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(54) Soft paper of high strength and method for production thereof.

(57) A paper having an advantageous combination of softness and strength is disclosed, which is based on a mixture of cellulosic pulps and in which

a) 55-90% by weight, of the total amount of cellulose fibres consists of a hardwood pulp, a waste paper pulp or a mechanical or semi-mechanical cellulosic pulp, or a mixture thereof, having a drainage resistance below 25°SR, and

b) 10-45% by weight, of the total amount of cellulose fibres consists of a sulphite pulp and/or sulphate pulp based on softwood and having a drainage resistance exceeding 30°SR.

The paper can be produced by preparing a stock from the cellulosic pulps a) and b) in the above amounts, whereupon the stock is taken up on a wire, and is drained and dried in per se known manner.

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The present invention concerns a soft but also strong paper which is based on a mixture of a hardwood pulp, a waste paper pulp or a mechanical or semi-mechanical cellulosic pulp, or a mixture thereof, and a sulphate pulp and/or sulphite pulp based on softwood; as well as a method for the production thereof.

Usually, it is required that a soft paper, e.g. tissue paper, should be not only soft, but also strong. To achieve a satisfactory compromise between qualitative properties, such as softness and strength, on the one hand, and financial considerations, on the other hand, one has mixed different cellulosic pulps of differing origins and properties when producing soft paper, for example tissue paper. Generally, one main component is long-fibred to impart strength to the paper, while the other main component is short-fibred to give the paper its softness and the desired absorption qualities.

The long-fibred pulp is usually based on softwood, such as pine wood or spruce wood, which has been chemically delignified by a sulphate or sulphite process. The short-fibred pulp is generally based on hardwood, such as birch wood, eucalyptus wood, aspen wood or oak wood, which has been delignified by a sulphate process. At times, the cellulosic raw material may to a certain extent be based also on mechanical and semi-mechanical pulp, such as groundwood pulp, TMP and CTMP pulp and waste paper pulp. The long-fibred pulps, for example chemical pulp from spruce wood or pine wood, has a fibre length of about 3-3.5 mm and a fibre width of about 0.04 mm. A short-fibred pulp based on birch sulphate has an average fibre length of 1.3 mm and a fibre thickness which is about half of that of conifer fibres. The proportion of short fibres, so-called fines, is high. Mechanical, semi-mechanical and waste fibre pulp have a fibre length which usually is shorter than that of chemical pulp from spruce wood or pine wood. The proportion of fines may be high. When producing soft paper, it is desirable that the proportion of fines be kept as low as possible in order to reduce dusting.

To impart suitable paper-forming properties to the pulp, the latter is usually ground, e.g. in a beater or a refiner, which results in a paper of higher tensile strength. The degree of grinding is generally measured as the drainage resistance of the pulp according to Schopper-Riegler (SCAN C 19:65). The ^{0}SR value increases with increasing grinding of the pulp. Already during the production of cellulosic pulp for paper, the pulp usually is refined to 10-20^{0}SR.

When making tissue paper, the different pulps can be refined separately or in mixture. Grinding not only results in a higher tensile strength, but also in a higher tensile stiffness of the paper. Table 1 below illustrates this fact in connection with hand-made sheets of a mixture of 70% birch sulphate and 30% pine sulphate pulp. In TAPPI Journal 66 (2), 1983, pp 97-99, H. Hollmark states that the tensile stiffness of a paper correlates extremely well with softness determined by means of panel tests. The lower the tensile stiffness, the softer the paper, according to the test panel.

US Patent 2,706,155 discloses a method for producing soft paper, the starting material being a mixture of 25-70% oak wood pulp, the remainder being softwood pulp. The oak wood pulp is essentially unground, whereas the softwood pulp is refined. In an example, the softwood sulphate pulp was ground to 500 ml CSF, which corresponds to 25^{0}SR, and was then mixed with equal parts of essentially unrefined oak wood sulphate pulp to achieve the desired combination of tensile strength, tearing strength, softness and absorption qualities of the paper.

Soviet Patent 779,483 discloses the production of a paper from 40-60% bleached softwood sulphate pulp, 30-54% chemically refined aspen wood pulp and 5-15% birch wood sulphate pulp which has been further chemically refined to increase the strength of the paper.

An article in the Soviet periodial Sb. Tr. TsNIIB No. 15: 72-77 (1978) deals with hand-made sheets produced from softwood sulphite pulp, softwood sulphate pulp and hardwood sulphate pulp ground to 13-30^{0}SR, said sheets being tested as to absorption, compressibility, softness, tensile strength, bulk and strain. According to the article, a three-component mixture consisting of 50% softwood sulphate pulp (<25^{0}SR), 30% hardwood sulphate pulp (20-21^{0}SR) and 20% softwood sulphite pulp (20-21^{0}SR) resulted in the tissue paper with the best properties.

Soviet Patent 775,212 states that tissue paper produced from a mixture of softwood sulphate pulp, hardwood sulphate pulp and softwood sulphite pulp ground to 23-25^{0}SR becomes softer if the softwood sulphate pulp has first been ground to 18-20^{0}SR.

SV 1,008,324 discloses the production of typographic paper of good opacity and ink absorbency from a paper-making pulp containing 30-40% by weight of bleached softwood sulphate pulp ground to 50-55^{0}SR and 60-70% by weight of hardwood sulphate pulp ground to 30-35^{0}SR.

One method of imparting increased softness to the paper is to treat the paper or the paper stock with a fibre-fibre-bond-reducing agent, often called debonding agent. A fibre-fibre-bond-reducing agent usually comprises a primary, secondary, tertiary or quaternary ammonium compound containing a hydrocarbon group having 8-30 carbon atoms and, optionally, nonionic hydrophilic chains. It is common to combine the cationic ammonium compound with a nonionic surface-active compound. Such fibre-fibre-bond-reducing agents are inter alia described in US Patent Specifications 3,554,862, 3,554,863 and 4,144,122, as well as in GB Patent Specification 2,121,449. The fibre-fibre-bond-reducing agent markedly reduces the strength of the bonds between the fibres in the paper, while the softness increases. This is apparent from Table 1 bearing upon hand-made sheets from a mixture of 70% birch wood sulphate pulp and 30% pine wood sulphate pulp. US Patent Specification 4,795,530 tries to solve the inconvenience of strength reduction by applying the fibre-fibre-bond-reducing agent only to part of the thickness of the tissue paper, thereby to obtain an untreated part of paper maintaining its original strength. As is apparent from Table 1 below, the changes in tensile stiffness and tensile strength of the paper owing to a conventional increased grinding of a pulp mixture and the addition of a fibre-fibre-bond-reducing agent to the ground fibre mixture cancel each other out. When grinding is increased, the strength and the stiffness increase proportionally. When the amount of fibre-fibre-bond-reducing agent added is increased, the tensile stiffness as well as the tensile strength are proportionally reduced. Thus, the gain in strength is cancelled out by the loss in softness, and vice versa. There is, therefore, a generally expressed desire to improve the softness of a paper while maintaining a satisfactory strength.

It has now suprisingly been found that a paper advantageously combining softness and strength is obtained if based on a mixture of

a) a hardwood pulp, a waste paper pulp or a mechanical or semi-mechanical cellulosic pulp, or a mixture thereof, constituting 55-90% by weight, of the total amount of cellulose fibres and having a drainage resistance below 25^{0}SR, and

b) a sulphate pulp and/or sulphite pulp based on softwood and constituting 10-45% by weight, of the total amount of cellulose fibres and having a drainage resistance exceeding 30^{0}SR. The difference in drainage resistance between the cellulosic pulps b) and a) is preferably at least 10^{0}SR. The paper can be produced by preparing a stock from the above cellulosic pulps a) and b) in the given amounts, whereupon the stock mixture is taken up on a wire, and is drained and dried in per se known manner.

In a preferred embodiment, the soft paper also contains a fibre-fibre-bond-reducing agent in an amount of 0.05-2.5% by weight, as based on the amount of cellulose fibres. As mentioned earlier, a soft paper according to the invention has a surprisingly advantageous ratio of softness to strength. To achieve this effect, the cellulosic pulp b) should be ground to above 30^{0}SR, but preferably not above 80^{0}SR, since pulps of so high grinding degrees require comparatively large amounts of fibre-fibre-bond-reducing agents to give the paper a satisfactory softness. The cellulosic pulp b) preferably has 35-60^{0}SR. The cellulosic pulp a) should be essentially unground or ground to less than 25^{0}SR, preferably less than 20^{0}SR.

Whether the long-fibred pulp b) has been obtained by a sulphate process or by a sulphite process is of no decisive importance. Also, whether it originates from pine wood, spruce wood or another conifer is of no vital importance either. It is, however, desirable that it has been ground in such a manner that the fibres have been shortened as little as possible. The grinding results in a fibre of higher flexibility. To benefit from this increased flexibility of the long-fibred ground cellulosic pulp, there is preferably an addition of a fibre-fibre-bond-reducing agent serving to reduce the increase in strength resulting from the grinding, when the pulp forms a sheet of paper. The agent is added in such a manner as to be able to act on the bonds between the fibres. Preferably, the addition takes place at a stage during the preparation of the stock, but the fibre-fibre-bond-reducing agent may also be added to the cellulosic pulp a) and/or the cellulosic pulp b) or to the wet, formed or dried paper web.

Preparation of Hand-made Sheets and Measuring Techniques

The cellulosic pulps were ground in a beater according to SCAN C 25:67 to the desired drainage resistance determined in a Schopper-Riegler apparatus according to SCAN Standard C 19:65. In those cases when one did not want to noticeably change the drainage resistance of the cellulosic pulp, the latter was wet-defibrated according to SCAN C 18:65.

Before the formation of sheets, the cellulosic pulp, alternatively the mixture of cellulosic pulp, was stirred, optionally in the presence of a fibre-fibre-bond-reducing agent, at a pulp concentration of about 2% by weight for 10 min. In the production of sheets, use was made of tap water of 30^{0}C whose pH had been adjusted to 6-7. The sheets were dried and conditioned according to SCAN P 2:75, whereupon the basis weight of the sheets was determined according to SCAN P 6:63. When measuring tensile strength and tensile stiffness according to SCAN P 44:81, but with 15 mm broad straps, one used a tensile-strength tester of the mark Alwetron TH1, made by Lorentzen & Wettre, Stockholm. The indices of tensile strength and tensile stiffness, respectively, were determined by division by the basis weight of the sheet, in order to eliminate the influence thereof.

Comparison

In the comparative study, pine wood sulphate pulp and birch wood sulphate pulp were mixed. The pulps, ground as below, were mixed in such a manner that 70% by weight consisted of birch wood sulphate pulp and 30% by weight consisted of pine wood sulphate pulp. Hand-made sheets were formed in accordance with the above-described method. The following results were obtained.

Table 1

	Birch wood pulp (°SR)	Pine wood pulp (°SR)	Ten-sile index (Nm/g)	Stiff-ness index (Nm/g)	Strength/ Stiffness *1000
Without debonder	12	12	19.3	2780	6.9
Without debonder	18.5	18.5	35.6	5250	6.8
With, 2 kg ptp*)	18.5	18.5	32.3	4680	6.9
With, 4 kg ptp	18.5	18.5	28.0	3960	7.1
With, 16 kg ptp	18.5	18.5	19.9	2740	7.3
Without debonder	26	26	55.0	7950	6.9
With, 2 kg ptp	26	26	38.3	5600	6.8
With, 4 kg ptp	26	26	30.6	4400	7.0
With, 16 kg ptp	26	26	22.3	3140	7.1

*) ptp = per ton pulp

As is apparent from these results, an increased grinding of a pulp mixture combined with an addition of fibre-fibre-bond-reducing agent to the ground fibre mixture does not noticeably affect the ratio of strength to stiffness (see the last column of the Table). When grinding is increased, the strength as well as the tensile stiffness are proportionally increased. When more of the fibre-fibre-bond-reducing agent is added, the tensile stiffness is reduced proportionally, as is the strength. Thus, the gain in tensile strength is cancelled out by a reduced softness, and vice versa.

Example 1

A long-fibred pine wood sulphate pulp was ground to 13, 16.5, 20, 27 and 45°SR. Then, 30 parts by weight of the long-fibred pulp was mixed with 70 parts by weight of short-fibred wet-defibrated birch wood sulphate pulp, whereupon hand-made sheets were produced. The following results were obtained.

Table 2

	Birch wood pulp (°SR)	Pine wood pulp (°SR)	Ten-sile index (Nm/g)	Stiff-ness index (Nm/g)	Strength/ Stiffness *1000
Without debonder	14	13	15.5	2240	6.9
Without debonder	14	16.5	18.7	2750	6.8
With, 4 kg ptp	14	16.5	12.2	1770	6.9
Without debonder	14	20	21.5	3110	6.9
With, 4 kg ptp	14	20	14.8	2110	7.0
Without debonder	14	27	26.1	3640	7.2
With, 4 kg ptp	14	27	15.3	2120	7.2
Without debonder	14	45	32.8	4050	8.1
With, 4 kg ptp	14	45	16.6	1750	9.5

As is apparent from these results, the ratio strength/stiffness of the paper is roughly constant at a drainage resistance of 13-27°SR of the pine wood pulp, but is considerably improved when pine wood pulp of 45°SR is used.

Further, it can be seen that a stock containing pine wood pulp ground to a drainage resistance of 45°SR and with an addition of a fibre-fibre-bond-reducing agent results in an even better ratio.

Example 2

A pine wood sulphate pulp according to Example 1 and ground as below was mixed with a short-fibred pulp consisting of a wet-defibrated eucalyptus wood sulphate pulp. For the sheet formation, use was made of a pulp mixture of 70% eucalyptus wood sulphate pulp and 30% ground pine wood sulphate pulp. The following results were obtained.

Table 3

	Euca-lyp-tus wood pulp (°SR)	Pine wood pulp (°SR)	Ten-sile index (Nm/g)	Stiff-ness index (Nm/g)	Strength/ Stiffness *1000
Without debonder	16	12	19.0	2740	6.9
Without debonder	16	45	29.6	3620	8.2
With, 4 kg ptp	16	45	18.9	2100	9.0

From the above Table, it can be gathered that the ratio of tensile strength to tensile stiffness is advantageous for the paper according to the invention.

Example 3

A spruce wood sulphite pulp ground as below was mixed with a short-fibred wet-defibrated birch wood sulphate pulp. For the sheet formation, use was made of a pulp mixture of 70% birch wood sulphate pulp and 30% ground spruce wood sulphite pulp. The following results were obtained.

Table 4

	Birch wood pulp (°SR)	Spruce wood pulp (°SR)	Tension index (Nm/g)	Stiffness index (Nm/g)	Strength/Stiffness *1000
Without debonder	13	12	18.0	2790	6.5
Without debonder	13	39	30.9	4510	6.9
With, 4 kg ptp	13	39	15.5	1990	7.8
Without debonder	13	47	33.2	4660	7.1
With, 2 kg ptp	13	47	25.7	3420	7.5
With, 4 kg ptp	13	47	19.9	2520	7.9

From the above Table, it can be gathered that the ratio of tensile strength to tensile stiffness also in this case is advantageous for the paper according to the invention.

Example 4

A long-fibred pine wood sulphate pulp ground as below was mixed with a short-fibred wet-defibrated birch wood sulphate pulp. For the sheet formation, use was made of a pulp mixture of 80% birch wood sulphate pulp and 20% ground pine wood sulphate pulp. The following results were obtained.

Table 5

	Birch wood pulp (°SR)	Pine wood pulp (°SR)	Tensile index (Nm/g)	Stiffness index (Nm/g)	Strength/ Stiffness *1000
Without debonder	14	12	18.1	2830	6.4
Without debonder	14	28	22.3	3410	6.5
With, 4 kg ptp	14	28	11.4	1630	6.7
Without debonder	14	46	27.4	3530	7.8
With, 4 kg ptp	14	46	14.7	2030	7.9

It is apparent from these results that the ratio of tensile strength to tensile stiffness is advantageous when the paper has a composition according to the invention.

Example 5

A pine wood sulphate pulp ground as below was mixed with a short-fibred wet-defibrated birch wood sulphate pulp. For the sheet formation, use was made of a pulp mixture of 60% birch wood sulphate pulp and 40% ground pine wood sulphate pulp. The following results were obtained.

Table 6

	Birch wood pulp (°SR)	Pine wood pulp (°SR)	Tensile index (Nm/g)	Stiffness index (Nm/g)	Strength/ Stiffness *1000
Without debonder	14	12	19.1	2750	6.9
Without debonder	14	28	25.5	3640	7.0
With, 4 kg ptp	14	28	16.7	2350	7.1
Without debonder	14	46	34.5	3970	8.7
With, 4 kg ptp	14	46	24.3	2620	9.3

As is apparent from these results, the ratio of tensile strength to tensile stiffness is advantageous when the paper has a composition according to the invention.

Example 6

A pine wood sulphate pulp ground as below was mixed with a deinked waste-paper-based pulp. The pulp had been produced in a deinking plant, the waste paper consisting of computer printouts, books, brochures and the like. For the sheet formation, use was made of a pulp mixture of 70% waste paper pulp and 30% ground pine wood sulphate pulp. The following results were obtained.

Table 7

	Waste paper pulp (°SR)	Pine wood pulp (°SR)	Tensile index (Nm/g)	Stiffness index (Nm/g)	Strength/ Stiffness *1000
Without debonder	24	12	32.0	4100	7.8
Without debonder	24	45	39.6	4660	8.5
With, 4 kg ptp	24	45	33.8	4020	8.4
With, 8 kg ptp	24	45	32.4	3700	8.8
With, 16 kg ptp	24	45	24.6	2660	9.2

It is apparent from these results that the ratio of tensile strength to tensile stiffness is advantageous when the paper has a composition according to the invention.

Example 7

A pine wood sulphate pulp ground as below was mixed with a wet-defibrated CTMP pulp. For the sheet formation, use was made of a pulp mixture of 70% CTMP and 30% ground pine wood sulphate pulp. The following results were obtained.

Table 8

	CTMP pulp (°SR)	Pine wood pulp (°SR)	Tensile index (Nm/g)	Stiffness index (Nm/g)	Strength/ Stiffness *1000
Without debonder	11	12	18.2	2200	8.3
Without debonder	11	45	31.6	2900	10.9
With, 4 kg ptp	11	45	21.6	2090	10.3
With, 6 kg ptp	11	45	17.5	1650	10.6

It is apparent from these results that the ratio of tensile strength to tensile stiffness is advantageous when the paper has a composition according to the invention.

Claims

1. Paper having an advantageous combination of softness and strength and based on a mixture of cellulosic pulps, **characterised** in that

a) 55-90% by weight, of the total amount of cellulose fibres consists of a hardwood pulp, a waste paper pulp or a mechanical or semi-mechanical cellulosic pulp, or a mixture thereof, having a drainage resistance below 25°SR, and

b) 10-45% by weight, of the total amount of cellulose fibres consists of a sulphite pulp and/or sulphate pulp based on softwood and having a drainage resistance exceeding 30°SR.

2. Paper as claimed in claim 1, **characterised** in that the cellulosic pulp b) has a drainage resistance not exceeding 80°SR.

3. Paper as claimed in claim 1 or 2, **characterised** in that the cellulosic pulp b) has a drainage resistance of 35-60°SR.

4. Paper as claimed in any one of claims 1-3, **characterised** in that the cellulosic pulp a) has a drainage resistance below 20°SR.

5. Paper as claimed in any one of claims 1-4, **characterised** in that it contains a fibre-fibre-bond-reducing agent.

6. Paper as claimed in claim 5, **characterised** in that the fibre-fibre-bond-reducing agent contains a compound with ammonium ions.

7. Paper as claimed in claim 5 or 6, **characterised** in that it contains 0.05-2.5% by weight of said fibre-fibre-bond-reducing agent.

8. Method of producing paper according to any one of claims 1-7**, characterised** in that a stock is prepared from

a) a hardwood pulp, a waste paper pulp or a mechanical or semi-mechanical cellulosic pulp, or a mixture thereof, having a drainage resistance below 25°SR, and is mixed with

b) a sulphite pulp and/or sulphate pulp based on softwood and having a drainage resistance exceeding 30°SR, the cellulosic pulp a) constituting 55-90% by weight of the total amount of cellulose fibres, and the cellulosic pulp b) constituting 10-45% by weight of the total amount of cellulose fibres, whereupon the stock mixture is taken up on a wire, and is drained and dried in per se known manner.

9. Method as claimed in claim 8, **characterised** in that the cellulosic pulp a) has a drainage resistance below 20°SR, and that the cellulosic pulp b) has a drainage resistance of 35-60°SR.

10. Method as claimed in claim 8 or 9, **characterised** by the addition, at some stage, of a fibre-fibre-bond-reducing agent preferably containing a compound with ammonium ions and preferably being present in an amount of 0.05-2.5% by weight, as based on the amount of cellulose fibres.

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 91202328.0

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.⁵)
A,D	Derwent's abstract No. 84-41023/07 SU 1008324, publ. week 8407 ---	1-10	D 21 H 11/00, 11/10
A,D	US-A-2 706 155 (FRANKLINE) *Claim 1-2* ---	1-10	
A,D	Dialog Information Services, File 351, WPI 81-91, Dialog accession no. 2696010, (PAPER RES INST. et al), SU 779483, A, 801117, 8131 (Basic) -----	1-10	

TECHNICAL FIELDS SEARCHED (Int Cl.⁵)

D 21 H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	04-12-1991	NILSSON B.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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