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(54) **Title:** PRODUCTION OF PAPER THAT IS HIGHLY STRETCHABLE IN THE CROSS DIRECTION

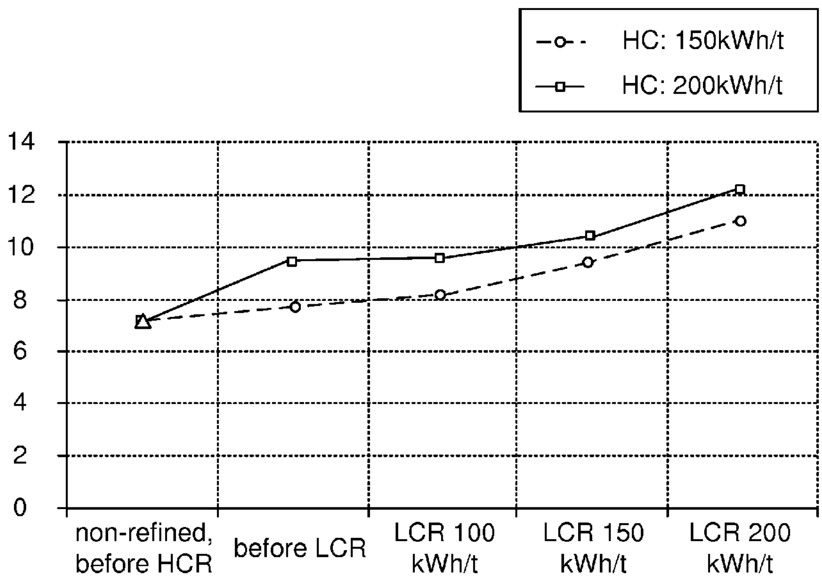

Fig. 3

(57) **Abstract:** There is provided a method of producing a paper having a grammage according to ISO 536 of 50-250 g/m2, a Gurley value according to ISO 5636-5 of above 15 s and a stretchability according to ISO 1924-3 in the cross direction of at least 8 %, said method comprising the steps of:a) providing a pulp, preferably sulphate pulp; b) subjecting the pulp to refining; c) diluting the pulp from step b) and discharging the diluted pulp at a discharge rate to a forming wire to form a paper web, wherein the speed of the forming wire is at least 7 m/min higher or at least 7 m/min lower than the discharge rate; d) pressing the paper web from step c); e) drying the paper web from step d), which drying comprises a step of compacting the paper web in a Clupak unit.

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PRODUCTION OF PAPER THAT IS HIGHLY STRETCHABLE IN THE CROSS DIRECTION

TECHNICAL FIELD

The invention relates to the production paper that is highly stretchable in the cross direction.

BACKGROUND

BillerudKorsnäs AB (Sweden) has marketed a highly stretchable paper under the name FibreForm® since 2009. The stretchability of FibreForm® in both the machine direction (MD) and the cross direction (CD) allows it to replace plastics in many applications. FibreForm® has been produced on paper machine comprising an Expanda unit that compacts/creps the paper in the machine direction to improve the stretchability.

SUMMARY

The object of the present disclosure is to provide a method of producing a paper that is highly stretchable in the cross direction without being a typical porous sack paper on a paper machine comprising a Clupak unit for compacting the paper in the machine direction.

There is thus provided a method of producing a paper having a grammage according to ISO 536 of 50-250 g/m², a Gurley value according to ISO 5636-5 of above 15 s and a stretchability according to ISO 1924-3 in the cross direction of at least 8 %, said method comprising the steps of:

a) providing a pulp, preferably sulphate pulp;

b) subjecting the pulp to refining;

c) diluting the pulp from step b) and discharging the diluted pulp at a discharge rate to a forming wire to form a paper web, wherein the speed of the forming wire is at least 7 m/min higher or at least 7 m/min lower than the discharge rate;

d) pressing the paper web from step c);

e) drying the paper web from step d), which drying comprises a step of compacting the paper web in a Clupak unit.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1 is a schematic illustration of a Clupak unit.

Fig 2 shows (on the y axis) the cross direction (CD) stretchability in % of paper produced from pulp subjected to HC refining at the consistencies 38.0 %, 36.1 % and 31.8 %. The x axis represents the chronological order.

Fig 3 shows (on the y axis) the stretchability in % of lab sheets produced from:
non-refined pulp (“non-refined, before HCR”);
pulp subjected to HC refining (150 or 220 kWh/t) only (“before LCR”); and
pulp subjected to HC refining (150 or 220 kWh/t) and LC refining (“LCR 100 kWh/t”, “LCR 150 kWh/t” and “LCR 200 kWh/t”).

DETAILED DESCRIPTION

The present disclosure relates to a method of producing a paper, which is preferably uncoated. Subsequent to the method of the present disclosure, the paper may be coated, e.g. to improve printing properties and/or to obtain barrier properties.

The paper obtained by the method is characterized by its stretchability, which is at least 8 % in the cross direction (CD). Preferably, the stretchability in CD is higher than 8 %, such as at least 9 % or at least 9.5 %. The stretchability enables formation of three-dimensional (double curvature) shapes in the paper, e.g. by press forming, vacuum forming or deep drawing. The formability of the paper in such processes is further improved if the stretchability is relatively high also in the machine direction (MD). Preferably, the stretchability in MD is at least 9 %, such as at least 10 %, such as at least 11 %. An upper limit for the stretchability in CD may for example be 15 %. An upper limit for the stretchability in MD may for example be 20 % or 25 %. The stretchability (in both MD and CD) is determined according to the standard ISO 1924-3.

In contrast to many sack papers, which may be highly stretchable, the paper of the present disclosure is not particularly porous. Instead, relatively low porosity may be preferred in the applications intended for the paper of the present disclosure. For example, glue and some coatings have a lower tendency to bleed through a paper of low porosity. Further, some printing properties are improved when the porosity is reduced.

The air resistance according to Gurley, i.e. the Gurley porosity, is a measurement of the time (s) taken for 100 ml of air to pass through a specified area of a paper sheet. Short time means highly porous paper. The Gurley porosity of the paper of the present disclosure is above 15 s. The Gurley porosity is preferably at least 20 s and more preferably 25 s, such as at least 35 s. An upper limit for may for example be 120 s or 150 s. The Gurley porosity (herein also referred to as the “Gurley value”) is determined according to ISO 5636-5.

The grammage of the paper of the present disclosure is 50-250 g/m^2. If a stretchable material having a grammage above 250 g/m^2 is desired, a laminate can be produced from a plurality of paper layers each having a grammage in the range of 50-250 g/m^2. Below 50 g/m^2 the strength and rigidity is typically insufficient. The grammage is preferably 60-220 g/m^2 and more preferably 80-200 g/m^2, such as 80-160 g/m^2, such as 80-130 g/m^2. The standard ISO 536 is used to determine the grammage. The Bendtsen roughness is typically lower when the grammage is lower.

The density of the paper is typically between 700 and 1000 kg/m^3. Preferred density ranges are 700-800 kg/m^3 and 710-780 kg/m^3. Higher density typically means reduced bending stiffness, which is often undesired.

For aesthetic and printing purposed, the paper of the present disclosure is preferably white. For example, its brightness according to ISO 2470 may be at least 80 %, such as at least 82 %. However, the paper may also be unbleached (“brown”).

It is also desired to be able to produce a stretchable paper with a relatively fine surface. Accordingly, the Bendtsen roughness according to ISO 8791-2 of at least one side of the paper may be 1900 ml/min or lower, such as 1700 ml/min or lower, such as 1500 ml/min or lower. A lower limit may be 800 ml/min or 500 ml/min.

The skilled person understands that the above Bendtsen roughness values relate to uncoated paper.

The method of the present disclosure comprises the step of:
a) providing a pulp.

The pulp is preferably a sulphate pulp (sometimes referred to as a “Kraft pulp”), which provides high tensile strength. For the same reason, the starting material used for preparing the pulp preferably comprises softwood (which has long fibers and forms a strong paper). Accordingly, the pulp may comprise at least 50 % softwood pulp, preferably at least 75 % softwood pulp and more preferably at least 90 % softwood pulp. The percentages are based of the dry weight of the pulp.

The tensile strength is the maximum force that a paper will withstand before breaking. In the standard test ISO 1924-3, a stripe having a width of 15 mm and a length of 100 mm is used with a constant rate of elongation. Tensile energy absorption (TEA) is sometimes considered to be the paper property that best represents the relevant strength of a paper. The tensile strength is one parameter in the measurement of the TEA and another parameter is stretchability. The tensile strength, the stretchability and the TEA value are obtained in the same test. The TEA index is the TEA value divided by the grammage. In the same manner, the tensile index is obtained by dividing the tensile strength by the grammage.

A dry strength agent, such as starch, may be added to improve tensile strength. The amount of starch may for example be 1-15 kg per ton paper, preferably 1-10 or 2-8 kg per ton paper. The starch is preferably cationic starch.

In the context of the present disclosure, “per ton paper” refers to per ton of dried paper from the paper making process. Such dried paper normally has a dry matter content (w/w) of 90-95 %.

The TEA index of the paper obtained by the method of the present disclosure may for example be at least 3.5 J/g (e.g. 3.5-7.5 J/g) in the MD and/or at least 2.9 J/g (e.g. 2.9-3.9 J/g) in the CD. In one embodiment, the TEA index is above 4.5 J/g (e.g. 4.6-7.5 J/g) in MD and/or above 3.0 J/g (e.g. 3.1-3.9 J/g) in CD.

One or more sizing agents may also be added to the pulp. Examples of sizing agents are AKD, ASA and rosin size. When rosin size is added, it is preferred to also add alum. Rosin size and alum is preferably added in a weight ratio between 1:1 and 1:2. Rosin size can for example be added in an amount of 0.5-4 kg per ton paper, preferably 0.7-2.5 kg per ton paper.

When the paper is white, the pulp is bleached.

The method further comprises the step of:
b) subjecting the pulp to refining.

It is shown under Examples below that the CD stretchability is increased by HC refining. By comparing the stretchability values obtained after HC refining at 150 and 220 kWh/ton paper, respectively, it has further been shown that a higher degree of HC refining results in higher CD stretchability. It is also shown that the CD stretchability is increased by LC refining. By comparing the stretchability values obtained at 100, 150 and 200 kWh/ton paper, respectively, it has further been shown that a higher degree of LC refining results in higher CD stretchability.

The effect of refining on stretchability is particularly pronounced when the refining is combined with “free drying”, which is further discussed below.

The effect LC refining, which hydrates the fibres, on CD stretchability is particularly pronounced when the LC refining is combined with the fibre orientation caused by the “jet/wire ratio” discussed below.

Accordingly step b) comprises subjecting the pulp to high consistency (HC) refining in one embodiment of the invention. In an alternative of complementary embodiment, step b) comprises subjecting the pulp to low consistency (LC) refining.

In a preferred embodiment, step b) comprises the substeps of:
b1) subjecting the pulp to high consistency (HC) refining; and
b2) subjecting the pulp from step b1) to low consistency (LC) refining.

The consistency of the pulp subjected to HC refining is preferably at least 33 % and more preferably above 36 %. In particularly preferred embodiments, the consistency of the pulp subjected to HC refining is at least 37 %, such as at least 38 % (see figure 2). A typical upper limit for the consistency may be 42 %.

The HC refining is typically carried out to the extent that the pulp obtains a Schopper-Riegler (SR) number of 13-19, such as 13-18. The SR number is measured according to ISO 5267-1. To reach the desired SR number, the energy supply in the HC refining may be at least 100 kWh per ton paper, such as above 150 kWh per ton paper. A typical upper limit may be 220 kWh per ton paper.

The consistency of the pulp subjected to LC refining is typically 2-6 %, preferably 3-5 %. The LC refining is typically carried out to the extent that the pulp obtains a Schopper-Riegler (SR) number of 18-40, preferably 19-35, such as 23-35. To reach the desired SR number, the energy supply in the LC refining may be 20-200 kWh per ton paper, such as 30-200 kWh per ton paper, such as 40-200 kWh per ton paper.

As well known to the skilled person, LC refining increases the SR number.

In one embodiment, the method further comprises the step of adding broke pulp to the pulp in step b) or between step b) and step c) (step c) is discussed below). The broke pulp is preferably obtained from the same method.

The method further comprises the step of:

c) diluting the pulp from step b) and discharging the diluted pulp at a discharge rate to a forming wire to form a paper web.

The diluted pulp is typically discharged as a jet stream through a slice in the headbox. The diluted pulp is then dewatered on the forming wire such that the paper web is formed. The diluted pulp typically has a pH of 5-6 and a consistency of 0.2-0.5 %.

In step c), the discharge rate is preferably (but not necessarily) at least 7 m/min higher or at least 7 m/min lower than the speed of the forming wire. Such difference in speed results in that the proportion of fibres that are oriented in the machine direction increases. This is in contrast to the case when the discharge rate is the same as the speed of the forming wire, which results in that the orientations of the fibres tend to be evenly distributed in all directions. An increased proportion of fibres oriented in the machine direction increases shrinkage in the cross direction during drying, which means that the CD stretchability is increased.

It has been shown that an increased speed difference results in an increased CD-stretch. Impaired formation has however been observed if the difference in speed is too high. Therefore, the difference in speed is typically not more than 30 m/min.

In a preferred embodiment, the discharge rate is 8-25 m/min higher or 8-25 m/min lower than the speed of the forming wire. In a more preferred embodiment, the discharge rate is 9-23 m/min higher or 9-23 m/min lower than the speed of the forming wire.

It is generally more preferred that the discharge rate is higher than the speed of the forming wire. Accordingly, in a preferred embodiment, the discharge rate is at least 7 m/min higher than the speed of the forming wire, such as 8-25 m/min higher than the speed of the forming wire, such as 9-23 m/min higher than the speed of the forming wire.

The ratio between the discharge rate and the speed of the forming wire is sometimes referred to as the jet/wire ratio.

In one embodiment of step c), the diluted pulp is discharged through a discharge gap of at least 40 mm, such as at least 50 mm, such as 50-70 mm. By using such a relatively large gap, the CD stretchability becomes more homogenous across the paper web. The “discharge gap” can also be referred to the as a “discharge opening” or “slice opening”. A slice typically has a stationary lip and a regulating lip. In such case, the discharge opening is the gap between the stationary lip and the regulating lip.

The paper web formed in step c) typically has a dry content of 15-25 %, such as 17-23 %.

The method further comprises the step of:
d) pressing the paper web from step c), e.g. to a dry content of 30-50 %, such as 36-46 %.

The pressing section used for step d) typically has one, two or three press nips. In one embodiment, a shoe press is used. In such case, the nip of the shoe press can be the only nip of the pressing section. A benefit of using a shoe press is improved stiffness in the final product.

The method further comprises the step of:
e) drying the paper web from step d), which drying comprises a step of compacting the paper web in a Clupak unit.

The step of compacting the paper web in the Clupak unit is normally carried out at a moisture content between 20 and 48 %. Normally, step e) comprises drying of the paper web both before and after the compacting in the Clupak unit.

The compacting in the Clupak unit increases the stretchability of the paper, in particular in the MD, but also in the CD. To improve surface/printing properties, the moisture content of the paper is preferably at least 30 % (e.g. 30-50 %), such as at least 35 % (e.g. 35-49 %), when entering the Clupak unit.

Higher moisture contents have also been shown to correlate with higher stretchabilities in the MD.

Further, the inventors have found that the increase in stretchability is facilitated by a relatively high nip bar line load, i.e. at least 22 kN/m, in the Clupak unit. Preferably, the nip bar line load is at least 25 kN/m or at least 28 kN/m. More preferably, the nip bar line load is at least 31 kN/m. A typical upper limit may be 38 kN/m. In the Clupak unit, the nip bar line load is controlled by the adjustable hydraulic cylinder pressure exerted on the nip bar. The nip bar is sometimes referred to as the “nip roll”. The relationship between nip bar line load and CD stretchability is shown under Examples below.

In one embodiment, the rubber belt tension in the Clupak unit is at least 5 kN/m (such as 5-9 kN/m), preferably at least 6 kN/m (such as 6-9 kN/m), such as about 7 kN/m. In the Clupak unit, the rubber belt tension is controlled by the adjustable hydraulic cylinder pressure exerted on the tension roll stretching the rubber belt.

The Clupak unit typically comprises a steel cylinder. When the paper web is compacted by the contraction/recoil of the rubber belt in the Clupak unit, it moves relative the steel cylinder. To reduce the friction between the paper web and the steel cylinder, it is preferred to add a release liquid. The release liquid may be water or water-based. The water-based release liquid may comprise a friction-reducing agent, such as polyethylene glycol or a silicone-based agent. In one embodiment, the release liquid is water comprising at least 0.5 %, preferably at least 1 %, such as 1-4 %, polyethylene glycol.

A Clupak unit is also described below with reference to figure 1.

After being compacted in the Clupak unit, the paper web is normally subjected to further drying.

In one embodiment, step e) comprises drying the paper web from the Clupak unit in a drying group and the speed of the paper web in the dryer group is 8-

14 % lower than the speed of the paper web entering the Clupak unit. A reason for lowering the speed in this manner is to maintain the MD stretchability obtained by the paper web in the Clupak unit.

The paper web is preferably allowed to dry freely during part of step e), in particular after the Clupak unit. During such “free drying”, which improves the stretchability, the paper web is not in contact with a dryer screen (often referred to as a dryer fabric). A forced, optionally heated, air flow may be used in the free drying, which means that the free drying may comprise fan drying.

As shown in table 1 below, the side of the paper that contacted the steel cylinder in the Clupak unit normally has a finer surface than the side of the paper that contacted the rubber belt in the Clupak unit. A chromed cylinder may be used instead of a steel cylinder. Accordingly, it is normally preferred to print side of the paper that contacted the steel/chromed cylinder.

Therefore, the method may further comprise the step of:
f) printing the side of the paper that contacted the steel/chromed cylinder of the Clupak unit in step e).

Fig 1 illustrates a Clupak unit 105, comprising an endless rubber belt 107 (sometimes referred to as a “rubber blanket”) contacted by two blanket rolls 108, 109, a guide roll 110, a tension roll 111 and a nip bar 112. A first hydraulic arrangement 113 exerts pressure on the tension roll 111 to stretch the rubber belt 107. A second hydraulic arrangement 114 exerts pressure on the nip bar 112 to press the rubber belt 107, which in turns presses the paper web 117 against a steel cylinder 115. A release liquid spray nozzle 116 is arranged to apply a release liquid to the steel cylinder 115.

EXAMPLES

<u>Full scale trial</u>

A full-scale trial was carried out to produce white stretchable paper on a paper machine normally used for producing sack paper. The production is described below.

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 %. The pulp was discharged through a discharge opening in the headbox to a forming wire to form a paper web. The slice lip was set to form a discharge gap of 60 mm. The speed of the forming wire was 10 m/min lower than the discharge rate of the pulp. 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. 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 % polyetylene glycol) was added in an amount of 250 litre/hour. The speed of the paper web in the dryer group directly downstream the Clupak was 11 % lower than the speed of the paper web entering the Clupak unit.

Properties of the paper produced in the trial are presented in table 1 below.

Table 1. Properties measured on samples obtained from the top of the jumbo roll.

Grammage (g/m^2)	150
Thickness (µm)	195
Density (kg/m^3)	764
Tensile strength, MD (kN/m)	12.4
Tensile strength, CD (kN/m)	6.9
Tensile index, MD (kNm/kg)	83
Tensile index, CD (kNm/kg)	46
Stretchability, MD (%)	14.4
Stretchability, CD (%)	9.9
TEA, MD (J/m^2)	1010
TEA, CD T (J/m^2)	479
TEA index, MD (J/g)	6.8
TEA index, CD (J/g)	3.2
Burst strength (kPa)	775
Burst index (mN/kg)	5.2
Bending resistance, MD (mN)	170
Bending resistance, CD (mN)	194
Bending resistance index, MD (Nm^6/kg^3)	50.4
Bending resistance index, CD (Nm^6/kg^3)	57.5
Gurley value (s)	38
Brightness (%)	83
Bendtsen roughness (ml/min), SS*	1596
Bendtsen roughness (ml/min), RS**	3246

* RS means the side of the paper contacting the rubber belt in the Clupak unit.

** SS means the side of the paper contacting the steel cylinder in the Clupak unit.

As shown in Table 1, a paper having a Gurley value of 38 s and a CD stretchability of 9.9 % was produced. It is assumed that the CD stretchability would have been even higher if the degree of LC refining had been higher.

The Bendtsen roughness values would have been lower if they had been measured on a paper sample taken from another position in the jumbo roll or after rewinding. The Bendtsen roughness values in table 1 are thus higher than those of the paper that is shipped to the customer.

Effect of consistency in the HC refining

In a full scale trial according to the above, the consistency of the pulp subjected to HC refining was first 38 % and then lowered in two steps to 36.1 % and 31.8 %, respectively, by reducing the degree to which the pulp was pressed before the HC refining. The CD stretchability of the resulting paper was measured three times for the 38 % pulp, four times for the 36.1 % pulp and three times for the 31.8 % pulp. The results are presented in Figure 2, which indicate that the CD stretchability is generally increased by increasing the consistency of the pulp subjected to HC refining. A particularly positive effect on the CD stretchability is shown for a consistency above 36 %.

Effect of nip bar line load in the Clupak unit

In a full scale trial according to the above, two different line loads were used and the CD stretchability of the resulting paper was measured. The results are presented in Table 2, which shows that the average CD stretchability was increased by 6.8 % by increasing the nip bar line load from 22 to 33 kN/m.

Table 2.

	Nip bar line load (kN/m)	Stretchability, CD (%)
Sample 1	33	9.95
Sample 2	22	9.51
Sample 3	33	9.81
Sample 4	22	9.00
Sample 5	33	10.04
Sample 6	22	9.38

Average	33	9.93
Average	22	9.30

<u>Laboratory trial</u>

The correlation between refining and stretchability in the cross direction (CD) was tested in a laboratory trial. In the laboratory trial, non-oriented lab sheets were formed from pulps subjected to different degrees of high consistency and low consistency refining. The stretchability of the lab sheets, which is considered to be representative of the CD stretchability of paper formed on a paper machine, was then tested. The results of the laboratory trial are presented in Figure 3, which shows that both HC refining and LC refining increase the stretchability. A particularly beneficial effect is obtained when HC and LC refining is combined. Figure 3 further shows that there is a positive correlation between the degree of LC refining and the stretchability. It also shows that an increase in the degree of HC refining increases the stretchability.

CLAIMS

1. Method of producing a paper having a grammage according to ISO 536 of 50-250 g/m², a Gurley value according to ISO 5636-5 of above 15 s and a stretchability according to ISO 1924-3 in the cross direction of at least 8 %, said method comprising the steps of:
a) providing a pulp, preferably sulphate pulp;
b) subjecting the pulp to refining;
c) diluting the pulp from step b) and discharging the diluted pulp at a discharge rate to a forming wire to form a paper web, wherein the speed of the forming wire is at least 7 m/min higher or at least 7 m/min lower than the discharge rate;
d) pressing the paper web from step c);
e) drying the paper web from step d), which drying comprises a step of compacting the paper web in a Clupak unit.

2. The method of claim 1, wherein the speed of the forming wire is 8-25 m/min higher or 8-25 m/min lower than the discharge rate.

3. The method of claim 1 or 2, wherein the diluted pulp is discharged through a discharge gap of at least 40 mm, such as at least 50 mm, such as 50-70 mm.

4. The method of any one of the preceding claims, wherein the paper has a stretchability according to ISO 1924-3 in the cross direction of at least 9 %, such as at least 9.5 %.

5. The method of any one of the preceding claims, wherein the paper has a stretchability according to ISO 1924-3 in the machine direction of at least 9 %, such as at least 10 %, such as at least 11 %.

6. The method of any one of the preceding claims, wherein step b) comprises subjecting the pulp to high consistency (HC) refining.

7. The method of claim 6, wherein the consistency of the pulp subjected to HC refining is at least 33 %, such as at least 37 %, such as at least 38 %.

8. The method of any one of the preceding claims, wherein step b) comprises subjecting the pulp to low consistency (LC) refining.

9. The method of claim 8, wherein the energy supply in the LC refining is 20-200 kWh per ton paper, such as 30-200 kWh per ton paper, such as 40-200 kWh per ton paper.

10. The method of any one of the preceding claims, wherein the paper web is compacted in the Clupak unit at a moisture content of 20-48 %, such as 30-45 %, such as 35-45 %.

11. The method of any one of the preceding claims, wherein the line load of the nip bar in the Clupak unit is at least 22 kN/m, such as at least 25 kN/m, such as at least 28 kN/m.

12. The method of any one of the preceding claims, wherein the grammage according to ISO 536 of the paper is 60-220 g/m^2, such as 80-200 g/m^2.

13. The method of any one of the preceding claims, wherein the Gurley value according to ISO 5636-5 of the paper is at least 20 s, preferably at least 25 s, more preferably at least 35 s.

14. The method of any one of the preceding claims, wherein step e) comprises drying the paper web from the Clupak unit in a drying group and the speed of the paper web in the dryer group is 8-14 % lower than the speed of the paper web entering the Clupak unit.

15. The method of any one of the preceding claims, wherein the Bendtsen roughness according to ISO 8791-2 of at least one side of the paper is 1900 ml/min or lower, such as 1700 ml/min or lower, such as 1500 ml/min or lower.

16. Method according to claim 1, wherein:
step b comprises the substeps of
b1) subjecting the pulp to high consistency (HC) refining at a consistency of 33-42 % to the extent that the pulp obtains a Schopper-Riegler (SR) number measured according to ISO 5267-1 of 13-19 and
b2) subjecting the pulp from step b1) to low consistency (LC) refining at a consistency of 2-6 % to the extent that the pulp obtains a Schopper-Riegler (SR) number measured according to ISO 5267-1 of 18-40; and
the speed of the forming wire is 7-30 m/min higher or 7-30 m/min lower than the discharge rate in step c).

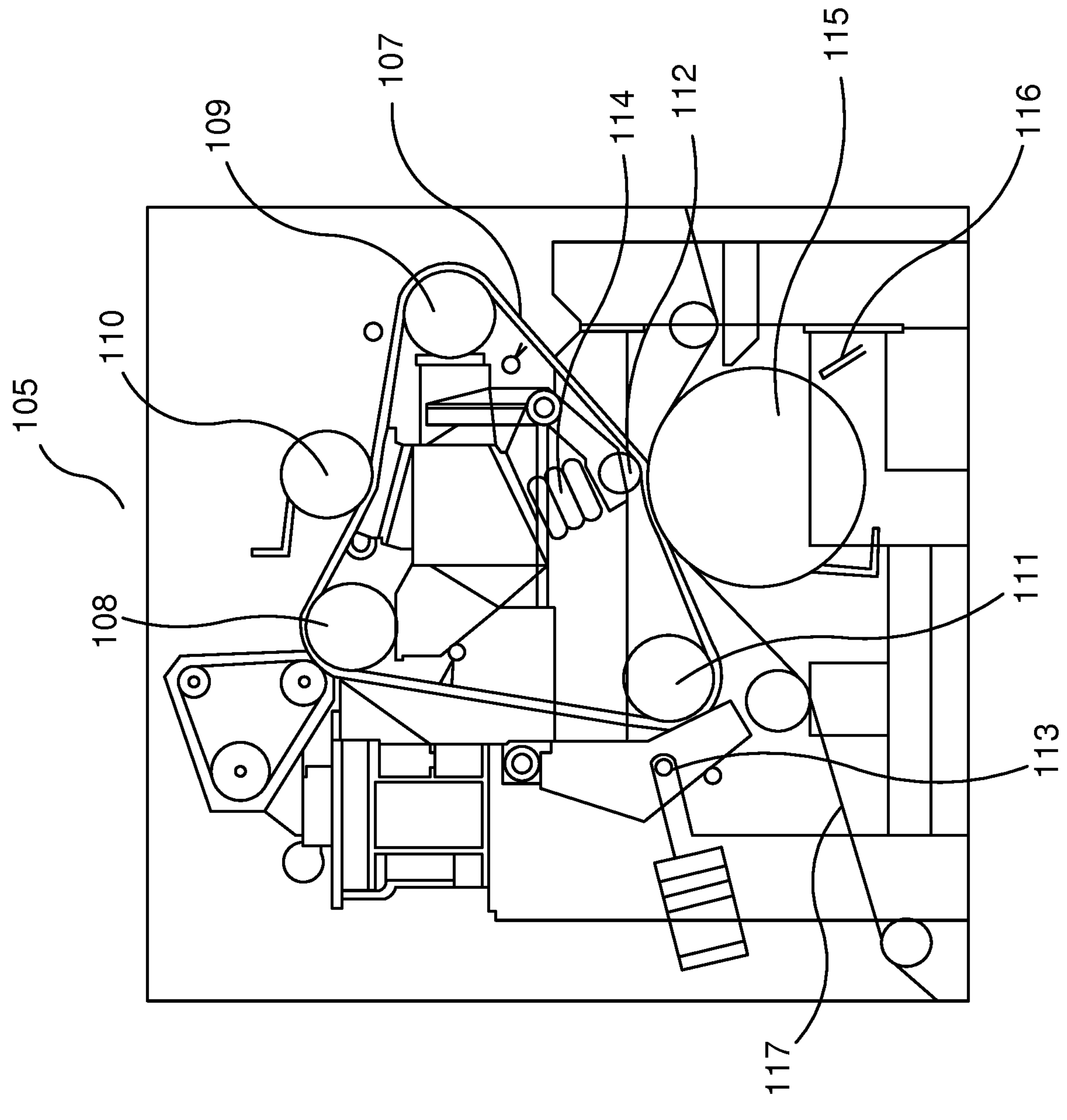

Fig. 1

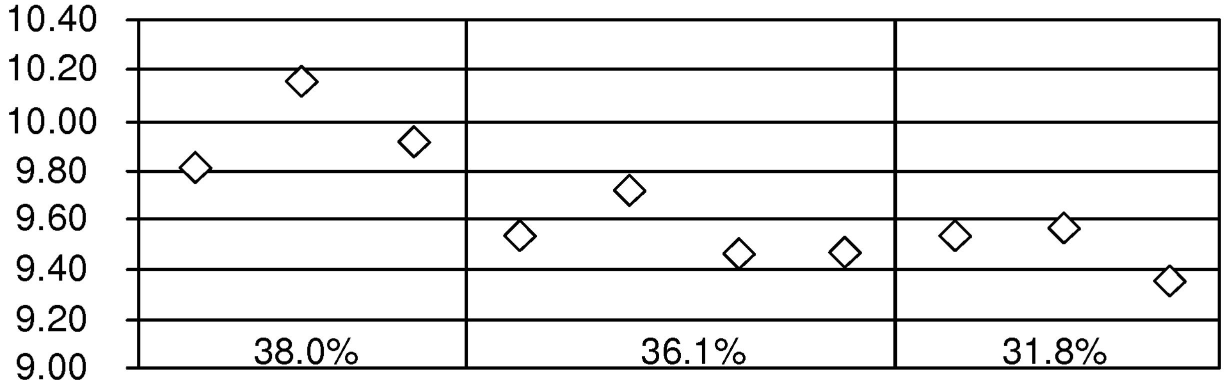
10.40
10.20
10.00
9.80
9.60
9.40
9.20
9.00
38.0%
36.1%
31.8%

Fig. 2

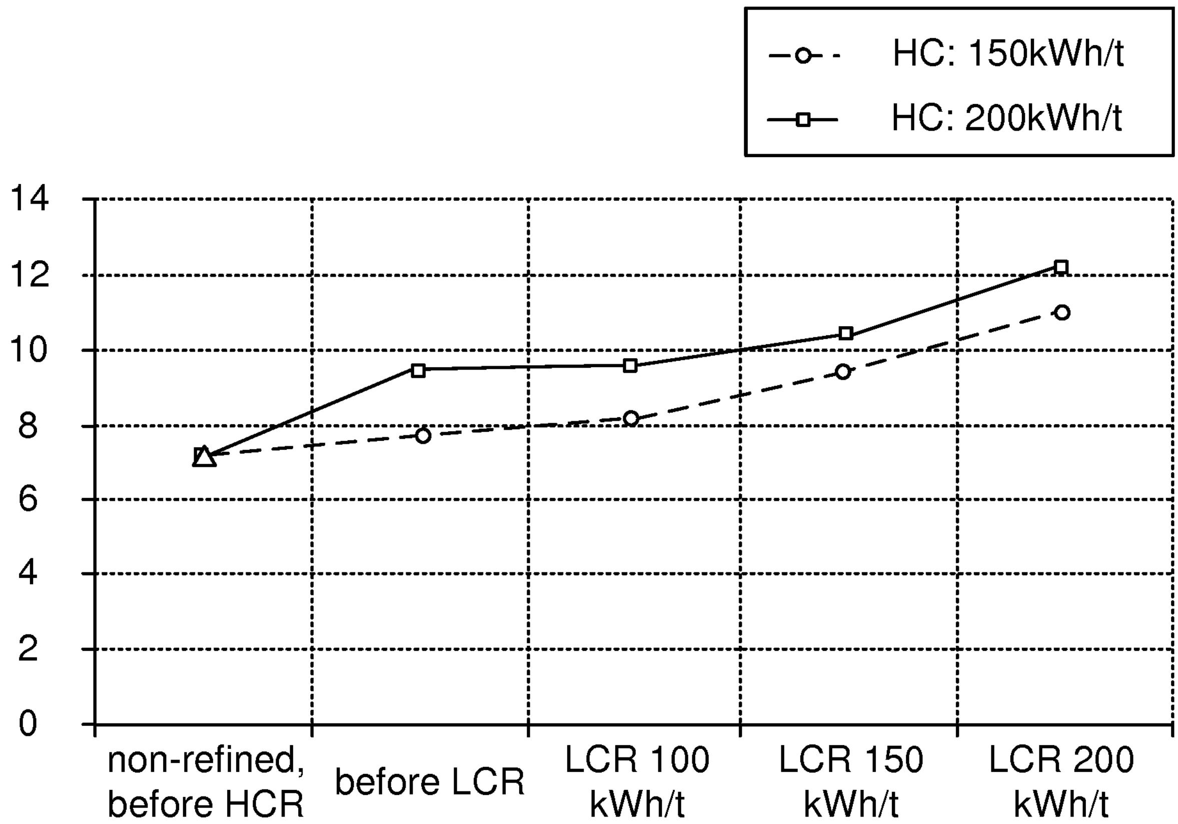
HC: 150kWh/t
HC: 200kWh/t
14
12
10
8
6
4
2
0
non-refined, before HCR
before LCR
LCR 100 kWh/t
LCR 150 kWh/t
LCR 200 kWh/t

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/058713

A. CLASSIFICATION OF SUBJECT MATTER
INV. D21H25/00 D21H27/00 D21H27/10 D21F5/00 D21H11/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D21H D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2007 262603 A (DAIO SEISHI KK) 11 October 2007 (2007-10-11) paragraphs [0016], [0017] paragraph [0024] - paragraph [0028] paragraphs [0062], [0063], [0066], [0078] paragraph [0038] - paragraph [0045] claims 1-3; table 1 -----	1-5, 10-15
X	EP 3 023 543 A1 (JUJO PAPER CO LTD [JP]) 25 May 2016 (2016-05-25) paragraph [0014] - paragraph [0040] claims 1-7; examples 1-4; table 1 -----	1-15
X	JP 2017 044623 A (JUJO PAPER CO LTD) 2 March 2017 (2017-03-02) paragraph [0037] - paragraph [0057] ----- -/--	1-15

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 May 2018	30/05/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Billet, Aina

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 092 003 A (HAGART-ALEXANDER CLAUD [CA] ET AL) 18 July 2000 (2000-07-18) column 5, line 26 - line 65; figure 1B column 6, line 41 - line 63 column 7, line 39 - line 53 column 15, line 5 - line 19 claims 1-36 -----	1-16
A	WO 99/02772 A1 (ASSIDOMAEN KRAFT PRODUCTS AB [SE]; NILSSON BJOERN [SE]; HAAKANSSON STE) 21 January 1999 (1999-01-21) claims 1-25; table 2 -----	1-16

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Information on patent family members

International application No
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