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(71) Applicant: **Billerud Aktiebolag (publ)**
169 27 Solna (SE)

(72) Inventors:
- **VALTANEN, Eero Antero**
  33960 PIRKKALA (FI)
- **LINDSTRÖM, Ove**
  952 91 Kalix (SE)
- **EMMOTH, Simon**
  975 92 Luleå (SE)

(74) Representative: **Kransell & Wennborg KB**
P.O. Box 27834
115 93 Stockholm (SE)

(54) **STRETCHABLE PAPER**

(57) The present disclosure provides a stretchable paper comprising at least 90% by dry weight of kraft pulp fibres, wherein the stretchability according to ISO 1924-3:2011 of the paper is at least 8.0 % in the machine direction (MD) and the cross direction (CD) and wherein the paper comprises 5-10 kg/tonne of cationic starch based on dry weight of the paper, 0.25-1.00 kg/tonne of AKD or ASA based on dry weight of the paper, 1.00-3.00 kg/tonne of rosin size based on dry weight of the paper and 0.5-5.0 kg/tonne of glyoxylated polyacrylamide (G-PAM) based on dry weight of the paper.

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to the field of stretchable papers, in particular to stretchable papers with wet strength properties.

BACKGROUND

[0002] Billerud 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, such as bags.

[0003] The interest in usage of paper bags is increasing. One drawback with paper bags compared with plastic bags is that the paper bags loose mechanical stability upon contact with water, such as when put down on wet ground.

SUMMARY

[0004] The present disclosure aims to provide an stretchable paper having wet strength properties.

[0005] Accordingly, the present disclosure provides the following listing of itemized embodiments:

1. A stretchable paper comprising at least 90% by dry weight of kraft pulp fibres, wherein the stretchability according to ISO 1924-3:2011 of the paper is at least 8.0 % in the machine direction (MD) and the cross direction (CD) and wherein the paper comprises 5-10 kg/tonne of cationic starch based on dry weight of the paper, 0.25-1.00 kg/tonne of AKD or ASA based on dry weight of the paper, 1.00-3.00 kg/tonne of rosin size based on dry weight of the paper and 0.5-5.0 kg/tonne of glyoxylated polyacrylamide (G-PAM) based on dry weight of the paper.

2. The paper of item 1, wherein the grammage of the paper according to ISO 536:2020 is 50-200 g/m^2, such as 90-175 g/m^2.

3. The paper of item 1 or 2, wherein the paper has a stretchability according to ISO 1924-3:2011 in MD of at least 10%, such as at least 11 %, such as at least 12 %.

4. The paper of any one of the preceding items, wherein the paper has a stretchability according to ISO 1924-3:2011 in CD of at least 9%.

5. The paper of any one of the preceding items, wherein the Bendtsen roughness according to ISO 8791-2:2013 of at least one side of the paper is 2000 ml/min or lower, such as 1850 ml/min or lower, such as 1600 ml/min or lower.

6. The paper of any one of the preceding items, wherein the wet immediate tensile strength in MD according to ISO 3781:1983 using 10 min immerse time, is at least 1.1 kN/m, such as at least 1.3 kN/m, such as at least 1.6 kN/m.

7. The paper of any one of the preceding items, wherein the wet immediate tensile strength in CD according to ISO 3781:1983 using 10 min immerse time, is at least 1 kN/m, such as at least 1.15 kN/m, such as at least 1.25 kN/m.

8. The paper of any one of the preceding items, wherein the ratio of wet immediate tensile strength in MD to dry tensile strength in MD, wherein the wet tensile index is tested according to ISO 3781:1983 using 10 min immerse time, is at least 10%, such as at least 12%, such as at least 14%.

9. The paper of any one of the preceding items, wherein the Gurley value according to ISO 5636-5:2013 of the paper is at least 15 s, such as at least 20 s, such as at least 25 s, such as at least 30 s.

10. The paper of any one of the preceding items, wherein the density of the paper according to ISO 534:2011 is 620-900 kg/m^3.

11. The paper of any one of the preceding items, wherein the tensile energy absorption (TEA) index in MD according to ISO 1924-3:2011 is at least 4.0 J/g, such as at least 4.3 J/g.

12. The paper of any one of the preceding items, wherein the TEA index in CD according to ISO 1924-3:2011 is at least

3.0 J/g.

13. The paper of any one of the preceding items, wherein the Cobb 60 s value measured according to ISO 535:2014 of both sides of the paper is typically below 30 g/m^2, such as 18-25 g/m^2.

14. Method of producing a kraft paper having a stretchability according to ISO 1924-3:2011 in the MD and CD of at least 8 %, wherein the method comprises the following steps:

a) providing a kraft pulp;

b) diluting the kraft pulp into a pulp stock;

c) adding to the stock based on dry weight of the pulp stock 5-10 kg/tonne of cationic starch, 0.25-1.00 kg/tonne of AKD or ASA, 1.00-3.00 kg/tonne of rosin size and 0.5-5 kg/tonne glyoxylated polyacrylamide (G-PAM);

d) diluting the pulp stock in a headbox;

e) adding the diluted pulp stock from the headbox to a forming wire to obtain a paper web;

f) pressing the paper web; and

g) drying the pressed paper web into a paper, which drying comprises a step of compacting the paper web in a Clupak unit or an Expanda unit.

15. The method of item 14, wherein step c) further comprises adding retention aid(s) to the pulp stock, wherein the/each retention aid is added in an amount of 0.03-0.12 kg/tonne based on dry weight of the pulp stock; and the dilution in step d) is conducted with a headbox dilution ratio of 9-13 %, wherein the headbox dilution ratio is the dilution water flow into the headbox divided by the pulp stock flow into the headbox.

16. The method of item 14 or 15, wherein the G-PAM is added in an amount of 1.0-4.0 kg/tonne based on dry weight of the pulp stock, such as 1.8-3.0 kg/tonne based on dry weight of the pulp stock.

17. The method of any one of the items 14-16, wherein the kraft pulp is softwood pulp.

18. The method of any one of the items 14-17, wherein the headbox dilution ratio is 9.5-12 %, such as 9.5-11.5 %.

19. The method of any one of the items 14-18, wherein the/each retention aid is added an amount of 0.04-0.10 kg/tonne based on dry weight of the pulp stock, such as 0.04-0.08 kg/tonne based on dry weight of the pulp stock.

20. The method of any one of the items 14-19, wherein one retention aid is cationic, such as a cationic polymer, such as cationic polyacrylamide (cPAM), polyethyleneimine (PEI) or mixtures thereof.

21. The method of any one of the items 14-20, wherein one retention aid is anionic, such as anionic inorganic particles, such as silica microparticles, bentonite clay or mixtures thereof.

22. The method of any one of the items 14-21, wherein the headbox has a vertical lip opening of 42-60 mm, such as 45-56 mm.

23. The method of any one of the items 14-22, wherein the diluted pulp stock has a consistency of 0.20-0.30 % based on dry weight when added to the forming wire.

24. The method of any one of the items 14-23, wherein the kraft pulp is subjected to high consistency (HC) refining followed by low consistency (LC) refining before dilution into a pulp stock in step b).

25. The method of any one of the items 14-24, wherein the kraft pulp is unbleached.

26. The method of item 25, wherein less than 0.05 kg/tonne of anionic polymer is added to the pulp stock, such as no anionic polymer is added to the pulp stock.

27. The method of any one of the items 14-24, wherein the kraft pulp is bleached.

28. The method of item 27, wherein an anionic polymer, such as anionic polyacrylamide (A-PAM), is added to the pulp stock.

29. The method of item 28, wherein the anionic polymer, such as anionic polyacrylamide (A-PAM), is added in a total amount of 0.20-1.00 kg/tonne dry fibre, such as 0.25-0.75 kg/tonne dry fibre, such as 0.35-0.55 kg/tonne dry fibre.

30. A kraft paper, wherein the paper is having a stretchability according to ISO 1924-3:2011 in MD and CD of at least 8 %, and an approved water-resistant carrying capacity according to a modified version of EN13590:2003, wherein the modified version of EN13590:2003 is conducted accordingly:

- produce from the paper a block-bottomed self-opening satchel carrier bag (SOS bag) with handles according to dimensions in EN13590:2003, wherein the block-bottomed fold as well as side seam and handles are adhered with a polyvinyl acetate (PVAc) adhesive;
- fill the paper SOS-bag with filling material according to EN13590:2003;
- provide a tray filled with water;
- arrange the paper SOS-bag with filling material on the tray for at least 1 minute to saturate the bottom of the SOS-bag with water;
- using the test equipment of EN13590:2003 lift the bag from the tray and hold it in the air for 3 minutes;
- conduct the determination of carrying capacity according to EN13590:2003, wherein lowering the bag is conducted so that the bag is lowered onto the tray with water thereby immersing the bottom of the bag each time the bag is lowered;
- lift and lower the bag 1000 times or until it breaks according to EN13590:2003; and
- the test is passed if at least three bags are tested and average times of lifting the bags before breakage according to EN13590:2003 is at least 500 times.

31. A block-bottomed self-opening satchel carrier bag (SOS bag) formed from the paper according to any one of the items 1-13.

DETAILED DESCRIPTION

[0006] As a first aspect of the present disclosure, there is provided a stretchable paper comprising at least 90% by dry weight of kraft pulp fibres, wherein the stretchability according to ISO 1924-3:2011 of the paper is at least 8.0 % in the machine direction (MD) and the cross direction (CD) and wherein the paper comprises 5-10 kg/tonne of cationic starch based on dry weight of the paper, 0.25-1.00 kg/tonne of AKD or ASA based on dry weight of the paper, 1.00-3.00 kg/tonne of rosin size based on dry weight of the paper and 0.5-5.0 kg/tonne of glyoxylated polyacrylamide (G-PAM) based on dry weight of the paper.

[0007] The pulp is a kraft pulp since such pulp provides mechanical strength. Kraft pulp is also known as sulphate pulp.

[0008] The combination of cationic starch, AKD or ASA, rosin size and G-PAM is beneficial for properties of both short-term and long-term dry and wet strength of the stretchable paper. Alkyl Ketene Dimers (AKD), Alkenyl Succinic Anydrides (ASA) and rosin size are internal sizing agents that provides ability to resist wetting and penetration by liquids. The paper comprises AKD or ASA in an amount of 0.25-1.00 kg/tonne, preferably 0.3-0.7 kg/tonne, based on dry weight of the paper. The paper comprises rosin size an amount of 0.5-5.0 kg/tonne, preferably 0.7-3.0 kg/tonne, based on dry weight of the paper. The paper comprises cationic starch in an amount of 5-10 kg/tonne, preferably 5-9 kg/tonne paper, based on dry weight of the paper. The cationic starch provides strength properties, in particular dry strength properties, as well as retention of the AKD or ASA. The dry strength properties are important are, amongst others, for the strainability. The paper may further comprise alum, for example in an amount of 5-10 kg/tonne based on dry weight of the paper. Although not necessary, it is beneficial to include alum since the role of the aluminium ion is to aid anchoring of the rosin size onto the anionic fibre surfaces. Alum therefore improves the retention of the rosin size.

[0009] The grammage of the paper according to ISO 536:2020 is typically 50-200 g/m^2, such as 90-175 g/m^2. Below 50 g/m^2 the strength and rigidity are typically insufficient. The inventors have also realized that if the grammage is at least 90 g/m^2, the wet strength properties, such as the immediate tensile strength, are at a level where a SOS paper bag can be produced and dipped into water several hundreds of time without breaking.

[0010] The paper has a stretchability of at least 8 % in the machine direction (MD) and cross direction (CD). Compacting in a Clupak unit or Expanda unit increases the stretchability of the paper, in particular in MD. The Clupak unit typically comprises a steel cylinder or a chromed cylinder and a rubber blanket. When the paper web is compacted by the contraction/recoil of the rubber blanket in the Clupak unit, it moves relative the steel/chromed cylinder and becomes micro-creped, especially in MD. The Expanda unit typically comprises a venturi section formed in a nip between a rubber and a steel roll. On running the rubber roll more slowly than the steel roll, the web will shrink in MD and become micro-creped. Preferably, the stretchability in MD is even higher than 8 %, such as at least 10 %, such as at least 11% or at least 12 %. 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 by that the stretchability is relatively high also in the cross direction (CD). Preferably, the stretchability in CD is at least 9 %. An upper limit for the stretchability in MD may for example be 20 % or 25 %. An upper limit for the stretchability in CD may for example be 15 %. The stretchability (in both MD and CD) is determined according to the standard ISO 1924-3:2011. The paper web is preferably allowed to dry freely 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. A stretchability of at least 8% in MD in particular in MD is beneficial also in production and usage of paper bags produced from the paper.

[0011] The Bendtsen roughness according to ISO 8791-2:2013 of at least one side of the paper is 2000 ml/min or lower, such as 1850 ml/min or lower. It is desired to be able to produce a stretchable paper with a relatively fine surface.

[0012] Preferably, the wet immediate tensile strength in the machine direction (MD) according to ISO 3781:1983 using 10 min immerse time, is at least 1 kN/m, such as at least 1.3 kN/m, such as at least 1.6 kN/m. In the cross direction (CD), the wet immediate tensile strength in CD according to ISO 3781:1983 using 10 min immerse time, is at least 1 kN/m, such as at least 1.15 kN/m, such as at least 1.25 kN/m. Preferably, the ratio of wet immediate tensile strength in MD to dry tensile strength in MD, wherein the wet tensile index is tested according to ISO 3781:1983 using 10 min immerse time, is at least 10%, such as at least 12%, such as at least 14%. The result is presented as percentage, i.e. the percentage of wet strength out of dry strength. If the number is 100 %, the paper is be performing equally good wet as dry with respect to tensile index.

[0013] The air resistance according to Gurley, i.e. the Gurley value or 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 typically at least 25 s, such as at least 30 s according to ISO 5636-5:2013. The inventors have realized that the wet strength properties are improved if the Gurley value is not too low, in particular if the Gurley value is at least 25 s it is beneficial for provision of a paper bag produced from the paper that can be put down on wet ground several hundreds of times.

[0014] The Cobb 60 s value measured according to ISO 535:2014 of both sides of the paper is typically below 30 g/m^2, such as 18-25 g/m^2.

[0015] The density of the paper according to ISO 534:2011 is typically 620-900 kg/m^3. Higher density typically means reduced bending stiffness, which is often undesired.

[0016] The tensile strength is the maximum force that a paper will withstand before breaking. Tensile energy absorption (TEA), that is the area under the cure tensile strength vs stretch, is a measure of how tough the material is. The TEA index is the TEA value divided by the grammage. The TEA index in MD according to ISO 1924-3:2011 is typically at least 4.0 J/g, such as at least 4.3 J/g. The TEA index in CD according to ISO 1924-3:2011 is typically at least 3.0 J/g. A paper of higher tensile strength and stretch has higher TEA value. Thus, a paper of higher grammage typically has a higher TEA value. For TEA index, on the other hand, this effect is substantially insignificant as a higher TEA value is balanced by a higher grammage and a lower TEA value is compensated for in the division by a lower grammage. Consequently, the TEA index does not vary to any great extent depending on grammage. The TEA value, on the other hand, is typically varied with grammage. Accordingly, the grammage of the paper according to ISO 536:2020 maybe 50-125 g/m^2 and TEA in MD according to ISO 1924-3:2011 is then least 375 J/m^2, such as at least 425 J/m^2. Alternatively, the grammage of the paper according to ISO 536:2020 may be 126-200 g/m^2 and TEA in MD according to ISO 1924-3:2011 is at least 600 J/m^2, such as at least 650 J/m^2.

[0017] As a second aspect of the present disclosure there is provided a method of producing a kraft paper having a stretchability according to ISO 1924-3:2011 in the MD and CD of at least 8 %, wherein the method comprises the following steps:

a) providing a kraft pulp;

b) diluting the kraft pulp into a pulp stock;

c) adding to the stock based on dry weight of the pulp stock 5-10 kg/tonne of cationic starch, 0.25-1.00 kg/tonne of AKD or ASA, 1.00-3.00 kg/tonne of rosin size and 0.5-5 kg/tonne glyoxylated polyacrylamide (G-PAM);

d) diluting the pulp stock in a headbox;

e) adding the diluted pulp stock from the headbox to a forming wire to obtain a paper web;

f) pressing the paper web; and

g) drying the pressed paper web into a paper, which drying comprises a step of compacting the paper web in a Clupak unit or an Expanda unit.

[0018] Typically, the G-PAM is added in an amount of 1.0-4.0 kg/tonne based on dry weight of the pulp stock, such as 1.8-3.0 kg/tonne based on dry weight of the pulp stock.

[0019] Typically, step c) further comprises adding retention aid(s) to the pulp stock, wherein the/each retention aid is added in an amount of 0.03-0.12 kg/tonne based on dry weight of the pulp stock; and
the dilution in step d) is conducted with a headbox dilution ratio of 9-13 %, wherein the headbox dilution ratio is the dilution water flow into the headbox divided by the pulp stock flow into the headbox.

[0020] The inventors have realized that surface roughness is improved, i.e. lowered, by using a dilution ratio of 9-13% in the headbox. A low surface roughness is beneficial for printing properties and lamination with a plastic film or glue, and in particular for low amounts of glue the roughness should be low. Typically, the headbox dilution ratio is 9.5-12 %, such as 9.5-11.5 %. This is an increased dilution ratio compared with what is customary for paper and identified as an optimum in combination with the amount of retention aid(s) for obtaining a smooth paper. The dilution of the stock will, thereby, to a greater extent be conducted in the headbox instead of before the headbox. The dilution is typically conducted by using a headbox having actuators as well as several dilution zones in the headbox. Further, the actuator average dilution percentage is typically 56-64 % open, such as 60-62% open. The headbox dilution ratio is the dilution water flow into the headbox divided by the pulp stock flow into the headbox. Typically, the dilution ratio is increased by increasing the dilution water flow without making any significant adjustments of the pulp stock flow.

[0021] Preferably, the final consistency of the pulp stock in the headbox, that is the pulp stock applied to the forming wire, is 0.20-0.30 % based on dry weight when added to the forming wire. Such consistency is comparable to consistencies regularly used when forming paper. That is, even though the dilution ratio is higher than is customary for paper, the final consistency is not substantially altered.

[0022] The amount of pulp stock that is applied on the wire per second is controlled by a slice opening arrangement of the headbox. The slice opening arrangement consists of two lips that are parallel to each other, a stationary lip and a regulating lip. Depending on the distance between the lips i.e. vertical lip opening, the pulp stock flow from the headbox to the wire can be varied. Typically, the headbox has a vertical lip opening of 42-60 mm, such as 45-56 mm. Typically, the lip opening is lower when the grammage is lower and higher when the grammage is higher. For example, when the intended grammage is 50-120 g/m^2, such as 90-120 g/m^2, the lip opening is typically 42-50 mm, and when the intended grammage is 120-200 g/m^2, such as 120-175 g/m^2 the lip opening is typically 50-60 mm. Combining such vertical lip opening with the headbox dilution ratio and amount of retention aid(s), synergistically further improves roughness.

[0023] To further improve surface roughness, retention aid(s) may be added to the pulp stock, wherein the/each retention aid is added in an amount of 0.03-0.12 kg/tonne based on dry weight of the pulp stock. Preferably, the/each retention aid is added an amount of 0.04-0.10 kg/tonne based on dry weight of the pulp stock, such as 0.04-0.08 kg/tonne based on dry weight of the pulp stock. Typically, one retention aid is cationic, such as a cationic polymer, such as cationic polyacrylamide (cPAM), polyethyleneimine (PEI) or mixtures thereof. If a cationic retention aid is added in such amount, the paper will be less open, which is beneficial for low surface roughness. Typically, one other retention aid is anionic, such as anionic inorganic particles, such as silica microparticles, bentonite clay, or mixtures thereof. In case only one type of retention aid is added, it is preferred that this type is an anionic retention aid. The inventors have realized that there is a synergistic effect with respect to improved roughness of the addition of retention aid(s) wherein the/each retention aid is added in an amount of 0.03-0.12 kg/tonne, preferably 0.04-0.10 kg/tonne, such as 0.04-0.08 kg/tonne, based on dry weight of the pulp stock and using the specific dilution ratio in the headbox.

[0024] It is preferred that the kraft pulp is a softwood pulp as the long fibres of softwood provides mechanical strength. Accordingly, the kraft 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.

[0025] The kraft pulp may be bleached or unbleached. If the kraft pulp is unbleached, typically less than 0.05 kg/tonne of anionic polymer is added to the pulp stock, such as no anionic polymer is added to the pulp stock. The inventors have realized that since unbleached pulp is inherently anionic there is no need for adding an additional anionic polymer to the pulp stock, which is beneficial from a cost and environmental perspective. On the other hand, in case the kraft pulp is bleached, typically an anionic polymer, such as anionic polyacrylamide (A-PAM), is added to the pulp stock to balance the charge of the pulp. The anionic polymer, such as A-PAM, may be added in a total amount of 0.20-1.00 kg/tonne dry fibre, such as 0.25-0.75 kg/tonne dry fibre, such as 0.35-0.55 kg/tonne dry fibre.

[0026] The paper may be calendered after being compacted in the Clupak unit or the Expanda unit. In such case, the calender is preferably a soft nip calender. A soft nip calender comprises a soft, resilient, calender roll and a hard backing roll, typically a steel roll. The steel roll may be heated, by e.g. steam or oil. If the paper is calendered, the Bendtsen roughness according to ISO 8791-2:2013 of at least one side of the paper typically becomes 200-700 ml/min.

[0027] Typically, the kraft pulp is subjected to high consistency (HC) refining followed by low consistency (LC) refining before dilution into a pulp stock in step b). The HC refining and the LC refining increase the stretchability in both MD and CD. The consistency of the pulp subjected to HC refining is typically 25-40 %, such as 30-40 %, such as 33-40 %. The consistency of the pulp subjected to LC refining is typically 2-6 %. The total energy supply energy supply in the HC and LC refining may be 500-1000 kWh per ton paper.

[0028] The examples and embodiments discussed above in connection to the first aspect apply to the second aspect *mutatis mutandis.*

[0029] As a third aspect of the present disclosure there is provided a kraft paper, wherein the paper is having a stretchability according to ISO 1924-3:2011 in MD and CD of at least 8 %, and an approved water-resistant carrying capacity according to a modified version of EN13590:2003, wherein the modified version of EN13590:2003 is conducted accordingly:

- produce from the paper a block-bottomed self-opening satchel carrier bag (SOS bag) with handles according to dimensions in EN13590:2003, wherein the block-bottomed fold as well as side seam and handles are adhered with a polyvinyl acetate (PVAc) adhesive;
- fill the paper SOS-bag with filling material according to EN13590:2003;
- provide a tray filled with water;
- arrange the paper SOS-bag with filling material on the tray for at least 1 minute to saturate the bottom of the SOS-bag with water;
- using the test equipment of EN13590:2003 lift the bag from the tray and hold it in the air for 3 minutes;
- conduct the determination of carrying capacity according to EN13590:2003, wherein lowering the bag is conducted so that the bag is lowered onto the tray with water thereby immersing the bottom of the bag each time the bag is lowered;
- lift and lower the bag 1000 times or until it breaks according to EN13590:2003; and
- the test is passed if at least three bags are tested and average times of lifting the bags before breakage according to EN13590:2003 is at least 500 times.

[0030] The wet immediate tensile strength evaluates the short-term wet strength properties. However, also the long-term wet strength properties are important. The long-term wet strength properties were evaluated by producing paper bags from the papers. The paper bags were filled with filling material simulating what one would carry in a paper bag, and the bag was alternating between lifting and be put on the ground into water to simulate one lifting the bag form the ground and placing the bag on a wet ground over and over again, just as a typical consumer uses a paper bag.

[0031] Thereby, a paper according to the present disclosure provides a combination of stretchability and short-term as well as long-term wet strength properties.

[0032] The examples and embodiments discussed above in connection to the first and second aspects apply to the third aspect *mutatis mutandis.*

[0033] As a fourth aspect of the present disclosure, there is provided a block-bottomed self-opening satchel carrier bag (SOS bag) formed from the paper according to the first aspect of the present disclosure.

[0034] The examples and embodiments discussed above in connection to the first ,second and third aspects apply to the fourth aspect *mutatis mutandis.*

EXAMPLES

Preparation of paper

[0035] Unbleached softwood kraft pulp was provided. The pulp was diluted into a pulp stock and subjected to high consistency (HC) refining (240-280 kWh per ton pulp) at a consistency of about 33-36 % followed by low consistency (LC) refining to a total energy consumption of 790-810 kWh/ton pulp. To the refined pulp stock, cationic acrylamide (cPAM) was added in a content of 0.15 kg/tonne or 0.08 kg/tonne based on dry weight as well as anionic silica microparticles in a content of 0.3-0.35 kg/tonne or 0.08 kg/tonne based on dry weight. Cationic starch (7 kg per dry tonne paper), rosin size (2 kg per dry tonne paper), alum (8.1 kg per dry tonne paper) and AKD (0.5 kg per dry tonne paper) were also added. Glyoxylated polyacrylamide (G-PAM) was either added in an amount of 2.4 kg/tonne or not added at all to the refined pulp stock.
[0036] The pulp stock was forwarded into a headbox (Voith Sulzer type ModuleJet SD year 1998), wherein the pulp stock was diluted. The stock flow into the headbox was 2469 l/s, and the dilution water flow was 207 l/s or 257 1/s. 207 l/s provides a dilution ratio of 8.4 % (207/2469*100) and 257 l/s provides a dilution ratio of 10.4% (257/2469*100). In both cases, the stock was diluted to a final headbox consistency of 0.23-0.25 % based on dry weight.
[0037] The stock was, thereafter, added to a forming wire with a speed of 440 m/min to obtain a paper web. The vertical lip of the headbox was set to 48 mm, 50 mm or 52-56 mm. The paper web was dewatered in a press section having three nips. The dewatered paper web was then dried in a subsequent drying section including one Clupak unit to obtain a paper. Papers were produced having a grammage of 100 g/m^2, 120 g/m^2 and 150 g/m^2.
[0038] The differences in production process between the papers are presented in table 1 below.

Evaluation of the produced papers

[0039]

Table 1. Production process variables for references (Refs) and inventive examples (IEs) of papers.

Paper#	Retention aids	GPAM addition	Headbox dilution ratio	Headbox lip opening	Grammage (g/m^2)
1	cPAM: 0.15 kg/tonne SM[1]: 0.3-0.35 kg/ton	0 kg/tonne	8.4 %	48 mm	100 & 150
2	cPAM: 0.15 kg/tonne SM[1]: 0.3-0.35 kg/ton	0 kg/tonne	10.4 %	48 mm	100 & 150
3	cPAM: 0.08 kg/tonne SM[1]: 0.08 kg/ton	0 kg/tonne	10.4 %	48 mm	100 & 150
4	cPAM: 0.08 kg/tonne SM[1]: 0.08 kg/tonne	2.4 kg/tonne	10.4 %	45 mm	100
5	cPAM: 0.08 kg/tonne SM[1]: 0.08 kg/tonne	2.4 kg/tonne	10.4 %	50 mm	120
[1] Anionic Silica Microparticles					

[0040] The papers were evaluated according to the following standards:

- Grammage: ISO 536:2020
- Stretchability CD and MD: ISO 1924-3:2011
- Bendtsen roughness on the print side, i.e. wire side: ISO 8791-2:2013
- Wet immediate tensile strength in MD and CD: ISO 3781:1983 using 10 min immerse time
- Tensile strength in MD: ISO 1924-3:2011
- Gurley seconds: ISO 5636-5:2013

[0041] The index values are obtained by dividing respective property with grammage.
[0042] As a measure of how well a wet paper is performing, the wet immediate tensile index measured according to ISO 3781:1983 using 10 min immerse time was divided by the dry, i.e. regular, tensile index measured according to

1924-3:2011. The result is presented as percentage, i.e. the percentage of wet strength out of dry strength. If the numbers would be 100 %, the paper would be performing equally good wet as dry with respect to tensile index.

[0043] Properties of the papers produced in the trials are presented in table 2 below.

Table 2. Properties of produced papers.

Paper#	Grammage (g/m^2)	Stretch CD (%)	Stretch MD (%)	Bendtsen Roughness print (wire) side (ml/min)	Wet tensile index MD (kN/m)	Wet tensile index CD (kN/m)	Wet tensile index to dry tensile index in MD ratio (%)
1	100	9.7	12.2	2094	0.55	-	5.9
1	150	9.8	13.4	2597	1.10	-	7.8
2	100	9.3	12.6	2185	-	-	-
2	150	9.9	12.9	1934	-	-	-
3	100	9.6	12.8	1407	-	-	-
3	150	9.4	13.2	1728	-	-	-
4	100	10.3	14.1	1372	1.42	-	15.3
5	120	10.0	13.2	1800	1.86	1.34	15.7

[0044] The inventors have realized that kraft paper having therein G-PAM in combination with cationic starch, AKD and rosin size in the particular amounts used herein provides for a high wet strength in combination with high stretch at break in both MD and CD, which is shown for papers 4-5. Regarding paper 4 it is fair to assume that the wet tensile index in CD also is comparable to the one in paper 5 since it contains the same additives. Moreover, smooth papers in terms of low Bendtsen roughness was obtained for papers 3-5. Hence, the inventors also realized that the amount of retention aids and headbox dilution ratio provides for the low roughness, which is beneficial for printing. Moreover, the inventors have further realized that due to the inherent anionic charge of unbleached pulp, the G-PAM can be added without addition of an anionic wet strength polymer, which is beneficial form a cost and environmental perspective.

[0045] Further mechanical properties of the papers were evaluated and presented in table 3 below.

Table 3. Properties of papers.

Paper#	Grammage (g/m^2)	TEA MD (J/m^2)	TEA CD (J/m^2)	TEA Index MD (J/g)	TEA Index CD (J/g)	Gurley value (s)
1	100	450	280	4.5	2.8	19
1	150	710	460	4.7	3.0	-
4	100	511	353	5.0	3.5	30
5	120	641	447	5.3	3.7	38

Wet strength evaluation of paper bags made from the produced papers

[0046] To test the long-term wet strength of the papers, the water-resistant carrying capacity according to a modified version of EN13590:2003 was conducted. The modified version of EN13590:2003 was conducted accordingly:

- produce from the paper a block-bottomed self-opening satchel carrier bag (SOS bag) with handles according to dimensions in EN13590:2003, wherein the block-bottomed fold as well as side seam and handles are adhered with a polyvinyl acetate (PVAc) adhesive;

- fill the paper SOS-bag with filling material according to EN13590:2003;

- provide a tray filled with water;

- arrange the paper SOS-bag with filling material on the tray for at least 1 minute to saturate the bottom of the SOS-bag with water;

- using the test equipment of EN13590:2003 lift the bag from the tray and hold it in the air for 3 minutes;
- conduct the determination of carrying capacity according to EN13590:2003, wherein lowering the bag is conducted so that the bag is lowered onto the tray with water thereby immersing the bottom of the bag each time the bag is lowered;
- lift and lower the bag 1000 times or until it breaks according to EN13590:2003.

[0047] The test is passed if the average times of lifting the bag before breakage according to EN13590:2003 was at least 500 times.

[0048] The papers used for producing the bags were paper #1 (100 g/m^2), paper# 4 (150 g/m^2) and paper# 5. Up to three bags per paper were produced and tested. The results from the test are shown in Table 4 below.

Table 4. Number of lifts of the different bags.

	Paper# 1 (100 g/m^2)	**Paper# 3 (150 g/m^2)**	**Paper# 4**
Bag #1	15	38	163
Bag #2	16		999
Bag #3	18		999
Average	16.3	38	720.3

[0049] The inventors realized that it was not only the short-term wet strength properties as evaluated by the wet immediate tensile strength according to ISO 3781:1983 using 10 min immerse time. But, also the long-term wet strength properties. The long-term wet strength properties were evaluated by producing paper bags from the papers. The paper bags were filled with filling material simulating what one would carry in a paper bag, and the bag was alternating between lifting and be put on the ground into water to simulate one lifting the bag form the ground and placing the bag on a wet ground over and over again. The inventors realized that the paper 5 containing the particular combination of kraft pulp containing G-PAM in combination with cationic starch, AKD and rosin size, could be transformed into bags that could repeatedly be lifted and put on the wet ground for several hundreds of times. In fact, for Bag #2 and Bag #3, the test was cancelled after reaching 999 times since neither of the bags had broken at that point so if the test would have continued until breakage those numbers would be even higher.

Claims

1. A stretchable paper comprising at least 90% by dry weight of kraft pulp fibres, wherein the stretchability according to ISO 1924-3:2011 of the paper is at least 8.0 % in the machine direction (MD) and the cross direction (CD) and wherein the paper comprises 5-10 kg/tonne of cationic starch based on dry weight of the paper, 0.25-1.00 kg/tonne of AKD or ASA based on dry weight of the paper, 1.00-3.00 kg/tonne of rosin size based on dry weight of the paper and 0.5-5.0 kg/tonne of glyoxylated polyacrylamide (G-PAM) based on dry weight of the paper.

2. The paper of claim 1, wherein the grammage of the paper according to ISO 536:2020 is 50-200 g/m^2, such as 90-175 g/m^2.

3. The paper of claim 1 or 2, wherein the paper has a stretchability according to ISO 1924-3:2011 in MD of at least 10%, such as at least 11 %, such as at least 12 %.

4. The paper of any one of the preceding claims, wherein the paper has a stretchability according to ISO 1924-3:2011 in CD of at least 9%.

5. The paper of any one of the preceding claims, wherein the Bendtsen roughness according to ISO 8791-2:2013 of at least one side of the paper is 2000 ml/min or lower, such as 1850 ml/min or lower, such as 1600 ml/min or lower.

6. The paper of any one of the preceding claims, wherein the wet immediate tensile strength in MD according to ISO 3781:1983 using 10 min immerse time, is at least 1.1 kN/m, such as at least 1.3 kN/m, such as at least 1.6 kN/m.

7. The paper of any one of the preceding claims, wherein the Gurley value according to ISO 5636-5:2013 of the paper is

at least 25 s, such as at least 30 s.

8. Method of producing a kraft paper having a stretchability according to ISO 1924-3:2011 in the MD and CD of at least 8 %, wherein the method comprises the following steps:

a) providing a kraft pulp;
b) diluting the kraft pulp into a pulp stock;
c) adding to the stock based on dry weight of the pulp stock 5-10 kg/tonne of cationic starch, 0.25-1.00 kg/tonne of AKD or ASA, 1.00-3.00 kg/tonne of rosin size and 0.5-5 kg/tonne glyoxylated polyacrylamide (G-PAM);
d) diluting the pulp stock in a headbox;
e) adding the diluted pulp stock from the headbox to a forming wire to obtain a paper web;
f) pressing the paper web; and
g) drying the pressed paper web into a paper, which drying comprises a step of compacting the paper web in a Clupak unit or an Expanda unit.

9. The method of claim 8, wherein step c) further comprises adding retention aid(s) to the pulp stock, wherein the/each retention aid is added in an amount of 0.03-0.12 kg/tonne based on dry weight of the pulp stock; and
the dilution in step d) is conducted with a headbox dilution ratio of 9-13 %, wherein the headbox dilution ratio is the dilution water flow into the headbox divided by the pulp stock flow into the headbox.

10. The method of claim 8 or 9, wherein the G-PAM is added in an amount of 1.0-4.0 kg/tonne based on dry weight of the pulp stock, such as 1.8-3.0 kg/tonne based on dry weight of the pulp stock.

11. The method of any one of the claims 8-10, wherein the/each retention aid is added an amount of 0.04-0.10 kg/tonne based on dry weight of the pulp stock, such as 0.04-0.08 kg/tonne based on dry weight of the pulp stock.

12. The method of any one of the claims 8-11, wherein one retention aid is cationic, such as a cationic polymer, such as cationic polyacrylamide (cPAM), polyethyleneimine (PEI) or mixtures thereof.

13. The method of any one of the claims 8-12, wherein one retention aid is anionic, such as anionic inorganic particles, such as silica microparticles, bentonite clay or mixtures thereof.

14. A kraft paper, wherein the paper is having a stretchability according to ISO 1924-3:2011 in MD and CD of at least 8 %, and an approved water-resistant carrying capacity according to a modified version of EN13590:2003, wherein the modified version of EN13590:2003 is conducted accordingly:

- produce from the paper a block-bottomed self-opening satchel carrier bag (SOS bag) with handles according to dimensions in EN13590:2003, wherein the block-bottomed fold as well as side seam and handles are adhered with a polyvinyl acetate (PVAc) adhesive;
- fill the paper SOS-bag with filling material according to EN13590:2003;
- provide a tray filled with water;
- arrange the paper SOS-bag with filling material on the tray for at least 1 minute to saturate the bottom of the SOS-bag with water;
- using the test equipment of EN13590:2003 lift the bag from the tray and hold it in the air for 3 minutes;
- conduct the determination of carrying capacity according to EN13590:2003, wherein lowering the bag is conducted so that the bag is lowered onto the tray with water thereby immersing the bottom of the bag each time the bag is lowered;
- lift and lower the bag 1000 times or until it breaks according to EN13590:2003; and
- the test is passed if at least three bags are tested and average times of lifting the bags before breakage according to EN13590:2003 is at least 500 times.

15. A block-bottomed self-opening satchel carrier bag (SOS bag) formed from the paper according to any one of the claims 1-7.

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EUROPEAN SEARCH REPORT

Application Number
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D21H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 March 2024	Ponsaud, Philippe

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