 21. Förfarande enligt något av patentkraven 7-20, varvid nämnda malda cellulosafiberkomposition har en längdviktad genomsnittlig fibrillytarea hos fibrer med en längd >0,2 mm som är minst 17 %, företrädesvis minst 20 %, mera föredraget minst 22 %, bestämd med användning av L & W Fiber Tester Plus.

22. Cellulosamassa för framställning av papper eller kartong, som innefattar minst 0,1 vikt-%, företrädesvis inom området 1-25 vikt-%, mera föredraget inom området 1-10 vikt-%, allra helst inom området 2-7 vikt-%, av den malda
5 cellulosafiberkompositionen enligt något av patentkraven 1-6, eller som erhållits genom förfarandet enligt något av patentkraven 7-21, baserat på torr vikt.

23. Cellulosamassa för framställning av papper eller kartong enligt patentkrav 22, varvid cellulosamassan är en kemi-termomekanisk massa (CTMP).
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24. Papper eller kartong bestående av ett eller flera skikt, varvid åtminstone ett skikt innefattar minst 0,1 vikt-%, företrädesvis inom området 1-25 vikt-%, mera föredraget inom området 1-10 vikt-%, allra helst inom området 2-7 vikt-%, av den malda cellulosafiberkompositionen enligt något av patentkraven 1-6, eller som
15 erhållits genom förfarandet enligt något av patentkraven 7-21, baserat på torr vikt

25. Användning av en mald cellulosafiberkomposition enligt något av patentkraven 1-6, eller som erhållits genom förfarandet enligt något av patentkraven 7-21, för att förbättra z-styrkan och/eller dragstyrkan hos ett papper
20 eller en kartong.