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(54) **FIBRE FRACTIONATION**

(57) There is provided a method of producing a multi-layer paperboard comprising a first layer, a second layer and a third layer, wherein the second layer is arranged between the first layer and the third layer, which method comprises the steps of:
a) providing a first broke pulp and optionally a second broke pulp;
b) mixing the first broke pulp with a chemical pulp to obtain a first pulp mixture;
c) fractionation of the first pulp mixture to obtain a reject fraction and an accept fraction;
d) mixing the reject fraction with the second broke pulp and/or an additional pulp to obtain a second pulp mixture;
e) forming the second layer from the second pulp mixture; and
f) forming the first layer from a pulp comprising the accept fraction.

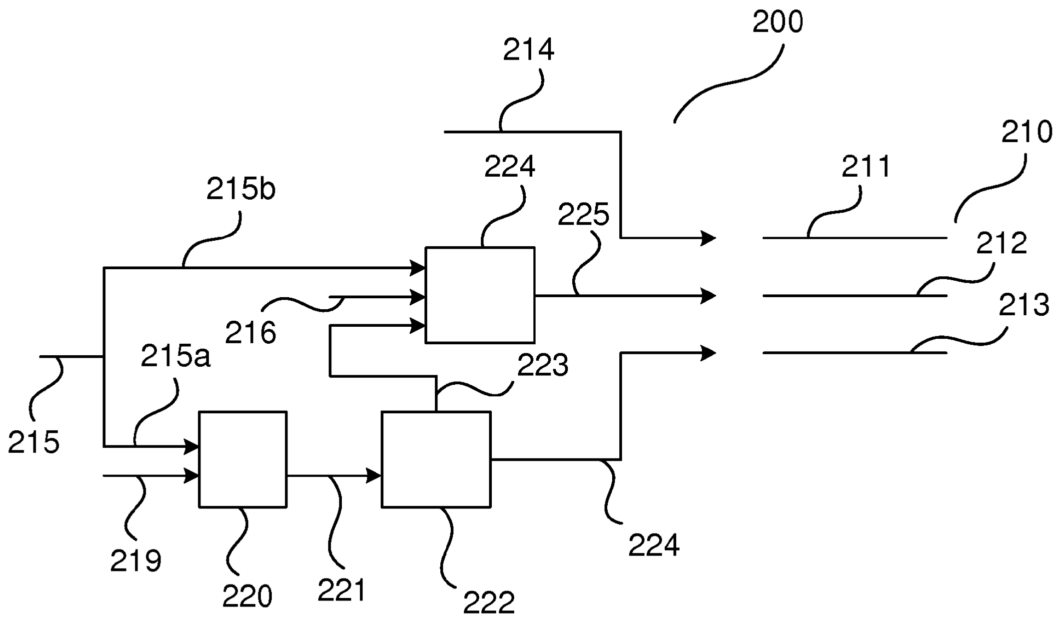

Fig. 2

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Description

TECHNICAL FIELD

[0001] The invention relates to the field of paperboard production in a paperboard machine.

BACKGROUND

[0002] Stiffness in the form of bending resistance is an important parameter for many paperboard applications. The prior art describes many ways of increasing this stiffness, preferably with minimal increase in fibre consumption as fibre is a main cost driver in paperboard production. One way is to produce a paperboard of at least three layers, wherein the outer layers have a relatively high tensile stiffness and the middle layer is bulky and relatively low tensile stiffness.

[0003] Another paperboard property of interest is the surface roughness, in particular that of the top surface that is typically intended for printing.

SUMMARY

[0004] It is an objective of the present disclosure to reduce the fibre consumption in production of multi-layer paperboard without decreasing the bending resistance.

[0005] The objective has been met by mixing broke pulp that was previously only used for the middle layer with chemical pulp that was previously used for the bottom layer and fractionating the mixture so as to obtain an accept fraction that is used for forming the bottom layer and a reject fraction that is mixed with unfractionated broke pulp and/or another pulp and then used for forming the middle layer.

[0006] Accordingly, the present disclosure provides a method of producing a multi-layer paperboard comprising a first layer, a second layer and a third layer, wherein the second layer is arranged between the first layer and the third layer, which method comprises the steps of:

a) providing a first broke pulp and optionally a second broke pulp;
b) mixing the first broke pulp with a chemical pulp to obtain a first pulp mixture;
c) fractionation of the first pulp mixture to obtain a reject fraction and an accept fraction;
d) mixing the reject fraction with the second broke pulp and/or an additional pulp to obtain a second pulp mixture;
e) forming the second layer from the second pulp mixture; and
f) forming the first layer from a pulp comprising the accept fraction.

[0007] The method of the present disclosure results in a substantial increase of the bending resistance index, which allows for a substantial reduction of the fibre consumption. Further, the method of the present disclosure allows for increased production rates. Also, it reduces the top surface roughness. This reduction allows for less calendering, which in turn further improves the bending resistance index.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figure 1 illustrates a traditional (non-inventive) method 100 of producing a three-layer paperboard 110 having a top layer 111, a middle layer 112 and a bottom layer 113. Refined bleached kraft pulp 114 is used to form the top layer 111. Broke pulp 115 and low-refined unbleached kraft pulp 116 is mixed in a mixing chest 117. A pulp mixture 118 from the mixing chest 117 is used to form the middle layer 112. High-refined unbleached kraft pulp 119 is used to form the bottom layer 113.

Figure 2 illustrates a non-limiting embodiment of an inventive method 200 of producing a three-layer paperboard 210 having a top layer 211, a middle layer 212 and a bottom layer 213. Refined bleached kraft pulp 214 is used to form the top layer 211. Broke pulp 215 is divided into a first portion 215a and a second portion 215b. The first portion 215a is mixed with refined unbleached kraft pulp 219 in a first mixing chest 220 to obtain a first pulp mixture 221. The first pulp mixture 221 is then fractioned in a fractionation device 222 such that a reject fraction 223 and an accept fraction 224 are obtained. The accept fraction 224 is then used to form the bottom layer 213. The reject fraction 223 is mixed with the second portion 215b of the broke pulp and unbleached chemical pulp 216 in a second mixing chest 224 to obtain a second pulp mixture 225. The second pulp mixture 225 is used to form the middle layer 212.

Figure 3 shows bending resistance index values (y axis (Nm^6/kg^3)) at 13 different positions (x axis) in the cross direction (CD) of board produced in Machine trial 1:

- before the inventive method (i.e. according to the traditional method);
- according to the inventive method; and
- after the inventive method (i.e. according to the traditional method).

The average bending resistance index was 12.2 Nm^6/kg^3 before the inventive method, 13.4 Nm^6/kg^3 with the inventive method and 12.3 Nm^6/kg^3 after the inventive method.

Figure 4 shows Bendtsen surface roughness values (y axis (ml/min)) at 13 different positions (x axis) in the CD of board produced in Machine trial 1:

- before the inventive method (i.e. according to the traditional method);
- according to the inventive method; and
- after the inventive method (i.e. according to the traditional method).

The average Bendtsen surface roughness was 105 ml/min before the inventive method, 58 ml/min with the inventive method and 95 ml/min after the inventive method.

Figure 5 shows Bendtsen surface roughness values (y axis (ml/min)) at 13 different positions (x axis) in the CD of board produced in Machine trial 2:

- before the inventive method (i.e. according to the traditional method) using a pre-calender line load of 20.0 kN/m;
- according to the inventive method using a pre-calender line load of 20.0 kN/m;
- according to the inventive method using a pre-calender line load of 15.0 kN/m;
- according to the inventive method using a pre-calender line load of 14.3 kN/m;
- according to the inventive method using a pre-calender line load of 13.0 kN/m;
- according to the inventive method using a pre-calender line load of 12.0 kN/m; and
- after the inventive method (i.e. according to the traditional method) using a pre-calender line load of 20.0 kN/m.

Figure 6 shows bending resistance index values (y axis (Nm^6/kg^3)) at 13 different positions (x axis) in the CD of board produced in Machine trial 2:

- before the inventive method (i.e. according to the traditional method) using a pre-calender line load of 20.0 kN/m;
- according to the inventive method using a pre-calender line load of 20.0 kN/m;
- according to the inventive method using a pre-calender line load of 15.0 kN/m;
- according to the inventive method using a pre-calender line load of 14.3 kN/m;
- according to the inventive method using a pre-calender line load of 13.0 kN/m;
- according to the inventive method using a pre-calender line load of 12.0 kN/m; and
- after the inventive method (i.e. according to the traditional method) using a pre-calender line load of 20.0 kN/m.

Figure 7 shows the average basis weight (y axis (g/m^2)) at 13 different positions (x axis) in the CD of board produced in Machine trial 2:

- before the inventive method (i.e. according to the traditional method) using a pre-calender line load of 20.0 kN/m;
- according to the inventive method using a pre-calender line load of 20.0 kN/m;
- according to the inventive method using a pre-calender line load of 15.0 kN/m;
- according to the inventive method using a pre-calender line load of 14.3 kN/m;
- according to the inventive method using a pre-calender line load of 13.0 kN/m;
- according to the inventive method using a pre-calender line load of 12.0 kN/m; and
- after the inventive method (i.e. according to the traditional method) using a pre-calender line load of 20.0 kN/m.

DETAILED DESCRIPTION

[0009] The present disclosure relates to a method of producing a multi-layer paperboard in a paperboard machine (i.e. of full-scale paperboard machine, not a pilot machine). The multi-layer paperboard comprises at least three layers. Consequently, it comprises a first layer, a second layer and a third layer, wherein the second layer is arranged between the first layer and the third layer. The second layer is thus a so-called middle layer. The multi-layer paperboard may comprise more than one middle layer, such as two or three middle layers. The third layer is typically a top layer, e.g. for printing, and the first layer is typically a bottom layer.

[0010] The method comprises the step of:

a) providing a first broke pulp and optionally a second broke pulp.

[0011] In one embodiment, step a) thus comprises providing the first broke pulp and the second broke pulp.

[0012] The first and the second broke pulp may be obtained from different broke pulps. However, they are typically obtained from the same broke pulp that is divided into two portions.

[0013] The broke pulp(s) is/are normally (and preferably) obtained from same method as it/they is/are used in.

[0014] The method further comprises the step of:

b) mixing the first broke pulp with a chemical pulp to obtain a first pulp mixture.

[0015] The dry weight ratio of broke pulp to chemical pulp in the first mixture may for example be between 15:85 and 70:30, preferably between 20:80 and 55:45. Accordingly, the proportion of broke pulp in the first pulp mixture may be 15-70 %, such as 20-55 %, by dry weight.

[0016] The chemical pulp of step b) is preferably unbleached. However, it may also be bleached. In one embodiment, the chemical pulp of step b) is a kraft pulp.

[0017] In one embodiment, the proportion of softwood pulp in the chemical pulp of step b) is at least 50 %, such as at least 75 %, such as at least 90 %, by dry weight.

[0018] The chemical pulp of step b) is normally refined even though the method of the present disclosure generally requires less refining than prior art methods. As an example, the chemical pulp of step b) may have been subjected to refining to a degree of 20-120 kWh/ton, such as 30-100 kWh/ton. As an example, the Schopper-Riegler (SR) number measured according to ISO 5267-1:1999 of the refined chemical pulp of step b) may be below 20, such as below 17, such as 16 or lower. A typical lower limit is 13.

[0019] The chemical pulp of step b) may comprise a strength agent, such as starch, e.g. starch in an amount of 5-10 kg/ton dry fibres.

[0020] Step b) is typically carried out in a mixing chest.

[0021] The method further comprises the step of:

c) fractionation of the first pulp mixture to obtain a reject fraction and an accept fraction.

[0022] The dry weight ratio of the reject fraction to the accept fraction is preferably between 20:80 and 75:25, more preferably between 30:70 and 55:45.

[0023] The fractionation may for example be carried out by means of one or more screens (see e.g. Fredlund M. et al., "Förbättrade kvalitetsegenskaper hos kartong genom fraktionering", STFI-rapport TF 23, Augusti 1996; and Grundström K-J, "STFIs silteknik höjer kvaliteten vid kommersiell drift", STFI Industrikontakt, 1995, no. 1, p. 7-8).

[0024] Preferably, the fractionation is carried out by hydrocyclones (see e.g. Jonas Bergström's Doctoral Thesis "Flow Field and Fibre Fractionation Studies in Hydrocyclones" (1996)).

[0025] It has been reported that a screen primarily fractionates fibres according to their length, while hydrocyclones primarily fractionate fibres according to their thickness. Thickness-based fractionation is considered to be particularly beneficial for the method of the present disclosure (i.a. because of the successful use of hydrocyclones in the machine trials described below). Accordingly, the average fibre wall thickness is preferably greater in the reject fraction than in the accept fraction. The average fibre wall thickness may for example be measured by a colorimetric-based quantification technology commercialized by PulpEye AB (Örnsköldsvik, Sweden) (see also US7289210 B2). PulpEye AB has developed a module for fibre wall thickness measurements called the PulpEye Fibre Wall Thickness (FWT) module. The PulpEye FTW module may be acquired for a measurement of an average fibre wall thickness of a sample. Alternatively, the sample may be sent to PulpEye AB for the measurement. The average fibre wall thickness may also be measured by the MorFi wall thickness device that has been developed by CTP and is industrialized and distributed by Techpap.

[0026] Further, the fines content (%) is preferably higher in the accept fraction than in the reject fraction. The fines content may be defined as the length-weighted proportion of fibres having a length below 0.2 mm. Such a proportion may be measured according to TAPPI T271, e.g. using the equipment kajaaniFS300. In one embodiment, the fines content is at least 50 % higher in the accept fraction than in the reject fraction.

[0027] Another way of distinguishing the accept fraction structurally from the reject fraction is by looking at the shives content. "Shives" are defined as fibre bundles having a width above 75 μm and a length above 0.3 mm. The unit of the shives content is number of shives per gram of dry material (#/g). In one embodiment, the shives content is at least 100

% higher, such as at least 150 % higher, in the reject fraction than in the accept fraction. The shives content may for example be measured using a PulpEye equipped with a shives content module.

[0028] It follows from the discussion above that it is preferred to use hydrocyclones for the fractionation of step c). The reject fraction from a fractionation with hydrocyclones typically has a consistency in the range of 1.0- 3.5 %. The accept fraction from a fractionation with hydrocyclones typically has a consistency in the range of 0.1-0.4 %.

[0029] The method further comprises the step of:

d) mixing the reject fraction with the second broke pulp and/or an additional pulp to obtain a second pulp mixture.

[0030] In one embodiment, the second pulp mixture is thus a mixture of the reject fraction and the second broke pulp. In this embodiment, the second broke pulp is thus provided in step a).

[0031] In another embodiment, the second pulp mixture is a mixture of the reject fraction and an additional pulp. For this embodiment, it is thus not required that step a) provides the second broke pulp.

[0032] In still another embodiment, the second pulp mixture is a mixture of the reject fraction, the second broke pulp and an additional pulp. In this embodiment, the second broke pulp is thus provided in step a). In this embodiment, the dry weight ratio of the second broke pulp to the additional pulp may be between 1:4 and 4:1, such as between 1:4 and 1:1.

[0033] The amount of the reject fraction that is added in the mixing of step d) is preferably such that its proportion in the second pulp mixture is 25-70 %, such as 30-60 %, such as 40-55 %, by dry weight.

[0034] The additional pulp may be a mechanical pulp, such as chemithermomechanical pulp (CTMP) or thermomechanical pulp (TMP), but it is preferably a chemical pulp. When the additional pulp is a chemical pulp, it is preferably provided by the same pulping process as the chemical pulp of step b). However, the chemical pulp added in the mixing of step d) may have been subjected to less refining than the chemical pulp of step b) or even no refining (since the chemical pulp added in the mixing of step d) will only be used in the second/middle layer).

[0035] In one embodiment, the method comprises the step of dividing a chemical pulp into a first part that becomes the chemical pulp of step b) and a second part that becomes the additional pulp that is added in the mixing of step d). It follows from the discussion above that in this embodiment, the first part is preferably subjected to more refining (typically measured as kWh/ton) than the second part. Accordingly, the Schopper-Riegler (SR) number (measured according to ISO 5267-1:1999) is preferably higher for the first part than for the second part.

[0036] The second pulp mixture may comprise a strength agent, such as starch, e.g. starch in an amount of 5-10 kg/ton dry fibres.

[0037] Step d) is typically carried out in a mixing chest.

[0038] The method further comprises the steps of:

e) forming the second layer from the second pulp mixture; and
f) forming the first layer from a pulp comprising the accept fraction.

[0039] In a preferred embodiment, the first layer is formed from the accept fraction in step f). According to this preferred embodiment, the accept fraction is not mixed with any other pulp before the first layer is formed.

[0040] The method may also comprise the step of forming the third layer from a pulp comprising chemical pulp, such as bleached chemical pulp, such as bleached kraft pulp. In one embodiment, the pulp used for forming the third layer is a mixture of hardwood pulp and softwood pulp. The pulp used for forming the third layer is preferably refined, e.g. such that it has a higher Schopper-Riegler (SR) number (measured according to ISO 5267-1:1999) than the chemical pulp of step b).

[0041] The pulp used to form the third layer may comprise a strength agent, such as starch, e.g. starch in an amount of 5-10 kg/ton dry fibres.

[0042] The forming of paperboard layers from pulps in a paperboard machine is well known to the skilled person and therefore not further discussed here.

[0043] The method may further comprise the step of coating the multi-layer paperboard by applying a coating composition, such as a pigment coating composition, onto the third layer, e.g. to further improve the printing properties.

[0044] The grammage measured according to ISO 536 of the multi-layer paperboard produced by the method is typically between 150 and 500 g/m^2, such as between 160 and 450 g/m^2, such as between 170 and 350 g/m^2. When the grammage is measured, any coating is excluded.

EXAMPLES

Machine trial 1

[0045] In Machine trial 1, an inventive method of producing a three-layer paperboard was compared to a traditional method of producing a three-layer paperboard.

[0046] In the traditional method, high-refined bleached kraft pulp was used to form a top layer, high-refined unbleached kraft pulp was used to form a bottom layer and a mixture of broke pulp and low-refined unbleached kraft pulp was used to form a middle layer. This is illustrated in figure 1.

[0047] In the inventive method (falling under the embodiment of figure 2), high-refined bleached kraft pulp was again used to form a top layer. In contrast to the traditional method, a first portion of the broke pulp was used for the bottom layer. In detail, a (first) mixture of broke pulp (30 %) and refined unbleached kraft pulp (70 %) was prepared and subsequently subjected to fractionation in hydrocyclones. The degree of refining of the refined unbleached was lower than for the high-refined unbleached pulp in the traditional method. The accept fraction from the fractionation was then used to form the bottom layer. To form a second pulp mixture for the formation of the middle layer, the reject fraction from the fractionation was added to a mixing chest. Further, a second portion of the broke pulp and low-refined unbleached kraft pulp were added to the mixing chest in a 1:2 dry weight ratio. The proportion of the reject fraction in the second mixture was 50 %.

[0048] The bending resistance index of the boards produced with the traditional and the inventive method was measured (see figure 3). It was shown that the inventive method increased the bending resistance index by about 9.4 %. Such an increase allows for a reduction of the basis weight by about 2 % (and thus a reduction of the fibre consumption by about 2 %). Further, the basis weight reduction allows for reduced steam consumption in the drying section.

[0049] Further, the roughness of the top surface of the boards produced with the traditional and the inventive method was measured (see figure 4). It was shown that the inventive method decreased the top surface roughness by about 42 %. This was highly surprising as the pulp used for the top layer was the same in the traditional method and the inventive method.

Machine trial 2

[0050] In Machine trial 2, a traditional method of producing a three-layer paperboard described under Machine trial 1 was compared to an inventive method of producing a three-layer paperboard ("Inventive trial 2").

[0051] In Inventive trial 2, the amount of starch (strength agent) in the middle layer was 8.5 kg/ton as compared to 6.8 kg/ton for the traditional method. Further, the amount of starch (strength agent) in the top layer was 8.0 kg/ton for Inventive trail 2 as compared to 6.0 kg/ton for the traditional method. The reason for increasing the amount of starch was to maintain the z direction strength when the composition of the middle layer was altered.

[0052] Just as in Machine trial 1, bleached kraft pulp was used to form a top layer, high-refined unbleached kraft pulp was used to form a bottom layer and a mixture of broke pulp and low-refined unbleached kraft pulp was used to form a middle layer in the traditional method. This is illustrated in figure 1. The degree of refining of the high-refined unbleached pulp of the bottom layer was 166 kWh/ton.

[0053] In Inventive trial 2 (falling under the embodiment of figure 2), bleached kraft pulp was again used to form a top layer. In contrast to the traditional method, a first portion of the broke pulp was used for the bottom layer. In detail, a (first) mixture of broke pulp (30 %) and refined unbleached kraft pulp (70 %) was prepared and subsequently subjected to fractionation in hydrocyclones. The degree of refining of the refined unbleached pulp was 80 kWh/ton, i.e. 52% less than for the high-refined unbleached pulp in the traditional method. The reduced refining reduces the energy consumption and facilitates dewatering. The accept fraction from the fractionation was then used to form the bottom layer. To form a second pulp mixture for the formation of the middle layer, the reject fraction from the fractionation was added to a mixing chest. Further, a second portion of the broke pulp and low-refined unbleached kraft pulp were added to the mixing chest in a 1:2 ratio. Even though the degree of refining was reduced for the unbleached kraft pulp used for the bottom layer, it was still higher than the degree of refining of the unbleached kraft pulp used exclusively for the middle layer (i.e. low-refined unbleached kraft pulp).

[0054] The roughness of the top surface of the board was decreased significantly by the Inventive trial 2 as compared to the traditional method. This allowed for a successive reduction of the line load in a pre-calender from 20 kN/m to 12 kN/m (see figure 5). At 12 kN/m, the surface roughness was still slightly lower than for the traditional method that used 20 kN/m. The line load reduction from 20 to 12 kN/m further improved the bending resistance index by about 8 % (see figure 6). In total, Inventive trial 2 decreased the basis weight by about 8 g/m^2 (corresponding to a reduction of the fibre consumption by almost 3 %) compared to the traditional method (see figure 7) without any negative impact on surface roughness or bending resistance. At the same time, Inventive trial 2 allowed for an increased production by almost 15 %, i.a. because the Inventive trial 2 consumes less steam per ton of produced board and allows for quicker dewatering.

Characterization of inject, accept fraction and reject fraction

[0055] A mixture of broke pulp and chemical pulp (i.e. a "first pulp mixture" according to the present disclosure, referred to as "inject" below) was fractionated using hydrocyclones into a accept fraction and a reject fraction.

[0056] Two samples were taken from each of the inject, the accept fraction and the reject fraction. The samples were sent to PulpEye for characterization. The results are presented in table 1 below.

Table 1. Characterization of samples. "Fines" have a length below 0.2 mm. "Shives" are defined as fibre bundles having a width above 75 μm and a length above 0.3 mm. The unit of the shives content is number of shives per gram of dry material (#/g).

Sample		Fines content (%)	Shives content (#/g)	Average fibre wall thickness (μm)
Inject	Sample 1	16.2	332	2.88
	Sample 2	16.6	238	2.89
Accept	Sample 1	26.2	121	2.82
	Sample 2	26.6	110	2.80
Reject	Sample 1	14.4	465	2.92
	Sample 2	12.9	613	2.92

Claims

1. A method of producing a multi-layer paperboard comprising a first layer, a second layer and a third layer, wherein the second layer is arranged between the first layer and the third layer, which method comprises the steps of:

   a) providing a first broke pulp and optionally a second broke pulp;
   b) mixing the first broke pulp with a chemical pulp to obtain a first pulp mixture;
   c) fractionation of the first pulp mixture to obtain a reject fraction and an accept fraction;
   d) mixing the reject fraction with the second broke pulp and/or an additional pulp to obtain a second pulp mixture;
   e) forming the second layer from the second pulp mixture; and
   f) forming the first layer from a pulp comprising the accept fraction.

2. The method of claim 1, wherein step a) comprises dividing a broke pulp into a first portion that is the first broke pulp and a second portion that is the second broke pulp.

3. The method of any one of the preceding claims, wherein the chemical pulp of step b) is unbleached.

4. The method of any one of the preceding claims, wherein the chemical pulp of step b) is kraft pulp.

5. The method of any one of the preceding claims, wherein the additional pulp is provided by the same pulping process as the chemical pulp of step b).

6. The method of claim 5, further comprising the step of dividing a chemical pulp into a first part that becomes chemical pulp of step b) and a second part that becomes the additional pulp that is added in the mixing of step d).

7. The method of claim 6, wherein at least the first part is refined such that the Schopper-Riegler (SR) number measured according to ISA 5267-1:1999 is higher for the chemical pulp of step b) than for the additional pulp that is added in the mixing of step d).

8. The method of any one of the preceding claims, wherein the Schopper-Riegler (SR) number measured according to ISA 5267-1:1999 of the chemical pulp of step b) is below 20, such as between 13 and 17.

9. The method of any one of the preceding claims, wherein the dry weight ratio of the reject fraction to the accept fraction is between 20:80 and 75:25, such as between 30:70 and 55:45.

10. The method of any one of the preceding claims, wherein the fractionation of step c) comprises fractionation in hydrocyclones.

11. The method of any one of the preceding claims, wherein proportion of reject fraction in the second pulp mixture is

25-70 %, such as 30-60 %, such as 40-55 %, by dry weight.

12. The method of any one of the preceding claims, wherein the third layer is formed from a pulp comprising chemical pulp, such as bleached chemical pulp.

13. The method of any one of the preceding claims, wherein the third layer is a top layer for printing and the first layer is a bottom layer.

14. The method of claim 12, further comprising the step of coating the multi-layer paperboard by applying a coating composition, such as a pigment coating composition, onto the top layer.

15. The method of any one of the preceding claims, wherein grammage measured according to ISO 536 of the multi-layer paperboard is between 150 and 500 g/m^2, such as between 160 and 450 g/m^2, such as between 170 and 350 g/m^2.

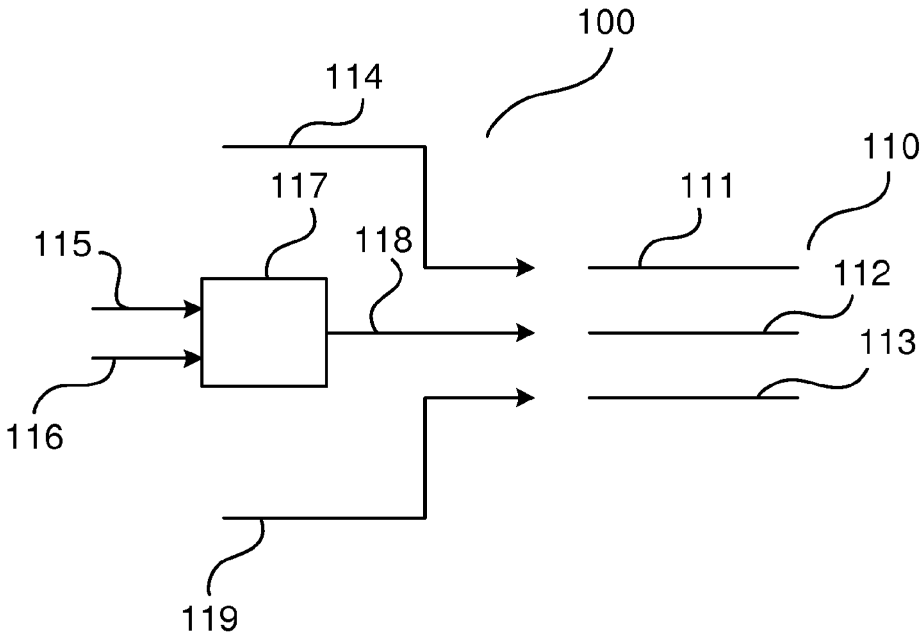
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Fig. 1

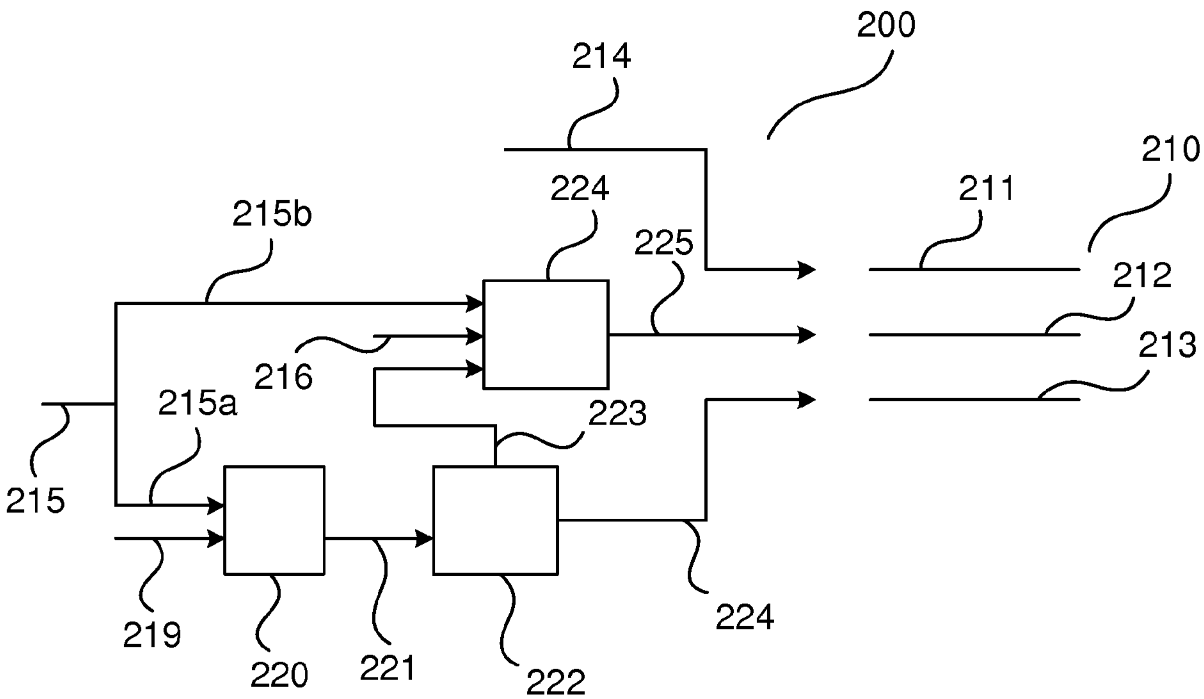
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Fig. 2

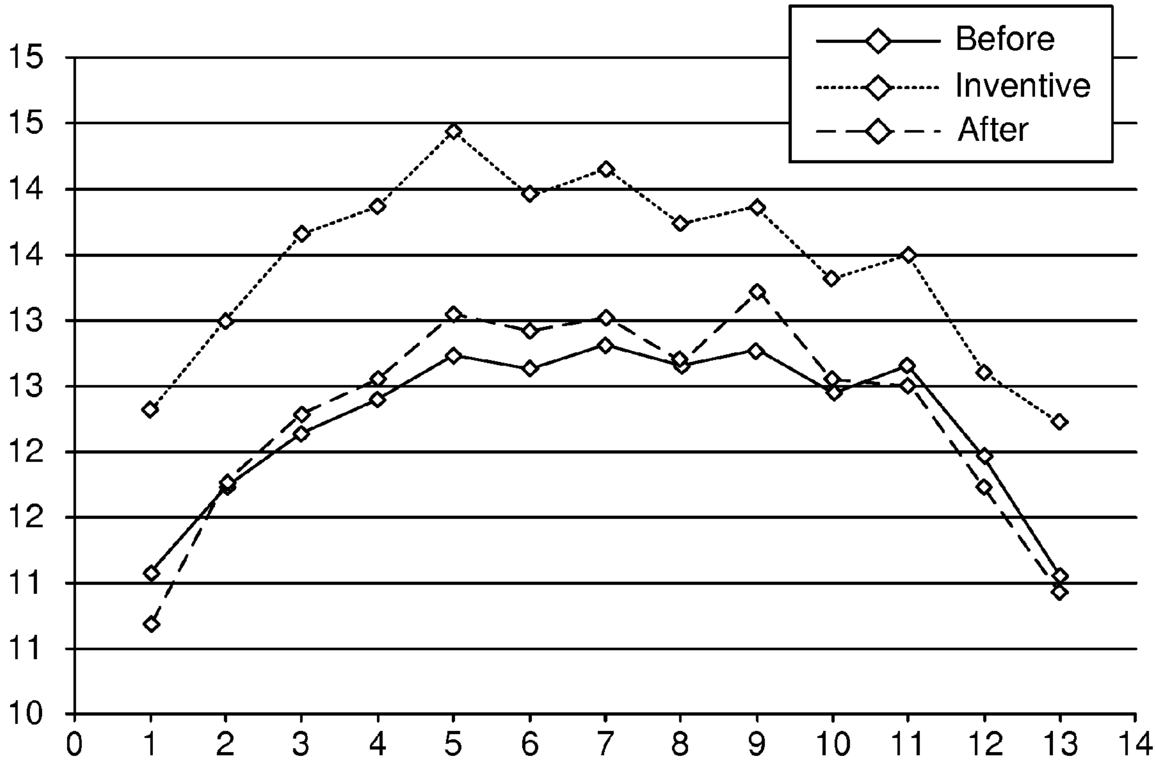
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Fig. 3

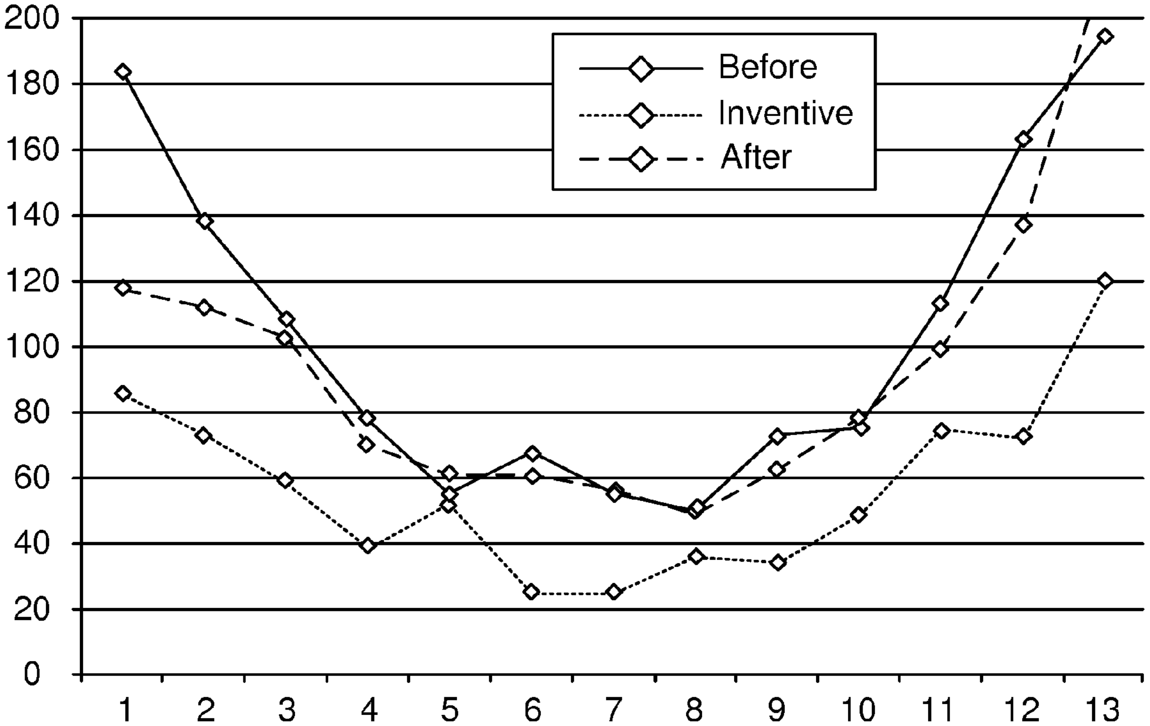
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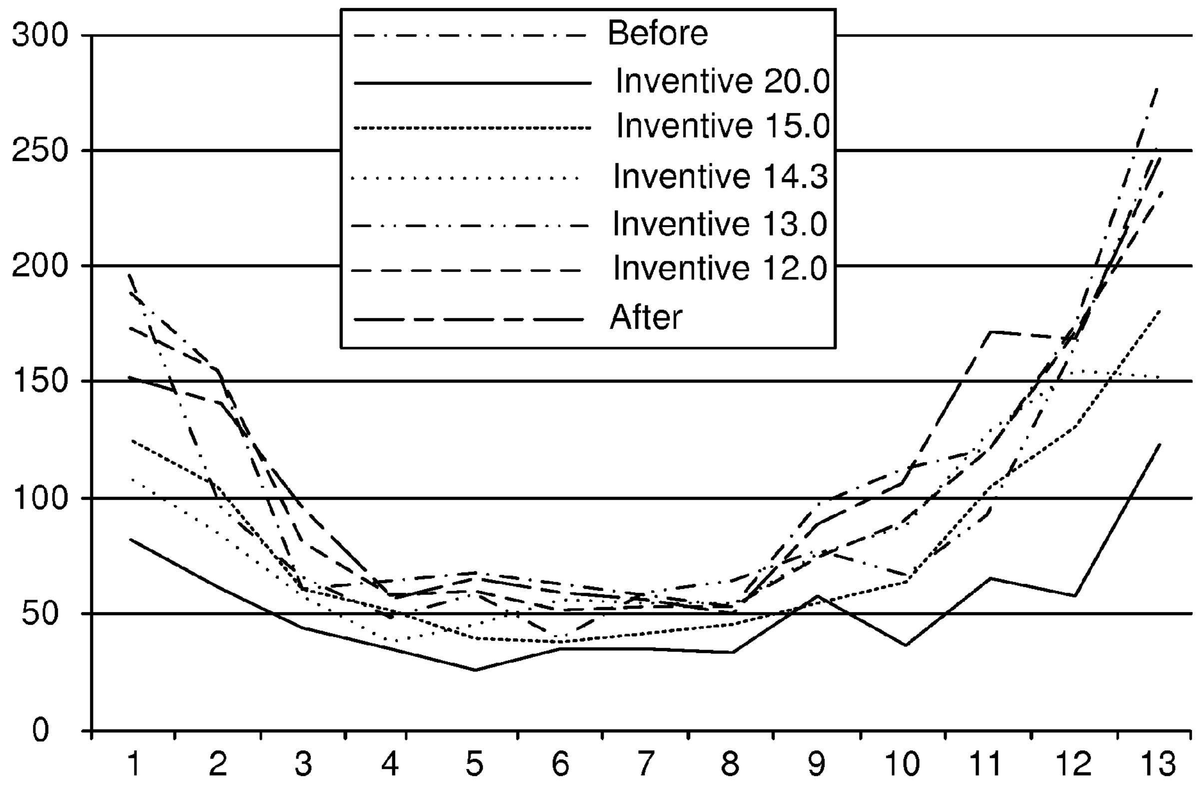
Fig. 4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After
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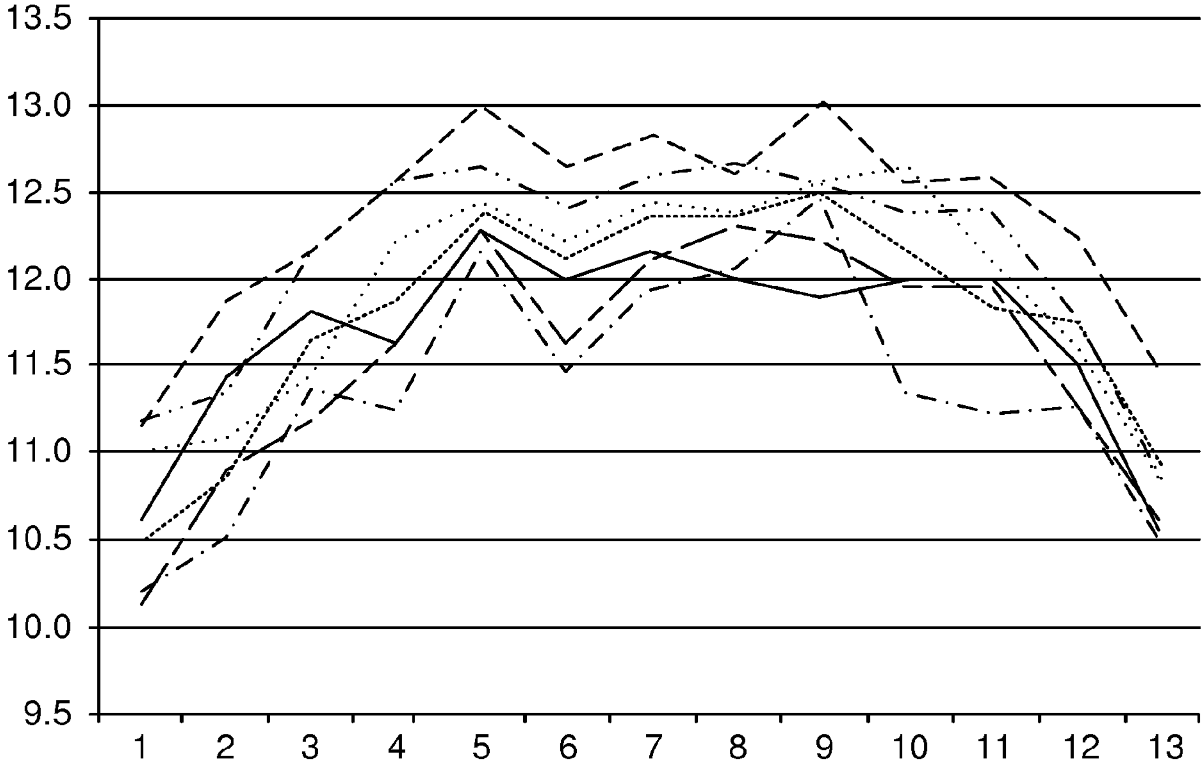
13

Fig. 5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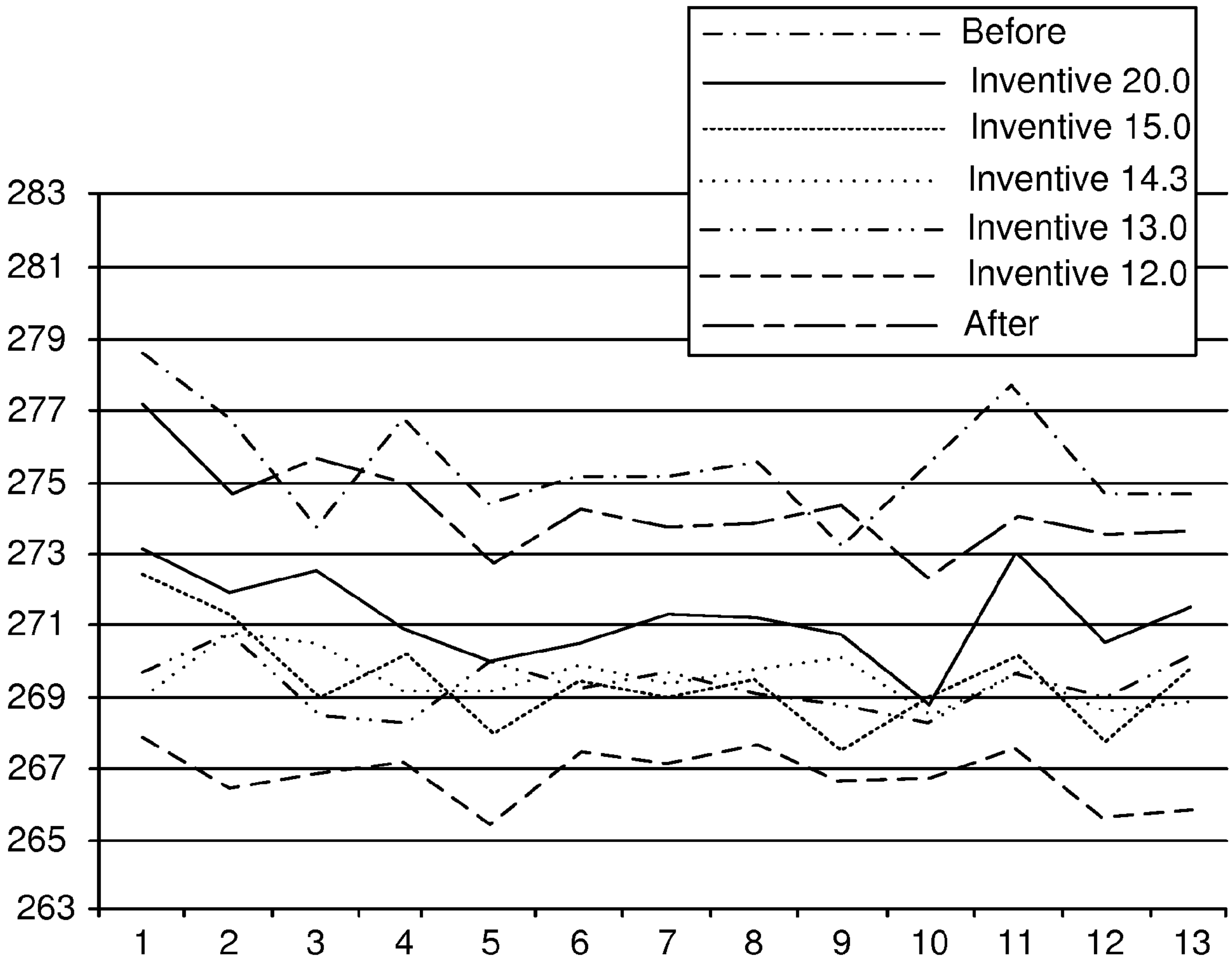
12
13

Fig. 6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Inventive 15.0
Inventive 14.3
Inventive 13.0
Inventive 12.0
After
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271
269
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263
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Fig. 7

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Application Number
EP 17 20 9806

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Place of search	Date of completion of the search	Examiner
Munich	12 April 2018	Karlsson, Lennart

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