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(54) **METHOD OF PRODUCING KRAFT PAPER AND KRAFT PAPER**

(57) There is provided a method of producing a kraft paper having a density measured according to ISO 534:2011 of 630-870 kg/m³ and a strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of 1.0-8.9 %, comprising a step of calen-

dering a paper web at a dry content of 55-79 %, wherein the line load of the calendering step is 8-90 kN/m, such as 10-70 kN/m, such as 12-50 kN/m, such as 15-40 kN/m. Further. A method of producing a porous sack paper as well as a new kraft paper qualities are also provided.

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Description**TECHNICAL FIELD**

5 **[0001]** The present disclosure relates to the production of kraft papers as well as new kraft paper qualities.

BACKGROUND

10 **[0002]** For many kraft paper applications, a smooth surface is desired, e.g. to improve printing quality. Calendering is frequently used for the purpose of obtaining such a smooth surface. Traditionally, calenders have been located at the end of the papermaking process (on-line). Paper has also been calendered separately (off-line) downstream the paper-making process.

15 **[0003]** The above-mentioned on-line and off-line calendering reduces the thickness of the paper. This generally considered a disadvantage for products that require a high bending stiffness since bending stiffness, as is well known, is strongly dependent on the thickness.

[0004] Extended soft nip calenders, such as belt calenders or shoe calenders, have been developed to limit the thickness reduction caused by calendering.

SUMMARY

20 **[0005]** The present inventor found that if a paper web is gently calendered in a moist state (i.e. before drying has been completed), surface properties of the resulting paper are significantly improved and the thickness is reduced but, unlike conventional calendering, the bending stiffness (measured as bending resistance) is not decreased. In many cases, the bending resistance is even increased in both directions of the paper.

25 **[0006]** There is thus provided a method of producing a kraft paper, comprising a step of calendering a paper web at a dry content of 55-79 %, wherein the line load of the calendering step is 8-90 kN/m, such as 10-70 kN/m, such as 12-50 kN/m, such as 15-40 kN/m. The kraft paper has a strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of 1.0-8.9 %. The density measured according to ISO 534:2011 of the kraft paper is preferably 630-870 kg/m³.

30 **[0007]** There is also provided a method of producing a porous sack paper having a Gurley value according to ISO 5636-5:2013 of less than 15 s, comprising the steps of compacting a paper web in a Clupak unit and calendering the paper web at a dry content of 55-79 %, wherein the line load of the calendering step is 8-90 kN/m, such as 10-70 kN/m, such as 12-50 kN/m, such as 15-40 kN/m. In the broadest embodiment of the porous sack paper, there is thus no limitation regarding the strain at break in the MD. Instead, there is a limitation regarding the Gurley value.

35 **[0008]** The present disclosure enables the production of new paper qualities.

[0009] Accordingly, there is provided a single-layer kraft paper having:

- a density measured according to ISO 534:2011 of 720-850 kg/m³;
- a strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of 1.0-2.9 %, such as 1.9-2.5 %; and
- a bending resistance index measured according to ISO 2493-1:2010 in the MD of 190-250 Nm⁶/kg³, such as 200-240 Nm⁶/kg³,

45 wherein at least one side of the kraft paper has a Bendtsen roughness measured according to ISO 8791-2 of 300-700 ml/min.

[0010] There is also provided a single-layer kraft paper having:

- a density measured according to ISO 534:2011 of 735-835 kg/m³;
- a strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of 3.0-4.5 %, such as 3.5-4.5 %; and
- a bending resistance index measured according to ISO 2493-1:2010 in the MD of 118-158 Nm⁶/kg³, such as 118-148 Nm⁶/kg³,

55 wherein at least one side of the kraft paper has a Bendtsen roughness measured according to ISO 8791-2 of 250-700 ml/min, such as 300-700 ml/min.

DESCRIPTION

[0011] According to a first aspect of the present disclosure, there is provided a method of producing a kraft paper having a strain at break in the machine direction (MD) of 1.0-8.9 %. In the present disclosure, the strain at break values are measured according to the standard SS-ISO 1924-3:2011

[0012] The density of the kraft paper is preferably 630-870 kg/m³. In embodiments of the first aspect, it is 690-850 kg/m³, such as 700- 830 kg/m³, such as 730-830 kg/m³. In the present disclosure, density is measured according to ISO 534:2011.

[0013] The grammage of the kraft paper may be 50-140 g/m². Preferably, it is 60-125 g/m².

[0014] In a particularly preferred embodiment, the grammage is 70-90 g/m², such as 75-85 g/m², when the strain at break in the MD is 1.0-2.9 % (see the third aspect discussed below). In the present disclosure, grammage is measured according to ISO 536:2012.

[0015] In another particularly preferred embodiment, the grammage is 95-130 g/m², such as 100-125 g/m², when the strain at break in the MD is 3.0-4.5 % (see the fourth aspect discussed below)

[0016] The method of the first aspect comprises a step of calendering a paper web at a dry content of 55-79 %, wherein the line load of the calendering step is 8-90 kN/m. A preferred dry content in the calendering step is 55-75 %. The line load is preferably 10-70 kN/m, such as 12-50 kN/m. In a particularly preferred embodiment, it is 15-40 kN/m. Benefits of line loads of ≤ 40 kN/m are shown in the examples section below.

[0017] This type of "wet" calendering, which uses a relatively low line load, surprisingly improves surface properties without decreasing the bending stiffness in the machine direction (MD). It may even improve the bending stiffness, in particular in the MD, even though it decreases the thickness of the paper. This is further discussed above in the summary section and shown below in the examples section.

[0018] The improved surface properties may be represented by relatively low Bendtsen roughness values. As an example, the Bendtsen roughness of at least one side of the kraft paper of the first aspect may be in the range of 300-700 ml/min. In the present disclosure, Bendtsen roughness is measured according to ISO 8791-2.

[0019] When the strain at break in a direction of the paper increases, the bending resistance the same direction typically decreases. Therefore, it may be preferred to avoid too high strain at break values when stiffness is a desired property. Accordingly, the strain at break in the MD of the kraft paper of the first aspect may be kept within the range of 1.0-6.0 %.

[0020] In embodiments of the first aspect wherein the strain at break in the machine direction (MD) of the kraft paper is 1.0-2.9 %, the bending resistance index in the MD of the kraft paper may be 190-250 Nm⁶/kg³ (see the third aspect discussed below).

[0021] In embodiments of the first aspect wherein the paper web is compacted in a Clupak unit, the strain at break values in the MD of the kraft paper are typically higher, i.e. 3.0-8.9 % and preferably 3.0-6.0 %. In such embodiments, the bending resistance index in the MD of the kraft paper may be 90-120 Nm⁶/kg³, such as 95-115 Nm⁶/kg³ (see the fourth aspect discussed below).

[0022] In the present disclosure, bending resistance is measured according to ISO 2493-1:2010. In this method, a bending angle of 15° and a test span length of 10 mm are used. To obtain the bending resistance index, the bending resistance is divided by the cube of the grammage.

[0023] The calender used for the calendering of the first aspect is preferably a soft nip calender, i.e. a calender in which a nip is formed between a roll with a hard surface, such as a metal surface, and a roll with a soft surface, such as a polymer-covered roll.

[0024] When a Clupak unit is used in the method of the first aspect, the paper web is preferably compacted in the Clupak unit before the step of calendering. As well known to the skilled person, a Clupak unit micro-crepes the paper web (compacts the paper web in the machine direction) such that the strain at break values increases in the MD.

[0025] The calender for the calendering step of the first aspect is preferably arranged in a drying section of a paper machine. In such a drying section, the paper web is thus dried before and after the calendering step.

[0026] The kraft paper of the first aspect is preferably a single-layer kraft paper. A paper produced using two or more headboxes is not a "single-layer" paper according to the present disclosure. Nor is a laminate a "single-layer" paper according to the present disclosure.

[0027] Also for a porous sack paper, the combination of a relatively high stiffness and a relatively fine surface is of interest. As an example, high stiffness is often beneficial when the sack paper is converted to sacks and a finer surface improves the quality of a print on the sack paper. As a second aspect of the present disclosure, there is thus provided a method of producing a sack paper. The sack paper of the second aspect is relatively porous in the sense that it has a Gurley value of less than 15 s. A typical lower limit for the Gurley value is 2 s or 3 s. The skilled person is knows how to produce sack paper of such Gurley values (see e.g. WO 99/02772, which i.a. teaches to carry our HC refining, reduce the degree of LC refining (or even omit LC refining) and increase the dosing of strengthening agent). In the present disclosure, the Gurley value is measured according to ISO 5636-5:2013.

[0028] The improved surface properties may be represented by relatively low Bendtsen roughness values. As an

example, the Bendtsen roughness of at least one side of the sack paper of the second aspect may be in the range of 300-700 ml/min.

[0029] The method of the second aspect comprises the steps of compacting a paper web in a Clupak unit and calendering the paper web at a dry content of 55-79 %, wherein the line load of the calendering step is 8-90 kN/m. A preferred dry content and preferred line loads are discussed above in connection with the first aspect.

[0030] The density of the sack paper is typically 670-800 kg/m³, such as 680- 750 kg/m³. The grammage of the sack paper may be 50-140 g/m². Preferably, the grammage is 60-120 g/m², such as 65-100g/m².

[0031] For sack papers, higher strain at break values are particularly preferred as they correspond to higher TEA values (and TEA is generally considered to be the value that best represents the relevant strength of the paper sack wall, which is supported by the correlation between TEA and drop test results). Accordingly, the strain at break in the MD of the sack paper may be 5.0-15.0 %. As well known to the skilled person, such strain at break values may be obtained if a Clupak unit is used in the production.

[0032] To provide strength, the sack paper of the second aspect is preferably a kraft paper.

[0033] As discussed above in connection with the first aspect, reduced stiffness is however often a side effect of increased strain at break values. Accordingly, a preferred sack paper produced according to the second aspect has a MD strain at break value in the range of 5.0-7.0 %, such as 5.0-6.5 %, and a bending resistance index in the MD of 86-108 Nm⁶/kg³.

[0034] The calender used for the calendering of the second aspect is preferably a soft nip calender (further discussed above in connection with the first aspect).

[0035] In the method of the second aspect, the paper web is preferably compacted in the Clupak unit before the step of calendering.

[0036] The calender for the calendering step of the second aspect is preferably arranged in a drying section of a paper machine. In such a drying section, the paper web is thus dried before and after the calendering step.

[0037] As understood by the skilled person, the methods of the first and the second aspect are carried out in a paper machine comprising a forming section (e.g. a wire section), a press section and a drying section. The paper web is thus formed in the forming section, dewatered in the press section and dried in the drying section to produce the kraft paper (first aspect) or porous sack paper (second aspect).

[0038] The present disclosure enables the production of a new kraft paper quality, which is particularly suited for packages for flour and sugar, especially the smaller packages of 0.5-2.5 kg found in grocery stores. This paper, which is provided as a third aspect of the present disclosure, is a single-layer kraft paper that has:

- a density of 720-850 kg/m³;
- a strain at break in the machine direction (MD) of 1.0-2.9 %, such as 1.9-2.5 %; and
- a bending resistance index in the MD of 190-250 Nm⁶/kg³, such as 200-240 Nm⁶/kg³,

wherein at least one side of the single-layer kraft paper has a Bendtsen roughness of 300-700 ml/min.

[0039] The density of the kraft paper of the third aspect is preferably 730-830 kg/m³, such as 750-830 kg/m³. The grammage of the kraft paper of the third aspect is preferably 50-140 g/m², such as 60-120 g/m², such as 65-100g/m², such as 70-90 g/m². In a particularly preferred embodiment, the grammage is 75-85 g/m².

[0040] The strain at break in the cross direction (CD) of the kraft paper of the third aspect may be 6.0-10.0 %, such as 7.0-9.0 %. Such a relatively high CD stretchability is beneficial as it results in high TEA values, which are beneficial in flour and sugar packages (to prevent package rupture).

[0041] The geometric tensile energy absorption (TEA) index of the kraft paper of the third aspect may for example be 1.9-2.2 J/g. In the present disclosure, the TEA values are measured according to the standard SS-ISO 1924-3:2011. To obtain the TEA index, the TEA value is divided by the grammage.

[0042] The geometric TEA index is calculated as the square root of the product of the TEA index in MD and CD:

$$\text{geometric TEA index} = \sqrt{(\text{TEA index (MD)} * \text{TEA index (CD)})}$$

[0043] The bending resistance index in the CD of the kraft paper of the third aspect may be 70-110 Nm⁶/kg³, such as 80-100 Nm⁶/kg³.

[0044] The Gurley value of the kraft paper of the third aspect is preferably 25-60 s, such as 25-45 s. Such Gurley values are beneficial during filling of the flour or sugar packages.

[0045] There is also provided a use of the kraft paper of the third aspect for forming a package for flour or sugar. Similarly, there is provided a method of forming a package for flour or sugar comprising the step of converting a paper of the third aspect into the package. The method may further comprise the step of filling the package with sugar or flour or another powdered food and optionally sealing the package after filling. This does not exclude other uses of the paper

of the third aspect.

[0046] The present disclosure enables the production of another new kraft paper quality, which is particularly suited for sacks for flour and sugar, especially the larger sacks of 10-20 kg that are delivered e.g. to bakeries. This paper, which is provided as a fourth aspect of the present disclosure, is a single-layer kraft paper that has:

- a density of 735-835 kg/m³;
- a strain at break in the machine direction (MD) of 3.0-4.5 %, such as 3.5-4.5 %; and
- a bending resistance index in the MD of 118-158 Nm⁶/kg³, such as 118-148 Nm⁶/kg³, such as 118-138 Nm⁶/kg³,

wherein at least one side of the kraft paper has a Bendtsen roughness measured according to ISO 8791-2 of 250-700 ml/min, such as 300-700 ml/min.

[0047] The density of the kraft paper of the fourth aspect is preferably 750-830 kg/m³, such as 750-820 kg/m³.

[0048] The grammage of the kraft paper of the fourth aspect may be 50-140 g/m², such as 80-130 g/m². To provide enough strength for the above-mentioned sack for flour or sugar, the grammage is preferably 95-130g/m². In a particularly preferred embodiment, the grammage is 100-125 g/m².

[0049] The strain at break in the cross direction (CD) of the kraft paper is of the fourth aspect may be 6.0-10.0 %, such as 7.0-9.0 %. Such a relatively high CD stretchability is beneficial as it results in high TEA values, which are beneficial in flour and sugar sacks (to prevent sack rupture).

[0050] The geometric tensile energy absorption (TEA) index of the kraft paper of the fourth aspect may for example be 2.4-2.8 J/g.

[0051] The Gurley value of the kraft paper of the fourth aspect is preferably 18-60 s, such as 20-40 s.

[0052] There is also provided a use of the kraft paper of the fourth aspect for forming a sack for flour or sugar. Similarly, there is provided a method of forming a sack for flour or sugar comprising the step of converting a paper of the fourth aspect into the sack. The method may further comprise the step of filling the sack with sugar or flour or another powdered food and optionally sealing the sack after filling. This does not exclude other uses of the paper of the fourth aspect.

[0053] All papers of the present disclosure are preferably bleached, which typically means a brightness of at least 78 % or at least 80 % according to ISO 2470-1:2016. Preferably, a brightness of a bleached paper of the present disclosure is at least 81 %, such as 81-89 % (ISO 2470-1:2016).

[0054] To provide high tensile strength (which contributes to high TEA), the starting material used for preparing the pulp that is used for forming the papers of the present disclosure preferably comprises softwood (which has long fibers and forms a strong paper). Accordingly, the papers of the present disclosure are preferably formed from a paper pulp comprising at least 50 % softwood pulp, such as at least 70 % softwood pulp. In some embodiments, at least 80 %, such as at least 90 %, is softwood pulp. In other embodiments, up to 30 %, such as 10-25 %, is hardwood pulp to improve formation and surface properties. The percentages are based on the dry weight of the pulp.

[0055] Preferably, only virgin pulp is used for forming the papers of the present disclosure.

EXAMPLES

Example 1

[0056] Full-scale trials were carried out to produce white stretchable papers on a paper machine that is also used for producing sack paper. Both wet-calendered paper and non-calendered (reference) paper was produced.

[0057] The production is described below.

[0058] A bleached softwood sulphate pulp was provided. The pulp was subjected to high consistency (HC) refining (180 kWh per ton paper) at a consistency of about 39 % and low consistency (LC) refining (65 kWh per ton paper) at a consistency of about 4.3 %. Cationic starch (7 kg per ton paper), rosin size (2.4 kg per ton paper) and alum (3.5 kg per ton paper) were added to the pulp. In the headbox, the pH of the pulp/furnish was about 5.8 and the consistency of the pulp/furnish was about 0.3 %. A paper web was formed on a wire section. The dry content of the paper web leaving the wire section was about 19 %. The paper web was dewatered in a press section having two nips to obtain a dry content of about 38 %. The dewatered paper web was then dried in a subsequent drying section having nine dryer groups, including one Clupak unit, arranged in series. In this context, the Clupak unit was thus considered to be a "dryer group". The Clupak unit was arranged as dryer group seven, which means that the paper web was dried in the drying section both before and after being compacted in the Clupak unit.

[0059] When entering the Clupak unit, the moisture content of the paper web was 40 %. The hydraulic cylinder pressure exerted on the nip bar was set to 30 bar, resulting in a line load of 33 kN/m. The hydraulic cylinder pressure stretching the rubber belt was set to 31 bar, resulting in a belt tension of 7 kN/m. To reduce the friction between the paper web and the steel cylinder in the Clupak unit, a release liquid (1.5 % polyethylene glycol) was added in an amount of 250 litre/hour. The speed of the paper web in dryer group eight, which was the dryer group arranged directly downstream

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the Clupak unit, was 11 % lower than the speed of the paper web entering the Clupak unit.

[0060] A downstream portion of dryer group eight was rebuilt to comprise a soft calender nip (i.e. a nip between a roll having a hard (steel) surface and a roll having a soft (rubber) surface). The paper web was thus slightly dried between the Clupak unit and the soft calender nip, such that the web of the paper was subjected to calendaring at a moisture content of 35 %. The line load was varied (see table 1). The temperature of the steel roll of the soft calender nip was about 100 °C. The reference paper was not subjected to calendaring.

[0061] The properties of the papers produced in the trials are presented in table 1 below.

Table 1. Paper properties of wet-calendered paper and non-calendered paper. The sample taken "After jumbo roll and winding" was obtained from the top (i.e. an outer layer) of a customer roll.

Trial	Wet-calendered paper	Wet-calendered paper	Wet-calendered paper	Wet-calendered paper	Non-calendered (reference) paper
Sample taken	After jumbo roll and winding	Top of jumbo roll			
Wet calendaring line load (kN/m)	30	30	40	50	0
Grammage (g/m ²)	150	150	150	150	150
Thickness (μm)	175	178	176	175	200
Density (kg/m ³)	861	859	867	870	765
Stretchability MD (%)	14.8	14.7	14.3	15.0	14.6
Stretchability CD (%)	9.6	10.0	9.7	9.8	9.9
TEA index MD/CD (J/g)	6.8/3.0	6.7/3.2	6.3/3.2	6.6/3.2	6.6/3.2
Burst index (mN/kg)	5.0	5.0	5.3	5.2	4.8
Bending resistance MD (mN)	180	190	175	169	165
Bending resistance CD (mN)	194	191	193	155	169
Bending resistance index MD (Nm ⁶ /kg ³)	53.3	56.3	51.9	50.1	48.9
Bending resistance index CD (Nm ⁶ /kg ³)	57.5	56.6	57.2	45.9	50.1
Gurley value (s)	82	86	92	103	57
Bendtsen roughness, SS* (ml/min)	738	747	806	749	1451
Bendtsen roughness, RS** (ml/min)	1492	1793	1728	1688	3541
* Steel side in calender, ** Rubber side in calender					

[0062] Table 1 shows that the method of Example 1 falls outside the scope of the present invention due to high stretchability and high Gurley values. Table 1 still demonstrates, however, that wet-calendering significantly improves surface properties. In particular, the side of the paper contacting the (hard) steel roll in the wet calendaring step obtained a fine surface (low Bendtsen roughness) independently of the line load. Surprisingly, it can thus be concluded that it was not necessary to use high line loads to obtain a significantly reduced Bendtsen roughness. More surprisingly, it was found that the wet calendaring generally did not decrease the stiffness (measured as the bending resistance index) of the paper. Instead, the bending resistance index in the MD was increased for all line loads tested despite that the

thickness was reduced by the wet calendering. The lower line loads (≤ 40 kN/m) even increased the bending resistance in both the MD and the CD.

[0063] Table 1 also illustrates that the winding of the paper to a jumbo roll and the subsequent winding to a customer roll improve the surface properties. The properties of the paper samples taken from the top of the jumbo roll are not a fair representation of the paper that is shipped to the customer. However, the effects seen by comparing paper samples taken from the same position are still valid.

Example 2

[0064] Full-scale trials were carried out to produce white papers on a paper machine that is also used for producing sack paper. Two wet-calendered papers (trials 2 and 5), one final-calendered paper (trial 1) and two non-calendered papers (trials 3 and 4) paper were produced.

[0065] The production is described below.

Example 2 - trials 1-3

[0066] A bleached softwood kraft pulp (100% virgin fibres) was provided. The pulp was subjected to high consistency (HC) refining (159 kWh per ton paper) at a consistency of about 35 % and low consistency (LC) refining (84 kWh per ton paper) at a consistency of about 4 %. Cationic starch (7.1 kg per ton paper), rosin size (2 kg per ton paper) and alum (2.9 kg per ton paper) were added to the pulp. In the headbox, the pH of the pulp/furnish was about 5 and the consistency of the pulp/furnish was about 0.25 %. A paper web was formed on a wire section. The dry content of the paper web leaving the wire section was about 18 %. The paper web was dewatered in a press section to obtain a dry content of about 42 %.

[0067] The dewatered paper web was then dried in a subsequent drying section having 8 dryer groups, including one Clupak unit, arranged in series. In this context, the Clupak unit was thus considered to be a "dryer group". The Clupak unit was arranged as dryer group 5, which means that the paper web was dried in the drying section both before and after the Clupak unit.

[0068] In trials 1-3, the Clupak unit was not operating and the paper web passed it without being compacted. In trials 4 and 5, the paper was however compacted in the Clupak unit (described below).

[0069] A soft nip calender was arranged between the Clupak unit and the following dryer group (the steel roll of the soft nip calender faced the wire side of the paper web). The temperature of the steel roll of the soft calender nip was about 50°C. In trial 2, the paper web was subjected to calendering in the soft nip calender at a dry content of about 65%. The pressure of the soft nip calender was set to 2.6 bar, corresponding to a line load of 15 kN/m. In trials 1 and 3, the soft nip calender was not operating and the paper web passed it without being calendered.

[0070] After the soft nip calender, the paper was further dried in dryer groups 6-8 to obtain a moisture content of 7.5 %.

[0071] A soft nip calender was arranged after the last dryer group (the steel roll faced the wire side of the paper web). The temperature of the steel roll of this soft calender nip was about 100 °C. In trial 1, the paper web was subjected to final calendering in this soft nip calender at a line load of 100 kN/m. In trials 2 and 3, the final soft nip calender was not operating and the paper web passed it without being calendered.

Example 2 - trials 4 and 5

[0072] A bleached softwood kraft pulp (100% virgin fibres) was provided. The pulp was subjected to high consistency (HC) refining (284 kWh per ton paper) at a consistency of about 35 % and low consistency (LC) refining (93 kWh per ton paper) at a consistency of about 4 %. Cationic starch (8.6 kg per ton paper), rosin size (3.7 kg per ton paper) and alum (4.9 kg per ton paper) were added to the pulp. In the headbox, the pH of the pulp/furnish was about 5 and the consistency of the pulp/furnish was about 0.25 %. A paper web was formed on a wire section. The dry content of the paper web leaving the wire section was about 18 %. The paper web was dewatered in a press section to obtain a dry content of about 42 %.

[0073] The dewatered paper web was then dried in a subsequent drying section having 8 dryer groups, including one Clupak unit, arranged in series. In this context, the Clupak unit was thus considered to be a "dryer group". The Clupak unit was arranged as dryer group 5, which means that the paper web was dried in the drying section both before and after the Clupak unit.

[0074] In trials 4 and 5, the paper was compacted in the Clupak unit.

[0075] A soft nip calender was arranged between the Clupak unit and the following dryer group (the steel roll of the soft nip calender faced the wire side of the paper web). The temperature of the steel roll of the soft calender nip was about 50 °C. In trial 5, the paper web was subjected to calendering in the soft nip calender at a dry content of 65%. The pressure of the soft nip calender was set to 2.6 bar, corresponding to a line load of 15 kN/m. In trial 4, the soft nip calender

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was not operating and the paper web passed it without being calendered.

[0076] After the soft nip calender, the paper was further dried in dryer groups 6-8 to obtain a moisture content of 7.5%.

[0077] A soft nip calender was arranged after the last dryer group (the steel roll faced the wire side of the paper web). In trials 4 and 5, the final soft nip calender was however not operating and the paper web passed it without being calendered.

[0078] The properties of the papers produced in the trials 1-5 of Example 2 are presented in table 2 below.

Table 2. "BR" means bending resistance. "BRI" means bending resistance index. "B. roug." means Bendtsen roughness. "TS" means top side. "WS" means wire side.

Trial	1	2 (inventive)	3	4	5 (inventive)
Clupak operating (yes/no)	No	no	no	yes	yes
Calendering	Final	wet	no	no	wet
Grammage (g/m ²)	80.53	79.33	78.27	79.98	79.80
Thickness (μm)	93.62	102.07	112.85	109.88	101.51
Density (kg/m ³)	860.18	777.21	693.58	727.88	786.13
Stretchability MD (%)	2.10	2.25	2.29	6.50	4.90
Stretchability CD (%)	7.38	7.40	10.90	9.45	7.58
TEA index MD/CD (J/g)	1.45/3.05	1.54/2.88	1.63/3.68	2.50/3.00	2.38/2.69
TEA index geomet. (J/g)	2.10	2.11	2.45	2.74	2.53
Burst index (mN/kg)	5.0	5.5	4.9	6.8	6.7
BRMD (mN)	85	111	102	44	53
BR CD (mN)	43	44	38	36	36
BRI MD (Nm ⁶ /kg ³)	162.8	222.3	212.7	86.0	104.3
BRI CD (Nm ⁶ /kg ³)	57.5	56.6	57.2	45.9	50.1
Gurley (s)	52.69	39.16	49.38	23.75	25.64
B. roug. TS (ml/min)	264	554	1376	1226	473
B. roug. WS (ml/min)	203	483	1007	706	401

[0079] Table 2 shows that wet-calendering significantly improves surface properties (compare trial 2 to trial 3 and trial 5 to trial 4). The line load of the "wet" calendering can be increased to e.g. 30 or 40 kN/m to further improve the Bendtsen roughness values, in particular those of trial 2. Further, table 2 confirms that that wet calendering generally does not decrease the stiffness (measured as the bending resistance index) of the paper despite a reduction of the thickness (compare trial 2 to trial 3 and trial 5 to trial 4). Instead, the bending resistance index in the MD was increased for both the Clupak-compacted and the non-compacted paper. For the non-compacted paper, the bending resistance index was increased also in the CD (compare trial 2 to trial 3).

[0080] By decreasing the compacting of the paper of trial 5 in the Clupak, an MD stretchability in the range of 3.0-4.5 % can be obtained. It is expected that such a decrease of the MD stretchability will increase the bending resistance index in the MD to a value in the range of 118-158 Nm⁶/kg³.

[0081] Based on the data in tables 1 and 2, it is expected that a wet-calendered paper will have significantly better surface properties than a final-calendered paper of the same bending resistance index. Consequently, the present disclosure i.a. facilitates production of paper with significantly improved surface properties without sacrificing any stiffness.

Claims

- 5 1. A method of producing a kraft paper having a density measured according to ISO 534:2011 of 630-870 kg/m³ and a strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of 1.0-8.9 %, comprising a step of calendering a paper web at a dry content of 55-79 %, wherein the line load of the calendering step is 8-90 kN/m, such as 10-70 kN/m, such as 12-50 kN/m, such as 15-40 kN/m.
- 10 2. The method according to claim 1, wherein the density measured according to ISO 534:2011 of the kraft paper is 690-850 kg/m³, such as 700-830 kg/m³, such as 730-830 kg/m³.
- 15 3. The method according to claim 1 or 2, wherein the strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of the kraft paper is 1.0-2.9 % and the bending resistance index in the MD of the kraft paper measured according to ISO 2493-1:2010 is 190-250 Nm⁶/kg³.
- 20 4. The method according to claim 1 or 2, wherein the paper web is compacted in a Clupak unit, the strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of the kraft paper is 3.0-8.9 %, such as 3.0-6.0 %, and the bending resistance index measured according to ISO 2493-1:2010 in the MD of the kraft paper is 90-120 Nm⁶/kg³, such as 95-115 Nm⁶/kg³.
- 25 5. A method of producing a sack paper having a Gurley value according to ISO 5636-5:2013 of 2-15 s, comprising the steps of compacting a paper web in a Clupak unit and calendering the paper web at a dry content of 55-79 %, wherein the line load of the calendering step is 8-90 kN/m, such as 10-70 kN/m, such as 12-50 kN/m, such as 15-40 kN/m.
- 30 6. The method according to claim 4 or 5, wherein the paper web is compacted in the Clupak unit before the step of calendering.
7. The method according to any one of the preceding claims, wherein the dry content in the calendering step is 55-75 %.
- 35 8. The method according to any one of the preceding claims, wherein the step of calendering is carried out in a drying section of a paper machine, in which drying section the paper web is dried before and after the calendering step.
9. The method according to any one of the preceding claims, wherein a soft nip calender is used for the calendering step.
- 40 10. The method according to any one of the preceding claims, wherein the Bendtsen roughness measured according to ISO 8791-2 of at least one side of the kraft or sack paper is 300-700 ml/min.
- 45 11. A single-layer kraft paper having:
 - a density measured according to ISO 534:2011 of 720-850 kg/m³;
 - a strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of 1.0-2.9 %; and
 - a bending resistance index measured according to ISO 2493-1:2010 in the MD of 190-250 Nm⁶/kg³, such as 200-240 Nm⁶/kg³,wherein at least one side of the kraft paper has a Bendtsen roughness measured according to ISO 8791-2 of 300-700 ml/min.
- 50 12. The kraft paper according to claim 11, wherein the density measured according to ISO 534:2011 is 730-830 kg/m³, such as 750-830 kg/m³.
- 55 13. The kraft paper according to claim 11 or 12, wherein the grammage measured according to ISO 536:2012 is 65-100g/m², preferably 70-90 g/m², more preferably 75-85 g/m².
14. A single-layer kraft paper having:
 - a density measured according to ISO 534:2011 of 735-835 kg/m³;
 - a strain at break measured according to SS-ISO 1924-3:2011 in the machine direction (MD) of 3.0-4.5 %, such as 3.5-4.5 %; and

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- a bending resistance index measured according to ISO 2493-1:2010 in the MD of 118-158 Nm⁶/kg³,

wherein at least one side of the kraft paper has a Bendtsen roughness measured according to ISO 8791-2 of 250-700 ml/min.

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- 15.** The kraft paper according to claim 14, wherein the grammage measured according to ISO 536:2012 is 50-140 g/m², such as 80-130 g/m², such as 95-130g/m², such as 100-125 g/m².

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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 168 362 A1 (BILLERUDKORSNÄS AB [SE]) 17 May 2017 (2017-05-17) * paragraphs [0011] - [0055] * -----	11-15	INV. D21F11/00 D21H27/10 D21G1/00
A	EP 2 186 939 A2 (VOITH PATENT GMBH [DE]) 19 May 2010 (2010-05-19) * paragraphs [0001] - [0048] * -----	1,5,11, 14	
A	DE 10 2010 029580 A1 (VOITH PATENT GMBH [DE]) 1 December 2011 (2011-12-01) * paragraphs [0006] - [0022] * -----	1,5,11, 14	
			TECHNICAL FIELDS SEARCHED (IPC)
			D21F D21H D21G
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 November 2018	Examiner Maisonnier, Claire
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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06-11-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3168362 A1	17-05-2017	CN 108350664 A	31-07-2018
		EP 3168362 A1	17-05-2017
		ES 2666830 T3	08-05-2018
		WO 2017080910 A1	18-05-2017
EP 2186939 A2	19-05-2010	DE 102008043727 A1	20-05-2010
		EP 2186939 A2	19-05-2010
DE 102010029580 A1	01-12-2011	CN 103097608 A	08-05-2013
		DE 102010029580 A1	01-12-2011
		EP 2576895 A2	10-04-2013
		WO 2011151239 A2	08-12-2011

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 9902772 A [0027]