(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 November 2016 (24.11.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/185332 A1

(51) International Patent Classification:
D21H 19/52 (2006.01) *D21C 9/00* (2006.01)
D21H 11/18 (2006.01) *D21H 19/84* (2006.01)
B32B 29/00 (2006.01) *D21H 27/30* (2006.01)
C08L 1/02 (2006.01)

(21) International Application Number:
PCT/IB2016/052738

(22) International Filing Date:
12 May 2016 (12.05.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1550625-6 15 May 2015 (15.05.2015) SE

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: PAPER OR BOARD MATERIAL HAVING A SURFACE COATING LAYER COMPRISING A MIXTURE OF MICROFIBRILLATED POLYSACCHARIDE AND FILLER

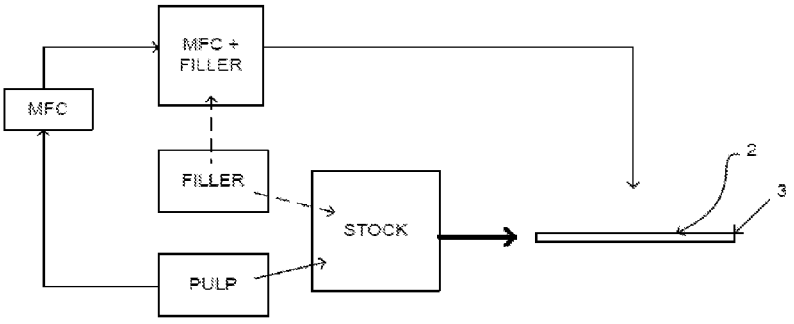

Fig. 13b

(57) **Abstract**: A paper or board material containing pulp fibre or wood fibre or non-wood fibre and made from a stock solution, having a first and second side, wherein the paper material is provided with a surface coating layer on at least one side thereof, wherein said surface coating layer comprises a mixture of a microfibrillated polysaccharide and a filler, wherein said mixture is applied onto said paper or board material and wherein said microfibrillated polysaccharide is obtained from a portion of a pulp raw material comprising said pulp fiber or wood fiber or non-wood fibre, which pulp raw material subsequently forms said paper or board material and said filler is at least partially redistributed from being introduced into said stock solution to said surface coating layer.

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PAPER OR BOARD MATERIAL HAVING A SURFACE COATING LAYER COMPRISING A MIXTURE OF MICROFIBRILLATED POLYSACCHARIDE AND FILLER

Technical field

The present disclosure relates to a method for applying a surface coating layer comprising a mixture of microfibrillated polysaccharide and filler onto a paper or board material, wherein the filler and microfibrillated polysaccharide are redistributed from being introduced into a stock solution. The present document relates to a paper or board material provided with a surface coating layer comprising a mixture of microfibrillated polysaccharide and filler obtained by the method.

Background

Filler is usually added to paper or to the outer layer of a board to improve optical properties. In the following, paper material refers to paper as well as the outer layer of board. The filler is usually mixed with the stock solution in the paper making machine. The filler does not contribute to bonding, only to grammage. As a result, strength indexes will decrease as filler is added, even though absolute strength value for the surface layer may be maintained. The filler may also act as a de-bonder, i.e. decrease strength in absolute terms for a given fibre network weight. Paper materials may also be coated with different types of pigments, such as calcium carbonate, talc, bentonite etc. to impart certain qualities on the paper material, such as weight, surface gloss, ink absorption etc. However, this pigment coating also increases the grammage of the paper material. These

types of papers are often used for high-quality printing. In WO2011056130 A1 a dispersion coating comprising colloidal particles of a polymer and a microfibrillated cellulose is disclosed in which the coating acts as a barrier on the surface of a substrate.

Summary

It is an object of the present disclosure, to provide an improved or alternative paper material, which eliminates or alleviates at least some of the disadvantages of the prior art paper materials.

More specific objects include providing a method for providing a paper material having improved characteristics as compared to conventionally produced paper materials.

The invention is defined by the appended independent claims. Embodiments are set forth in the appended dependent claims and in the following description and drawings.

According to a first aspect there is provided a method for providing a surface coating layer onto a paper material comprising pulp fiber or wood fiber made from a stock solution, wherein said method comprises the steps of:

providing a paper material having a first and second side;

providing a mixture of a microfibrillated polysaccharide and a filler; wherein the microfibrillated polysaccharide is obtained from a portion of a pulp raw material and is thus

redistributed from being introduced into the stock solution, wherein the remaining pulp raw material subsequently forms said paper material, and wherein said filler is at least partially redistributed from being introduced into the stock solution to said mixture;

applying said mixture of a microfibrillated polysaccharide and a filler onto at least one of the first or second side of said paper material, wherein said mixture forms a surface coating layer onto said paper material.

By "partially redistributed" is meant that a portion of the filler in said mixture is equivalent to a portion of filler which is conventionally added to the stock of said paper sheet material.

By "providing a paper material" is meant that the paper material, or board material may be provided by any conventional paper or board making machine, e.g as the Fourdrinier machine, where a stock of fibrous material is passed trough a series of steps to form a paper web, or any other type of machine for providing a fibrous material such as a sheet of paper or board.

By "providing a mixture of microfibrillated polysaccharide and filler" is meant that the microfibrillated polysaccharide and filler are mixed prior to the application onto the paper sheet. The mixture is preferably applied as a suspension or solution.

By this method it is possible to remove filler from actual paper material body to the surface coating layer

of the paper material using a binder, i.e. the microfibrillated polysaccharide, while maintaining the maximal strength properties of the fibrous part in the paper material body, at constant grammage of the resulting coated paper material compared to the conventional paper material. It has surprisingly been found that an application of a mixture of microfibrillated polysaccharide and filler onto the surface of a paper material product, thus forming a surface coating layer improves several important physical properties compared to conventional dosing in the stock.

According to a second aspect there is provided a method for providing a surface coating layer onto a paper material comprising pulp fiber or wood fiber made and from a stock solution, wherein said method comprises the steps of providing a pulp raw material comprising said pulp fiber or wood fiber for forming said paper material, providing a filler for introduction into said stock solution; wherein said paper material has a first and second side; wherein the method comprises the step of removing a portion of the pulp raw material for forming a microfibrillated polysaccharide thereof, wherein the remaining pulp raw material is introduced into the stock solution for subsequent forming of a base paper material on a wire section; and the step of removing at least a portion of the filler for introduction into the stock solution prior to this introduction; and providing a mixture of said microfibrillated polysaccharide and said filler that has been removed; and applying said mixture of the microfibrillated polysaccharide and the filler

onto at least one of the first or second side of the formed base paper material, wherein said mixture forms a surface coating layer onto said paper material.

This means that the total weight of the paper material will remain unchanged, but that a portion of the pulp raw material is used to form a microfibrillated polysaccharide, such as MFC. At least a portion of the filler which is conventionally introduced into the stock solution is instead mixed with the formed MFC. This mixture is then applied, i.e. reintroduced or redistributed into the process and onto the formed paper. The remaining portion of filler material may thus be introduced into the stock solution and form part of the base paper. The ratio of filler which is redistributed may depend on the end product, i.e. the type of paper product that is formed.

According to a third aspect there is provided a method for providing a surface coating layer onto a board material comprising pulp fiber or wood fiber made and from a stock solution, wherein said method comprises the steps of: providing a pulp raw material comprising said pulp fiber or wood fiber for forming said board material, providing a filler for introduction into said stock solution; wherein said board material has a first and second side; wherein the method comprises the step of removing a portion of the pulp raw material for forming the board material and forming a microfibrillated polysaccharide thereof, wherein the remaining pulp raw material is introduced into the stock solution for subsequent forming of a board material on a wire section;

and the step of removing the filler for introduction into the stock solution prior to this introduction; and providing a mixture of said microfibrillated polysaccharide and said filler that has been removed; and applying said mixture of the microfibrillated polysaccharide and the filler onto at least one of the first or second side of the formed base board material, wherein said mixture forms a surface coating layer onto said board material.

This means that the total weight of the board material will remain unchanged, but that some of the pulp raw material is used to form a microfibrillated polysaccharide, such as MFC. The filler, which is conventionally introduced into the stock solution is instead mixed with the formed MFC. This mixture is then applied, i.e. reintroduced or redistributed, into the process and onto the formed board.

According to one embodiment of the first, second or third aspect the microfibrillated polysaccharide may be a microfibrillated cellulose.

The mixture may be applied onto the base paper or board in a wire section of a paper or board making machine. The mixture may have a dry content in the range of 0.1 to 50 weight-% based on the total dry content.

Alternatively the mixture may be applied onto the base paper or board at or after a press section of a paper or board making machine, according to this alternative the mixture may have a dry content in the range of 55 to 75 weight-% based on the total dry content.

The mixture may be applied by any one of spray, foam and coating technologies.

According to one embodiment the surface layer may be applied as a continous film.

The mixture may further be applied onto the first and second side of said material.

According to an alternative embodiment the paper material may further comprise a wet strength additive.

The wet strength additive may thus be added to the stock for making the paper material.

According to one alternative the mixture may be applied directly onto a formed web in a paper making machine. The mixture may be applied at any one of a wire section, a press section or a drying section or online after the drying section or offline of said paper making machine, the mixture is applied by any method to apply a coating layer onto a paper surface, including coating and spraying.

According to a fourth aspect there is provided a paper or board product obtainable by the method according to the first, second or third aspect.

The paper material containing pulp fibre or wood fibre or non-wood fibre is thus made from a stock solution, has a first and second side, and the paper material is provided with a surface coating layer on at least one side thereof, wherein said surface coating layer comprises a mixture of a microfibrillated polysaccharide and a filler, wherein said mixture is applied onto said paper material and microfibrillated polysaccharide is obtained from a portion of a pulp raw

material and is thus redistributed from being introduced into the stock solution, wherein the remaining pulp raw material subsequently forms said paper material and said filler is at least partially redistributed from being introduced into the stock solution to said mixture.

By "redistributed from being introduced into the stock solution" is meant when referring to the filler that a portion of the filler in said mixture is equivalent to a portion of filler which is conventionally added to the stock of said paper material.

Since the microfibrillated polysaccharide, may be obtained from the same pulp as the paper product is subsequently made of, no new or additional materials needs to be introduced into the paper making process. Even further, as the filler may be any regular filler, conventionally used and added to the stock forming the paper material body this effective redistribution of the raw materials for forming a paper material product gives improved qualities, with regards to for instance tensile properties, brightness, smoothness and air permeability, but with no increase of the grammage.

It has surprisingly been found that an application of a mixture of microfibrillated polysaccharide and filler onto the surface of a paper material, thus forming a surface coating layer improves several important physical properties at constant product grammage compared to conventional dosing of the same amount of material in the stock. By "conventional dosing" in the stock is meant that filler is usually added to the stock to provide different characteristics, often visual, to the paper

material. Through the inventive mixture of microfibrillated polysaccharide and filler, some of the filler usually added to the stock is now instead added to the surface coating layer of the paper material, thus less filler is added and included in the paper material body. By removing filler from actual paper material body to the surface coating layer using a binder, the maximal strength properties of the fibrous part in the paper material may be maintained, at constant grammage of the paper.

Tensile properties improved, which indicates possibility to reduce grammage. For a board outer ply this implicates possibility to reduce grammage without bulk increase.

Brightness and smoothness improved, which indicates possibility to improve visual appearance and the air permeability increased.

By non-wood fibre is meant for instance fibers from wheat, sugar canes (Saccharum officinarum), oat, and grass such as Elephant grass.

By this product there is also provided a material which has improved surface qualities and the application of the mixture of microfibrillated polysaccharide and filler may even replace conventional pigment coating of the paper material, which is advantageous in that the grammage may be even further reduced. Conventional pigment coating further increases the grammage and reduces tensile index values (tensile strength index, tensile energy absorption index, tensile stiffness index,

strain to failure), and through this inventive product this can be greatly improved.

The mixture may be applied onto said paper material by any one of spray, foam or coating technologies.

According to one alternative the surface coating layer may be a continous film.

The paper material may be provided with said surface coating layer on both the first and second side and the paper material may be any one of a paper board, a magazine paper, fine paper, book paper, label paper, sack paper, liner and newspaper. According to one embodiment of the first aspect the microfibrillated polysaccharide may be a microfibrillated cellulose. The microfibrillated cellulose may be obtained from a portion of a pulp raw material, which pulp raw material subsequently forms said paper material.

The microfibrillated cellulose may be either one of a neverdried or dried microfibrillated cellulose.

The air permeability increased as compared to adding MFC to stock, which indicates reduced wet end runnability problems for MFC if coated instead of dosed in stock. This means that by redistributing the material used for making the paper material, i.e. manufacturing MFC from a portion of the pulp used for the paper material, and mix this with at least a portion of the filler which would conventionally be added to the stock, and then applying this mixture to the surface of the paper material (as a surface coating layer), there is provided a way of producing a paper material having better paper characteristics at constant, or even lower grammage.

According to one alternative the paper material product, may further comprise a wet strength additive.

By adding a wet strength additive or aid to the stock for making the paper material product, the coating performance of the paper material body may be improved, as the additive may prevent swelling during the coating procedure.

According to one alternative there is provide the use of a mixture of a microfibrillated polysaccharide and a filler for application as a surface coating layer onto a paper material. The microfibrillated polysaccharide may be a microfibrillated cellulose.

Brief Description of the Drawings

Embodiments of the present solution will now be described, by way of example, with reference to the accompanying schematic drawings in which:

Fig. 1 illustrates the used nomenclature.

Fig. 2 is a schematic flow scheme of a trial procedure.

Figs 3 to 11 are graphs showing different paper properties plotted against tensile stiffness (kN/m) of the paper material.

Fig. 12 illustrates schematically the method steps according to the invention.

Figs 13a and 13b illustrate the difference between a conventional method and the inventive method respectively.

Description of Embodiments

Fig. 1 illustrates the nomenclature used in the present disclosure. A board/paper surface coating layer 1 may be applied onto a paper surface 2 of a paper 3. The paper 3 may, according to one embodiment, also constitute a board outer ply. This board outer ply may be applied onto a first side 6 a board centre ply 4. According to one alternative embodiment a second board outer ply 5 may be applied on a second side 7.

In the description of the invention the term paper material is used interchangingly with the terms paper material, paper material body and board material. The term paper surface is used interchangeably with the terms board surface and base paper surface. Also the term paper/board surface coating layer is used to describe any type of coating of the paper surface, whether it relates to the inventive application of a microfibrillated polysaccharide and filler mixture, or to conventional pigment coating (pigment surface layer or pigment coating layer).

In one embodiment a fibrous paper material, such as a board, a fine paper, magazine paper etc. is provided with a surface coating layer comprising a mixture of a microfibrillated polysaccharide and a filler, i.e. the mixture is applied on the surface of the fibrous paper material.

The paper material may be made from any type of conventional pulp, such as alkaline, sodium, sulphate or Kraft, sulphite or mechanical pulp or any other type of

pulp conventionally used in the paper and/or board making process. Also non-wood types of pulp may be used.

The microfibrillated polysaccharide may be a microfibrillated cellulose. The microfibrillated cellulose (MFC) is also known as nanofibrillar cellulose (NFC) or cellulose microfibrils (CMF). It is a material typically made from wood cellulose fibers, both from hardwood or softwood fibers. It can also be made from microbial sources, agricultural fibers such as wheat straw pulp, bamboo or other non-wood fiber sources. In microfibrillated cellulose the individual microfibrils have been partly or totally detached from each other. A microfibrillated cellulose fibril is normally very thin (~20 nm) and the length is often between 100 nm to 10 µm. However, the microfibrils may also be longer, for example between 10-200 µm, but lengths even 2000 µm can be found due to wide length distribution. Fibers that has been fibrillated and which have microfibrils on the surface and microfibrils that are separated and located in a water phase of a slurry are included in the definition MFC.

Furthermore, cellulose whiskers, microcrystalline cellulose (MCC), nanocrystalline cellulose (NCC) or regenerated cellulose fibers and particles are also included in the definition MFC.

The fibrils may also be polymer coated fibrils, i.e. a fibril modified either chemically or physically.

According to one embodiment the MFC is obtained from the same pulp raw material as the paper material is then subsequently made from, i.e. the pulp fiber or wood

fiber. This means that a portion of the pulp raw material is used for the mixture, i.e. the surface coating layer, and the remaining portion is used to form the paper or base material.

The MFC may be formed through different techniques, such as extrusion, refining, grinding, and homogenization with or without aid chemicals (such as for instance enzymes).

The filler may be any conventional filler or combination of fillers, such as precipitated calcium carbonate, kaolin, talc, ground calcium carbonate, kaolin clay, calcined clay, synthetic silicate, titanium dioxide, plastic pigment or any other mineral or organic filler or pigment or other fillers known to the skilled person. Conventionally this filler is added into the stock material for forming the paper material product.
The filler material is usually mixed with a binder in order to bind the filler material togheter, either in the board or paper or at the surface of the paper or board. Depending on where in the paper or boardmaking process the filler material is to be added the binder may consist of different materials. For instance, if the binder is added in the stock the binder may be e.g. fines, starch or a polymer such as CPAM. If the filler material instead is added in the coating section the binder conventionally is latex or carboxy methyl cellulose (CMC). The binder may also be MFC.
According to the invention the filler, or at least a portion thereof, is now instead mixed with MFC as a binder and applied onto the surface of the fibrous paper

material, and this new and inventive manner of applying the components, i.e. the effective redistribution of the materials or the at least partial redistribution, provides for a fibrous paper material having improved characteristics.

The fibrous paper material may for instance be formed in a conventional paper making machine such as e.g. a Fourdrinier machine, where the pulp or stock material is formed into a web, and then pressed and dried in subsquent steps. Other conventional paper making or board making machines may also be used according to the invention for providing the fibrous paper sheet material. The mixture of the filler material and the MFC may thus be applied in or at the wire section, the pressing section or the drying section of a conventional paper or board making machine.

The mixture of binder (MFC) and filler may thus be applied onto the paper sheet (or board) surface at any suitable time during the paper or board making process. Depending on the position in the paper or board making process or machine where the mixture of filler and MFC is applied, it may either be a low consistency mixture, i.e. having a low dry content or a high consistency mixture, i.e. having a higher dry content. At CC (in the figure 12) there may be a high consistency of from about 55 to about 75 %, based on the total dry content of the mixture. At NCF1 there may be a lower consistency from about 0.1 to about 20% based on the total dry content of the mixture. At NCF2 there may be a consistency of from about 0.1 to about 60% based on the total dry content of

the mixture. After the treatment at NCF1 and just before entering the press section the consistency may be from 10 to about 15%. After the press section the consistency may be about 50%.

According to one embodiment the mixture is applied such that it forms a continous layer onto the paper material. The mixture thus applies as a so called functional coating, covering most or all of the surface of the paper material.

According to one embodiment the mixture is applied only onto a first surface or side of the paper material. According to another embodiment the mixture is applied onto a first and a second surface or side of the paper material.

According to one embodiment the mixture of MFC and filler, e.g. PCC, may be applied as a solution or suspension to the paper surface to form the surface coating layer of the paper material.

According to one alternative embodiment the mixture may be provided as a pre-mixture in a dry state. This provides for an easy way of storing and transporting the mixture prior to its use. The mixture may then be dissoluted in water or any other suitable solvent therefore, before applying it onto the paper surface.

The mixture may be applied trough different techniques. Conventional methods and techniques for applying the mixture may include spraying, through a head-box in particular for thin films or sheets, through coating applications such as blade, curtain, roll or rod coating,

through Liquid Application System (LAS) or through a size press.

In the below trial study the mixture was coated onto the paper material using a pilot coater, in the trial below a so called laboratory rod coater was used. The mixture may according to different embodiment be applied trough coating techniques, such as spray coating, various chemical coating techniques, roll-to-roll coating etc. According to a different embodiment the mixture may be applied to the paper surface as a foam.

Fig. 12 shows a schematic overview of the method according the present invention in relation to a conventional paper making process, showing different positions for addition of filler or filler pigments and binders. The conventional paper making process is firstly illustrated by an Add position in which step filler pigments and binders are added to the stock. Secondly in the conventional paper or board making process pigment and binders may be added to the coating section in the CC position.

The addition positions of the mixture of filler and MFC obtained from the pulp raw material, in the inventive method of paper making is shown by the positions NCF1 and NCF2 respectively.

At the NCF1 position, i.e. addition of filler and binder at the wire section of the paper or board making machine, a low consistency mixture is preferably added.

At the position NCF2, i.e. at or directly after the press section of the paper or board making machine, a high consistency mixture is preferably added.

Both the low and high consistency mixtures added in step NCF1 and NCF2 comprise a mixture of filler material and binder, i.e. MFC. Both the filler material and the MFC have been redistributed or moved from the conventional Add position. This means that a paper or board product may be produced using the same types of material, and also the same total or final amount of material as in a conventional process.

As an example for forming a 100 g/m^2 paper sheet or board 100 g/m^2 pulp and 5 g/m^2 filler may be added to the stock solution in the Add position in the conventional paper or board making process. This stock solution is then transferred for instance via a head box onto a wire section for dewatering and subsequent process steps, such as to the press section, drying section and coating section. In the coating section conventional coating pigments and binder may further be applied to the paper or board. This conventional paper or board making process is also shown in Fig. 13a, where pulp and filler are mixed into the stock solution and the subsequently forms the paper or board material 3.

According to the inventive method as shown in Figs 12 and 13b, the 5 g/m^2 filler may instead be added in either in the NCF1 or NCF2 position and applied to or on the surface 2 of the paper or board 3. This redistribution of the total filler amount is preferably made for a board material. Before the addition the filler is mixed with a binder, i.e. the MFC.

The MFC is formed from a portion of the pulp raw material which subsequently forms the board or paper. As an

example 5 g/m^2 of the pulp raw material may be used, i.e removed, to form MFC, which is then mixed with the filler before addition in the NCF1 or NCF2 position, to the 95 g/m^2 paper or board sheet. This means that in total the same amount of material, i.e. 100 g/m^2 pulp or fibers and 5 g/m^2 filler is used for making the paper or board, but a portion, alternativley all, of the filler is redistributed from the Add position, and mixed with a portion of the pulp, which is converted into MFC, from the Add position, and the mixture is added to in the NCF1 or NCF2 position.

Further, in the conventional process in a CC position coating pigments and binder in the range of 0 to 50 g/m^2 may be added. In the inventive method the addition in the CC step may be reduced or even excluded.

Depending on the end product different ratios of filler and binder may be used in the mixture.

This means that for a board product, which ususally comprises in the range of 2 to 7 % filler material, most or preferably all of the filler material may be redistributed from the Add position to either NCF1 or NCF2.

For a paper product the amount of filler added in the Add position is usually higher, and in the range of 20 to 50 %. This means that for a paper product, such as for instance a super calendered (SC) paper, where the amount of filler added in the Add position ususally is around 30 to 40 %, only a portion of this filler material is redistributed. Depending on the desired end product around 5 – 15 % is instead used in the mixture with MFC

as a binder and added in the NCF1 or NCF2 position. As an example, for forming a 70 g/m^2 paper sheet, the conventional addition of filler may be 35 g/m^2. According to the inventive method instead 5 g/m^2 of the pulp (i.e. the pulp fibers or wood fibers) would be redistributed to form MFC, and 5 g/m^2 of the filler would be redistributed and mixed with the MFC binder and added in the NCF1 or NCF2 posistion, thus forming a paper having a base paper weight of 65 g/m^2 fiber + 30 g/m^2 filler and a coating weight of 5 g/m^2 fiber and 5 g/m^2 filler.

The amount, or portion, of filler and the pulp that is redistributed depends on the end product and the desired properties of this product.

The ratio of filler to binder, i.e. MFC, in the mixture may be in a range of 1:2 to 2:1.

According to one embodiment a wet strength additive or aid is added to the fibrous stock material forming the paper material. The wet strengt additive may be any conventional typ of additive known to the skilled person. Examples are given in the trial study below, however the invention is not limited to these examples only.

Trial study

The primary goal of this trial study was to investigate if coating of a mixture of MFC and filler improved the performance in terms of strength and optical properties, at a constant grammage of the paper material.

It was observed that application of a mixture of microfibrillated cellulose and filler to the surface of a

paper material, thus forming a surface coating layer, improved several important physical properties compared to conventional dosing in the stock. Tensile properties improved, which indicates possibility to reduce grammage. For a board material this implicates that it might be possible to reduce the grammage without bulk increase. Brightness and smoothness improved, which indicates possibility to improve visual appearance. Air permeability increased (compared to adding MFC to stock), which indicates reduced wet end runnability problems for MFC if coated instead of dosed in stock.

Fig 2 illustrate in a flow scheme the experimental study and procedure.

Figs 3 to 11 illustrate trial results of different characteristics. The symbol code for each of Figs 3 to 10 is Square: 100% Kraft pulp, Rhomb: MFC, No Filler, Circle: Filler, no MFC, Star: MFC and Filler.

Preferred features of each aspect of the invention are as for each of the other aspects mutatis mutandis. The prior art document(s) mentioned herein are incorporated to the fullest extent permitted by law. The invention is further described in the following examples, together with the appended figures, which do not limit the scope of the invention in any way. Embodiments of the present invention are described as mentioned in more detail with the aid of examples of embodiments, together with the appended figures, the only purpose of which is to illustrate the invention and are in no way intended to

limit its extent.

Objective of trial

In this study, a paper material with 100 g/m^2 fibrous part was used as a model for a board outer ply. Several application strategies were compared with each other:

Addition of filler to stock or surface coating layer

Use of a substitute MFC added to stock or surface coating layer

Paper material were formed using a Dynamic Sheet Former (DSF) without filler or with 5% (equivalent to 5 g/m^2) filler, in the latter resulting in a paper material of grammage target 105 g/m^2. 5% (equivalent to 5 g/m^2) of the Kraft pulp were substituted to MFC for some trial points. The MFC was either added to the stock or coated to the surface of the paper material. Constraint drying was used before and after coating using an STFI drying unit. Uncoated paper material were rewetted and re-dried in constraint conditions. Wet strength aid or additivies, was added in stock to prevent swelling during coating or rewetting procedure. CPAM/Bentonite were added in stock for filler retention.

Focus was on studying a possible increase in tensile stiffness at given optical properties of the coated paper material compared to conventional paper material at same grammage, to improve bending force index of board.

Materials used in trial

All components used in the study, except MFC, were gathered from a board mill production line prior to the sheet forming. Additives were sampled from board mill primary storage tanks AKD: Aquapel F220 Rosin: HipHase 40D, Wet Strength Aid: Kymene G3 X-cel, CPAM: Fennopol K7426R, Bentonite: Opazil ADV, Filler : Kamintex (Caolin Clay)

Bleached Softwood Kraft pulp (BSK, or Kraft pulp) was sampled from incoming washing stage at the board mill (well washed internally produced pulp but not subjected to board machine white water). Never dried BSK was beaten to 29.7 °SR at RCK using a Voith Sulzer laboratory refiner and MFC was produced at RCK, batch #140186 (enzyme treated and fluidized BSK from same position as the Kraft pulp used in the study).

Prestudy

Prior to this study, a prestudy was carried out to improve the laboratory coating procedure. DSF paper material were prepared with a variety of additives to the stock: AKD sizing agent (2 g/kg), rosing sizing agent (2 g/kg), wet strength additive (2.2 g/kg), no additive (reference).

The DSF paper material were constraint dried using an STFI drying unit before coating with 5 g/m2 of MFC, and then dried once again using the STFI drying unit. All DSF paper materials contained a standard CPAM/silica retention system.

It was observed that rosin did not prevent swelling. MFC coated on the paper surface did not stick to a paper

material containing AKD, and it was easy to peel off the coating layer. MFC did however stick to the paper surface of a paper material containing wet strength additive, and the paper material did not swell significantly. In the following, paper material containing wet strength additive were used.

Experimental plan

In Table 1 the target values for pulp and additives are shown. All trial points contained a standard CPAM/bentonite retention system and wet strength aid: CPAM: 0.5 g/kg bentonite: 1.5 g/kg wet strength Aid: 2.2 g/kg.

Table 1. Experimental plan

Unit	(g/m^2)	(g/m^2)	(g/m^2)	(g/m^2)	(g/m^2)	(g/m^2)	(g/m^2)	(g/m^2)	
Material	BSK	Filler in stock	MFC in stock	MFC at surface	Mix 50/50 MFC/ Filler at surface	BSK + MFC	Total weight before coating	Total weight after coating	Comment
Trial point 1	100					100	100	100	Reference only BSK
Trial point 2	100	5				100	105	105	Filler dosed in stock
Trial point 3	95		5			100	100	100	MFC dosed in stock
Trial point 4	95	5	5			100	105	105	Mix of Filler and MFC dosed in stock
Trial point 5	95			5		100	95	100	MFC coated at dried sheet

Trial point 6	95	5		5		100	100	105	Filler dosed in stock, MFC coated at dried sheet
Trial point 7	95				10	100	95	105	Mix of Filler and MFC coated at dried sheet

As can be seen in Fig 2 a careful experimental procedure was established using repeated constrained drying of the DSF paper material and similar rewetting for all samples, coated or not, to compensate for influence from drying constraint. In the following, DSF paper material is referred to as *sheet*. A reference sheet, 1b, was not rewetted. Standard paper physical properties, humidity and ash content were then measured for conditioned samples. Geometrical averages were calculated for strength properties.

Grammage and ash content were not exactly according to recipe. A baseline correction value was calculated for dry organic part for all samples to minimize variation

and to illustrate optimal potential of application strategy.

MD/CD ratio for tensile properties varies between sheets and geometrical averages were calculated for all tensile properties.

In table 2 the experimental study on the grammage and baseline correction values are shown. The strength baseline correction value = 100/[grammage, dry, organic part].

Table 2. Grammage and baseline correction

Property	Grammage Target (g/m^2)	Grammage Measured (g/m^2)	Moisture content (%)	Ash c:t Target (%)	Ash c:t Measured (%)	Grammage cond., organic part (g/m^2)	Grammage dry, organic part (g/m^2)	Strength Baseline Correction value
1b; Reference only BSK, not rewetted	100	97.5	6.75	0	0.4	97.2	90.6	1.11
1a; Reference only BSK, rewetted	100	97.2	6.81	0	0.3	96.9	90.3	1.10

2; Filler dosed in stock	105	103.1	6.40	5	4.2	98.9	92.6	1.08
3; MFC dosed in stock	100	98.5	6.77	0	0.4	98.1	91.5	1.09
4; Mix of Filler and MFC dosed in stock	105	103.0	6.34	5	7.2	95.8	89.7	1.11
5; MFC coated at dried sheet	100	98.7	6.68	0	0.3	98.4	91.8	1.09
6; Filler dosed in stock, MFC coated at dried sheet	105	102.9	6.25	5	7.2	95.7	89.7	1.11
7; Mix of Filler and MFC coated at	105	100.8	6.38	5	6.0	94.8	88.8	1.13

dried sheet								
Amplitude			0.56			4.1	3.8	

Referring to Table 2, the filler was added to reach an ash content target of 5g/m^2 (~5%), based on pre-trial investigations. Sheets with 5 g/m^2 MFC had a Kraft pulp content target of 95 g/m^2. The grammage target was 100 g/m^2 for sheets without filler and 105 g/m^2 for sheets with filler either dosed in stock or coated on the surface as a mixture with MFC. All trial points except 1b were dried in constrain twice using an STFI drying unit. 1b was dried in constrain once before physical testing. As can be seen all trial points had lower grammage compared to target. The dry grammage of organic part was used to calculate strength baseline correc-tion values, to evaluate absolute contribution from fibre network and MFC.

The baseline correction value was used to calculate the expected tensile performance of a sheet containing 100 g/m^2 b.d. organic matter, i.e. pulp and MFC.

In the following, with reference to Fig. 3, the paper properties are plotted versus Tensile Stiffness, as this is an important strength property for a board surface layer.

Fig. 3 and 4 shows the ISO-brightness is plotted versus the tensile stiffness. The symbol code is: Square: 100% Kraft pulp, Rhomb: MFC, No Filler, Circle: Filler, no MFC, Star: MFC

and Filler. In Fig. 3 the influence on tensile stiffness on rewetting during constraint drying is illustrated. The tensile stiffness was increased during re-wetting and constraint drying. Sheets 1a and 1b were 100 % BSK. Tensile stiffness was decreased during addition of filler, and brightness was increased. Sheet 2 had a lower ash content compared to 4, 6 and 7. Reference sheet 1a was 100% BSK. Sheet nr 2 had an extra addition of 5% filler. Tensile stiffness was slightly decreased during addition of MFC to stock. Brightness was slightly decreased during coating with MFC. Reference sheet 1a was 100% BSK, sheets 3 and 5 with MFC were 95% BSK and 5% MFC. Tensile stiffness was increased during coating with MFC, and brightness was decreased. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler. The influence on tensile stiffness and brightness on addition of a mixture of MFC and filler to stock is also shown. Tensile stiffness was increased during addition of a mixture of MFC and filler to stock, brightness was slightly decreased. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler. The tensile stiffness and brightness were increased during coating of the surface of the paper sheet material with a mixture of MFC and filler. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler.

In the following, focus is on the influence of paper properties on coating of a mixture of filler and MFC compared to conventional paper making, i.e. adding filler to stock (no MFC); i.e comparing trial point 2 and 7. In Fig. 5 the light scattering S1 is plotted versus the tensile stiffness. The symbol code is Square: 100% Kraft pulp, Rhomb: MFC, No Filler, Circle: Filler, no MFC,

Star: MFC and Filler. The influence on tensile stiffness and light scattering on coating the surface of the paper sheet material with a mixture of MFC and filler is shown. MFC slightly reduces the scattering ability of the filler, independent of dosing strategy, though a higher filler content. By using filler in the surface of the paper sheet mateial instead of in the stock a better brighness may be achived. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler.

In Fig. 6 the smoothness (Bendtsen) is plotted versus the tensile stiffness. The influence on tensile stiffness and smoothness on coating the surface of the paper sheet with a mixture of MFC and filler is shown. Both the tensile stiffness and smoothness were improved during coating of the surface with a mixture of MFC and filler. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler.

In Fig. 7 the air permeability is plotted versus the tensile stiffness. The influence on tensile stiffness and air permeability on coating the surface of the paper sheet material with a mixture of MFC and filler is shown. MFC, dosed in stock or coated at board surface, decreases air permeability. For MFC dosed in stock, processability in wet- and press section may be impaired which is further illustrated by Fig. 7. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler.

In Fig. 8 the air permeability is plotted versus the tensile stiffness. The influence on tensile stiffness and

air permeability on coating the surface of the paper sheet material with a mixture of MFC and filler is shown. For MFC and filler coated on the surface, the base paper had a lower permeability compared to dosing MFC and filler in stock. This indicates improved wet end runnability. This means that even though it is easier to edd filler driectly into the stock the runnability may be impaired, i.e. the inventive method of applying a mixture of MFC and filler to the surface of the paper sheet (base paper) may increase the wet end runnability. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler.

In Fig. 9 the tensile strength is plotted versus the tensile stiffness. The influence in tensile stiffness and tenslite strength on coating the surface of the paper sheet material with a mixture of MFC and filler is shown. Tensile stiffness and strength were increased during coating of the surface with a mixture of MFC and filler. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler.

In Fig. 10 the strain at break is plotted versus the tensile stiffness. The influence of tensile stiffness and tenslie strain on coating the surface of the paper sheet material with a mixture of MFC and filler is shown. Tensile stiffness and strain were increased during coating of the surface with a mixture of MFC and filler. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler.

In Fig. 11 the tensile energy absorption is plotted versus the tensile stiffness. The influence on tensile

stiffness and tensile energy absorption (TEA) on coating the surface of the paper sheet material with a mixture of MFC and filler is shown. Tensile stiffness and TEA were increased during coating of the surface with a mixture of MFC and filler. Reference sheet 2 was 100% BSK + 5% filler, sheets 4, 6 and 7 with MFC were 95% BSK and 5% MFC + 5% filler

In conclusion the trial study shows that application of a mixture of MFC and filler onto the surface of a board or paper improves several important physical properties compared to conventional dosing in the stock. The tensile properties indicates the possibility to reduce grammage without bulk increase.

The effect on brightness of the paper sheet material indicates the possibility to improve visual appearance of the paper sheet material. The effect on smoothness indicates the possibility to improve visual appearance of the paper or board. The effect on air permeability (compared to adding MFC to stock) indicates reduced wet end runnability problems for MFC if coated instead of dosed in stock.

It was further observed that coating performance of the base paper was improved by adding wet strength aid to the stock, as this additive prevented swelling during the coating procedure.

In the below the results obtained in the study are further presented in tables 3 to 8. In Table 3 geometrical averages were calculated for all tensile properties as MC/CD ratios between trial points.

Table 3. Tensile strength related results, MC/CD ratios.

Trial point	Tensile Strength	Tens. Stretch at break	Tensile Energy Abs.	Tensile Stiffness
1a; Reference only BSK	2.05	0.75	1.41	1.95
1b; Reference only BSK, not rewetted	1.98	0.76	1.35	1.80
2; Filler dosed in stock	2.13	0.79	1.55	2.00
3; MFC dosed in stock	2.15	0.66	1.25	1.97
4; Mix of Filler and MFC dosed in stock	2.25	0.66	1.32	2.08
5; MFC coated at dried sheet	2.08	0.86	1.55	1.73
6; Filler dosed in stock, MFC coated at dried sheet	2.12	0.88	1.70	1.89
7; Mix of Filler and MFC coated at dried sheet	1.98	0.81	1.44	1.79

Table 4. Tensile strength related results, tensile stiffness.

Trial point	Tensile stiffness MD (kN/m)	Tensile stiffness CD (kN/m)	Tensile stiffness GM (kN/m)	Baseline correction	Tensile stiffness GM (kN/m), corrected
1a; Reference only BSK	1576	808	1128	1.11	1249
1b; Reference only BSK, not rewetted	1369	759	1020	1.10	1126
2; Filler dosed in stock	1508	754	1066	1.08	1151
3; MFC dosed in stock	1579	801	1125	1.09	1229
4; Mix of Filler and MFC dosed in stock	1564	750	1083	1.11	1207
5; MFC coated at dried	1507	871	1146	1.09	1248

sheet					
6; Filler dosed in stock, MFC coated at dried sheet	1460	772	1062	1.11	1184
7; Mix of Filler and MFC coated at dried sheet	1463	819	1094	1.13	1233

Table 5. Tensile strength related results, tensile strength.

Trial point	Tensile strength MD (kN/m)	Tensile strength CD (kN/m)	Tensile strength GM (kN/m)	Baseline correction	Tensile strength GM (kN/m), corrected
1a; reference only BSK	17.3	8.5	12.1	1.11	13.4
1b; Reference only BSK, not rewetted	16.5	8.3	11.7	1.10	12.9
2; Filler dosed in stock	15.8	7.4	10.8	1.08	11.7

3; MFC dosed in stock	17.9	8.3	12.2	1.09	13.4
4; Mix of Filler and MFC dosed in stock	17.0	7.6	11.4	1.11	12.7
5; MFC coated at dried sheet	17.1	8.2	11.8	1.09	12.9
6; Filler dosed in stock, MFC coated at dried sheet	15.6	7.3	10.7	1.11	11.9
7; Mix of Filler and MFC coated at dried sheet	15.5	7.8	11.0	1.13	12.4

Table 6. Tensile strength related results, tensile strength at break.

Trial point	Stretch at break MD (%)	Stretch at break CD (%)	Stretch at break GM (%)
1a; Reference only BSK	2.8	3.7	3.2

1b; Reference only BSK, not rewetted	3.3	4.4	3.8
2; Filler dosed in stock	2.7	3.4	3.0
3; MFC dosed in stock	2.9	4.5	3.6
4; Mix of Filler and MFC dosed in stock	2.7	4.1	3.3
5; MFC coated at dried sheet	3.0	3.5	3.2
6; Filler dosed in stock, MFC coated at dried sheet	2.8	3.1	2.9
7; Mix of Filler and MFC coated at dried sheet	2.9	3.5	3.2

Table 7. Tensile strength related results, Tensile Energy Absorbtion (TEA).

Trial point	TEA MD (J/m2)	TEA CD (J/m2)	TEA GM (J/m2)	Baseline correction	TEA GM (J/m2)

					corrected
1a; reference only BSK	315	223	265	1.11	293
1b; Reference only BSK, not rewetted	348	257	299	1.10	330
2; Filler dosed in stock	275	177	221	1.08	239
3; MFC dosed in stock	341	273	305	1.09	334
4; Mix of Filler and MFC dosed in stock	296	225	258	1.11	287
5; MFC coated at dried sheet	330	213	265	1.09	289
6; Filler dosed in stock, MFC coated at dried sheet	280	165	215	1.11	239
7; Mix of Filler and MFC coated at dried	292	202	243	1.13	274

sheet					

Table 8. Visual appearance related results.

Trial point	ISO-Brightness S1 (%)	Light scat.coeff.Ry C/2° S1 (m^2/kg)	Roughness Bendtsen uncomp. 0.1 MPa S1 (ml/min)	Air permeance L&W (um/Pa s)
1a; Reference only BSK	70.4	14.3	775	0.1990
1b; reference only BSK, not rewetted	71.0	13.9	962	0.1450
2; Filler dosed in stock	80.6	35.0	739	0.3340
3; MFC dosed in stock	69.9	12.6	910	0.0252
4; Mix of Filler and MFC dosed in stock	80.2	33.2	771	0.0588
5; MFC coated at dried	69.4	13.0	647	0.0030

sheet				
6; Filler dosed in stock, MFC coated at dried sheet	79.1	32.9	580	0.0030
7; Mix of Filler and MFC coated at dried sheet	81.9	33.4	323	0.0168

Various embodiments of the present invention have been described above but a person skilled in the art realizes further minor alterations, which would fall into the scope of the present invention. The breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents. For example, any of the above-noted compositions or methods may be combined with other known methods. Other aspects, advantages and modifications within the scope of the invention will be apparent to those skilled in the art to which the invention pertains.

CLAIMS

1. A method for providing a surface coating layer onto a paper material comprising pulp fiber or wood fiber made and from a stock solution, wherein said method comprises the steps of:

providing a paper material having a first and second side;

providing a mixture of a microfibrillated polysaccharide and a filler; wherein the microfibrillated polysaccharide is obtained from a portion of a pulp raw material and is thus redistributed from being introduced into the stock solution, wherein the remaining pulp raw material subsequently forms said paper material, and wherein said filler is at least partially redistributed from being introduced into the stock solution to said mixture;

applying said mixture of a microfibrillated polysaccharide and a filler onto at least one of the first or second side of said paper material, wherein said mixture forms a surface coating layer onto said paper material.

2. A method for providing a surface coating layer onto a paper material comprising pulp fiber or wood fiber made and from a stock solution, wherein said method comprises the steps of:

providing a pulp raw material comprising said pulp fiber or wood fiber for forming said paper material,

providing a filler for introduction into said stock solution; wherein said paper material has a first and second side;

characterized in that

the method comprises the step of removing a portion of the pulp raw material for forming a microfibrillated polysaccharide thereof, wherein the remaining pulp raw material is introduced into the stock solution for subsequent forming of a base paper material on a wire section;

and the step of removing at least a portion of the filler for introduction into the stock solution prior to this introduction; and

providing a mixture of said microfibrillated polysaccharide and said filler that has been removed; and

applying said mixture of the microfibrillated polysaccharide and the filler onto at least one of the first or second side of the formed base paper material, wherein said mixture forms a surface coating layer onto said paper material.

3. A method for providing a surface coating layer onto a board material comprising pulp fiber or wood fiber made and from a stock solution, wherein said method comprises the steps of:

providing a pulp raw material comprising said pulp fiber or wood fiber for forming said board material,

providing a filler for introduction into said stock solution; wherein said board material has a first and second side;

characterized in that

the method comprises the step of removing a portion of the pulp raw material for forming the board material and forming a microfibrillated polysaccharide thereof,

wherein the remaining pulp raw material is introduced into the stock solution for subsequent forming of a board material on a wire section;

and the step of removing the filler for introduction into the stock solution prior to this introduction; and

providing a mixture of said microfibrillated polysaccharide and said filler that has been removed; and

applying said mixture of the microfibrillated polysaccharide and the filler onto at least one of the first or second side of the formed base board material, wherein said mixture forms a surface coating layer onto said board material.

4. The method as claimed in any one of claims 1 to 3 , wherein said microfibrillated polysaccharide is a microfibrillated cellulose.

5. The method as claimed in any one of claim 1 to 4, wherein the mixture is applied onto the base paper or board in a wire section (NCF1) of a paper or board making machine.

6. The method as claimed in claim 5, wherein said mixture has a dry content in the range of 0.1 to 50 weight-% based on the total dry content.

7. The method as claimed in any one of claims 1 to 4, wherein the mixture is applied onto the base paper or board at or after a press section (NCF2) of a paper or board making machine.

8. The method as claimed in claim 7, wherein said mixture has a dry content in the range of 55 to 75 weight-% based on the total dry content.

9. The method as claimed in any one of the preceding claims, wherein said mixture is applied by any one of spray, foam and coating technologies.

10. The method as claimed in any one of the preceding claims, wherein said surface coating layer is applied as a continous film.

11. The method as claimed in any one of the preceding claims, wherein said mixture is applied onto the first and second side of said material.

12. The method as claimed in any one of the preceding claims, wherein said paper material further comprises a wet strength additive.

13. The method as claimed in any one of claims the preceding claims, wherein said mixture is applied directly onto a formed web in a paper making machine.

14. The method as claimed im any of the preceding claims, where additional filler is added to said mixture.

15. A paper or board product obtainable by the method as claimed in claims 1 to 14.

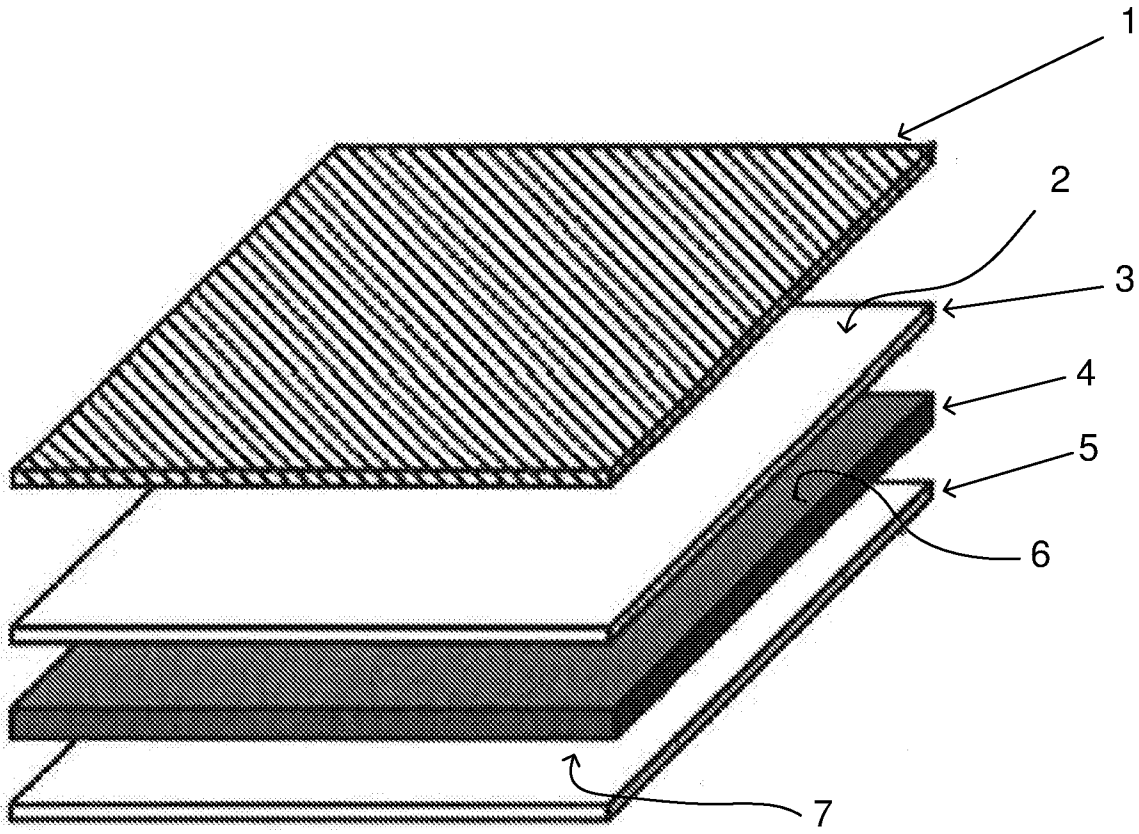
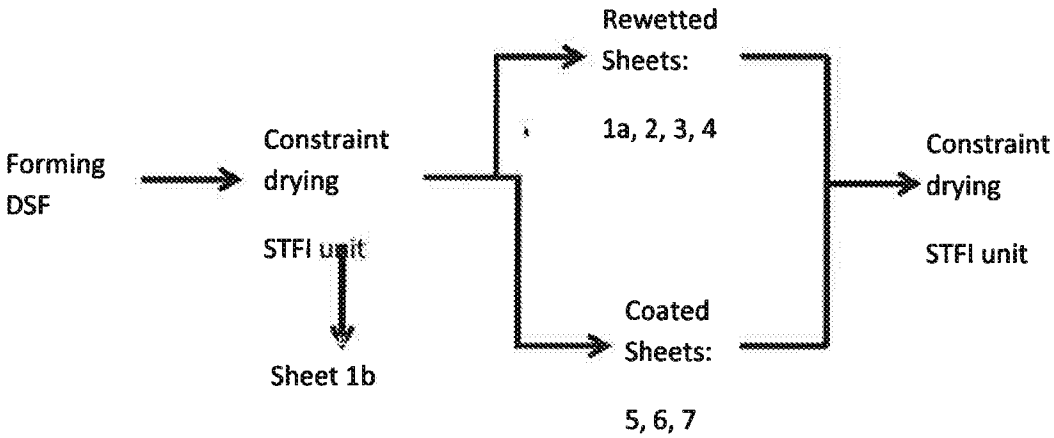


Fig. 1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DSF
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drying
STFI unit
Sheet 1b
Rewetted
Sheets:
1a, 2, 3, 4
Coated
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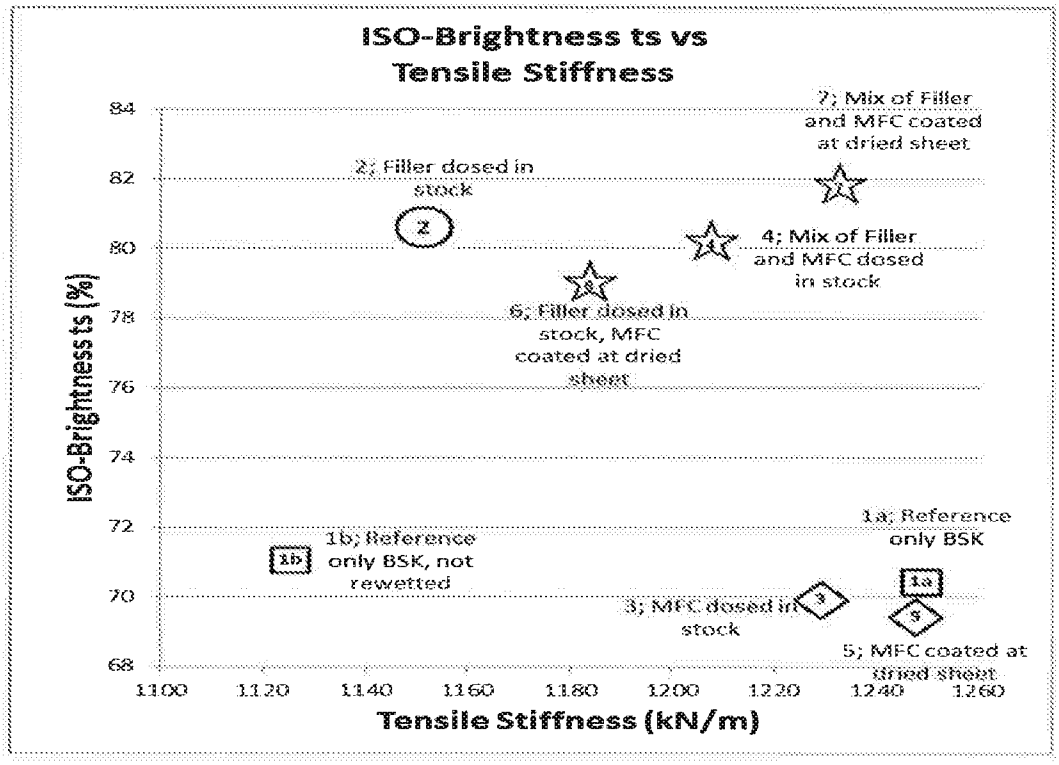
5, 6, 7
Constraint
drying
STFI unit

Fig. 2


ISO-Brightness ts vs
Tensile Stiffness
ISO-Brightness ts (%)
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74
72
70
68
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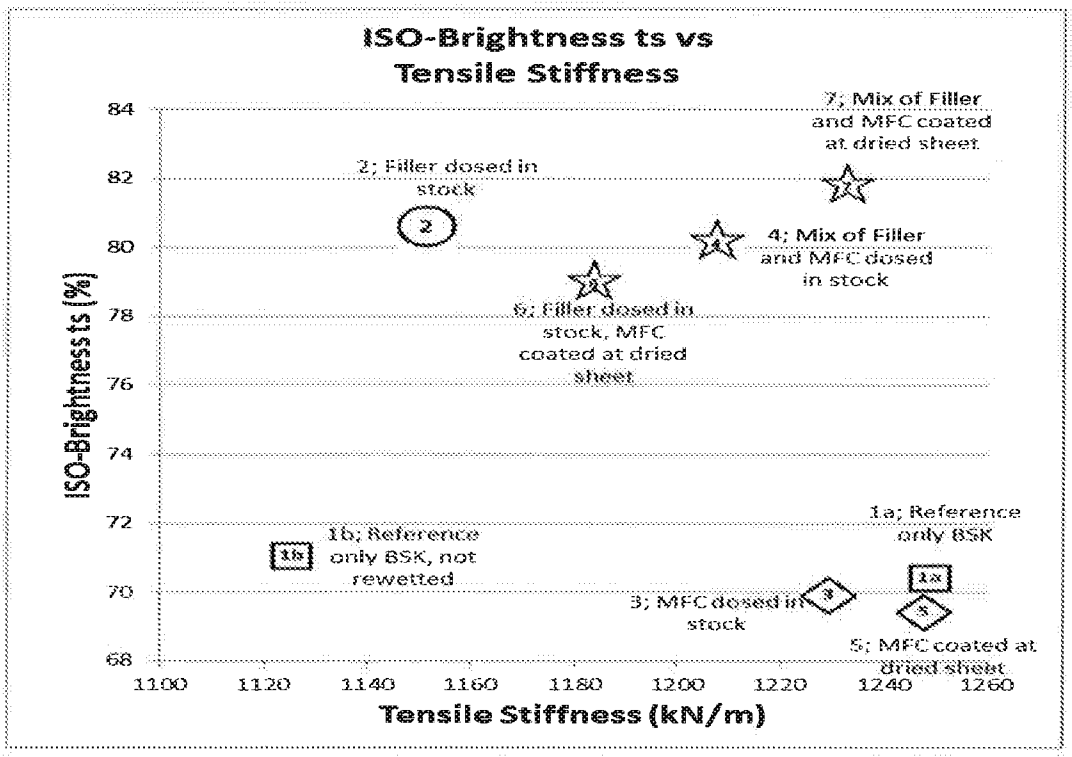
1140
1160
1180
1200
1220
1240
1260
Tensile Stiffness (kN/m)
7; Mix of Filler and MFC coated at dried sheet
2; Filler dosed in stock
4; Mix of Filler and MFC dosed in stock
6; Filler dosed in stock, MFC coated at dried sheet
1a; Reference only BSK
1b; Reference only BSK, not rewetted
3; MFC dosed in stock
5; MFC coated at dried sheet

Fig. 3


ISO-Brightness ts vs
Tensile Stiffness
ISO-Brightness ts (%)
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72
70
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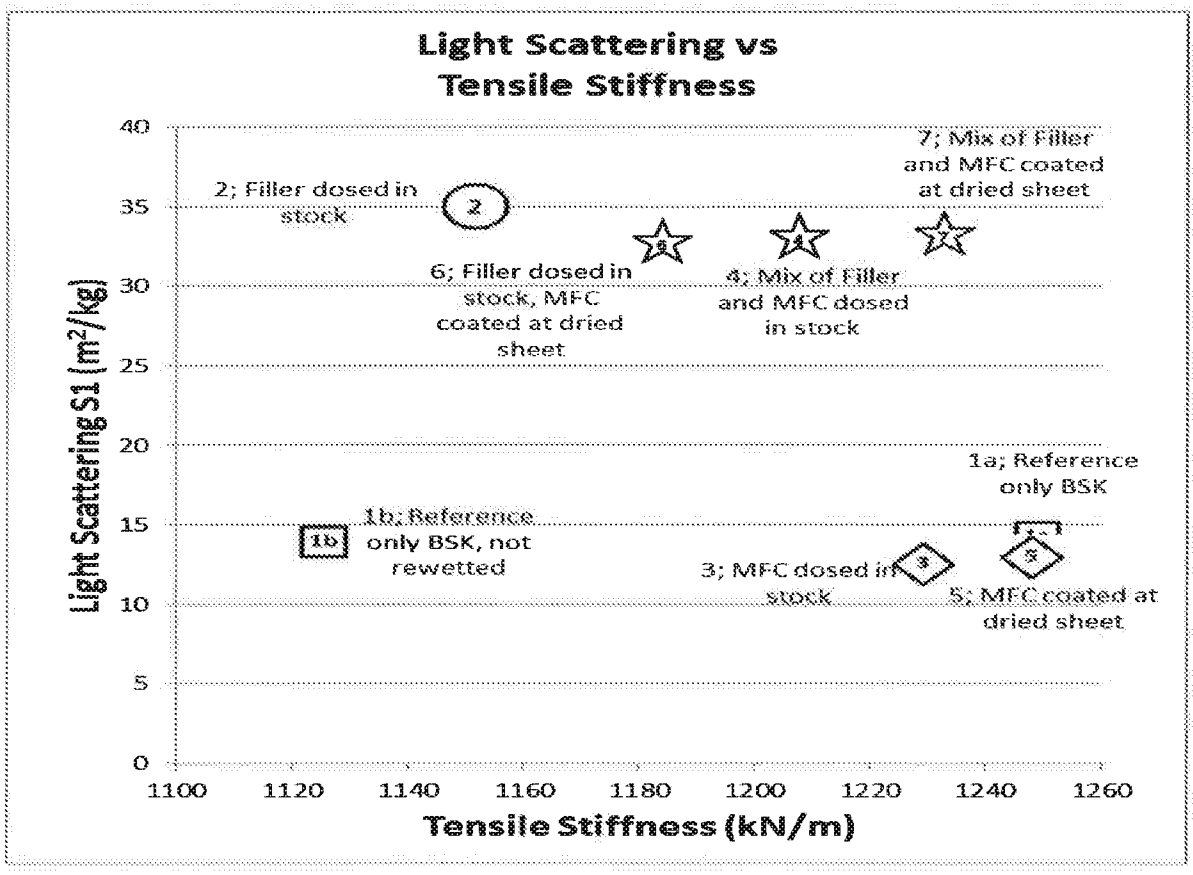
1160
1180
1200
1220
1240
1260
Tensile Stiffness (kN/m)
7; Mix of Filler and MFC coated at dried sheet
2; Filler dosed in stock
4; Mix of Filler and MFC dosed in stock
6; Filler dosed in stock, MFC coated at dried sheet
1a; Reference only BSK
1b; Reference only BSK, not rewetted
3; MFC dosed in stock
5; MFC coated at dried sheet

Fig. 4


Light Scattering vs
Tensile Stiffness
Light Scattering S1 (m²/kg)
Tensile Stiffness (kN/m)
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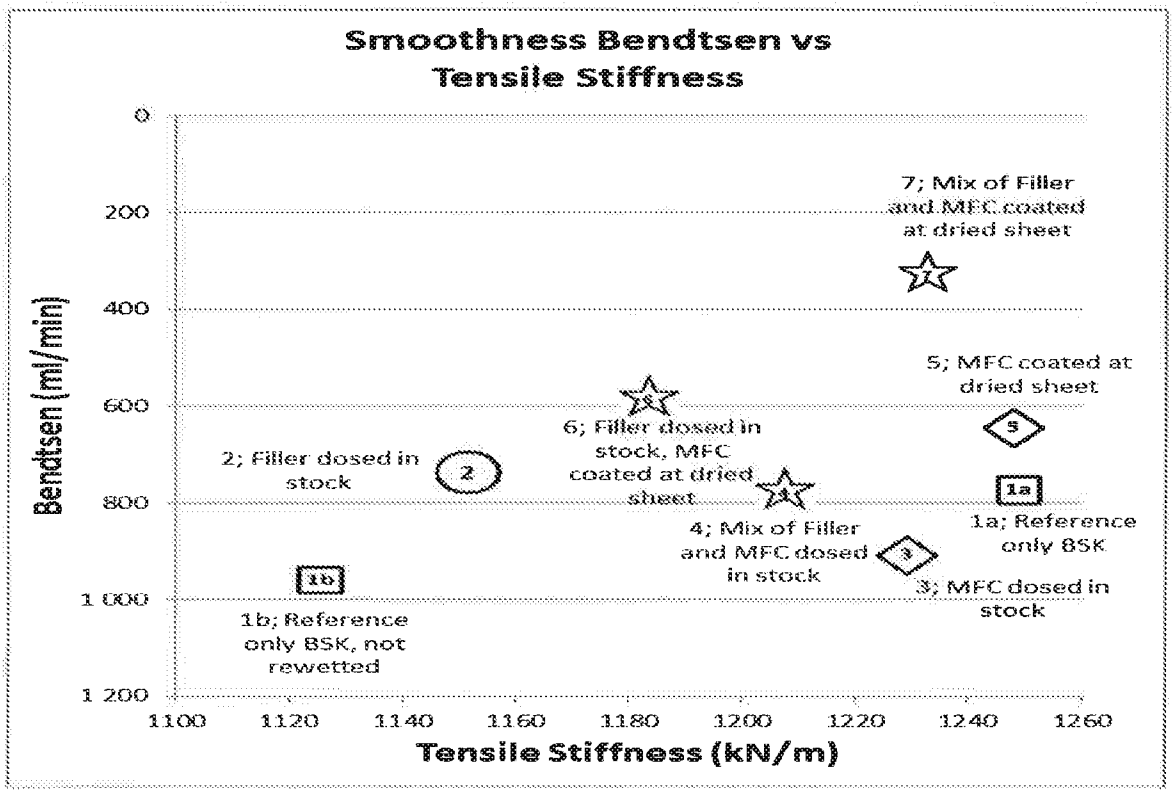
5
10
15
20
25
30
35
40
1100
1120
1140
1160
1180
1200
1220
1240
1260
2; Filler dosed in stock
6; Filler dosed in stock, MFC coated at dried sheet
4; Mix of Filler and MFC dosed in stock
7; Mix of Filler and MFC coated at dried sheet
1a; Reference only BSK
1b; Reference only BSK, not rewetted
3; MFC dosed in stock
5; MFC coated at dried sheet

Fig. 5


Smoothness Bendtsen vs
Tensile Stiffness
Bendtsen (ml/min)
Tensile Stiffness (kN/m)
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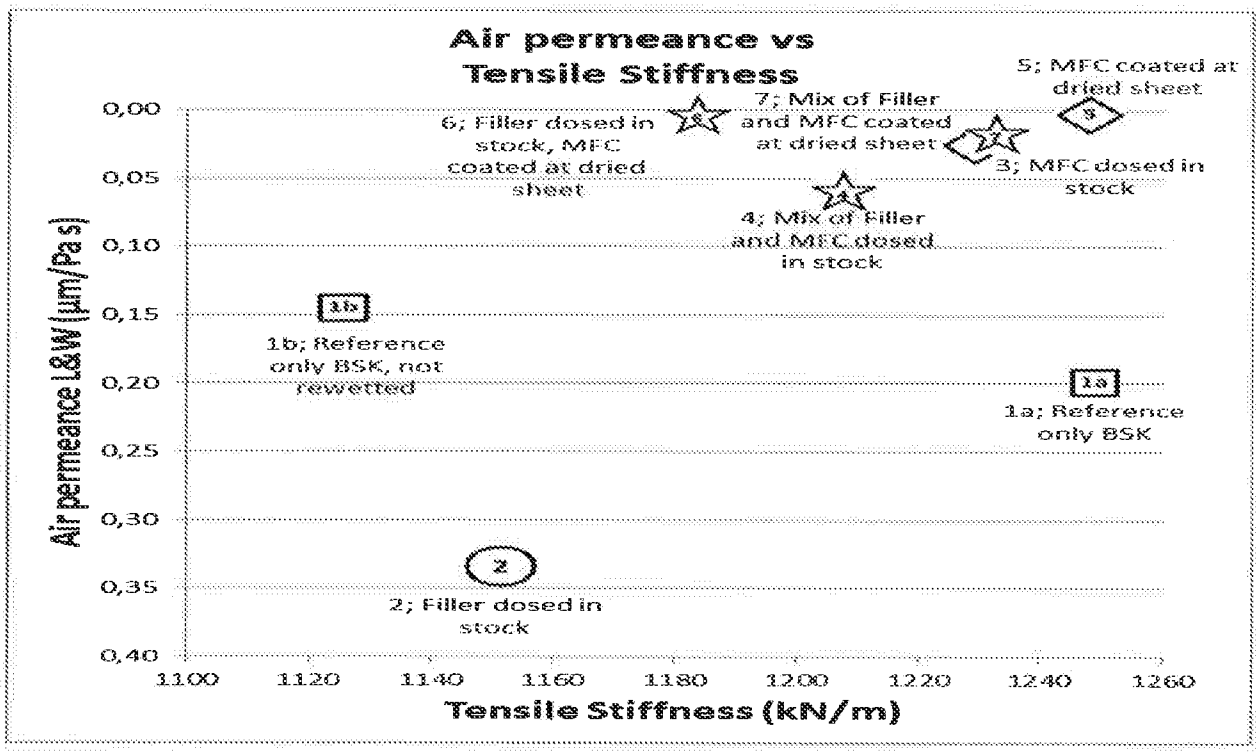
200
400
600
800
1 000
1 200
1100
1120
1140
1160
1180
1200
1220
1240
1260
7; Mix of Filler and MFC coated at dried sheet
5; MFC coated at dried sheet
6; Filler dosed in stock, MFC coated at dried sheet
2; Filler dosed in stock
4; Mix of Filler and MFC dosed in stock
1a; Reference only BSK
3; MFC dosed in stock
1b; Reference only BSK, not rewetted

Fig. 6


Air permeance vs
Tensile Stiffness
Air permeance L&W (µm/Pa s)
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0,10
0,15
0,20
0,25
0,30
0,35
0,40
1100
1120
1140
1160
1180
1200
1220
1240
1260
Tensile Stiffness (kN/m)
1b; Reference only BSK, not rewetted
1a; Reference only BSK
2; Filler dosed in stock
3; MFC dosed in stock
4; Mix of Filler and MFC dosed in stock
5; MFC coated at dried sheet
6; Filler dosed in stock, MFC coated at dried sheet
7; Mix of Filler and MFC coated at dried sheet

Fig. 7

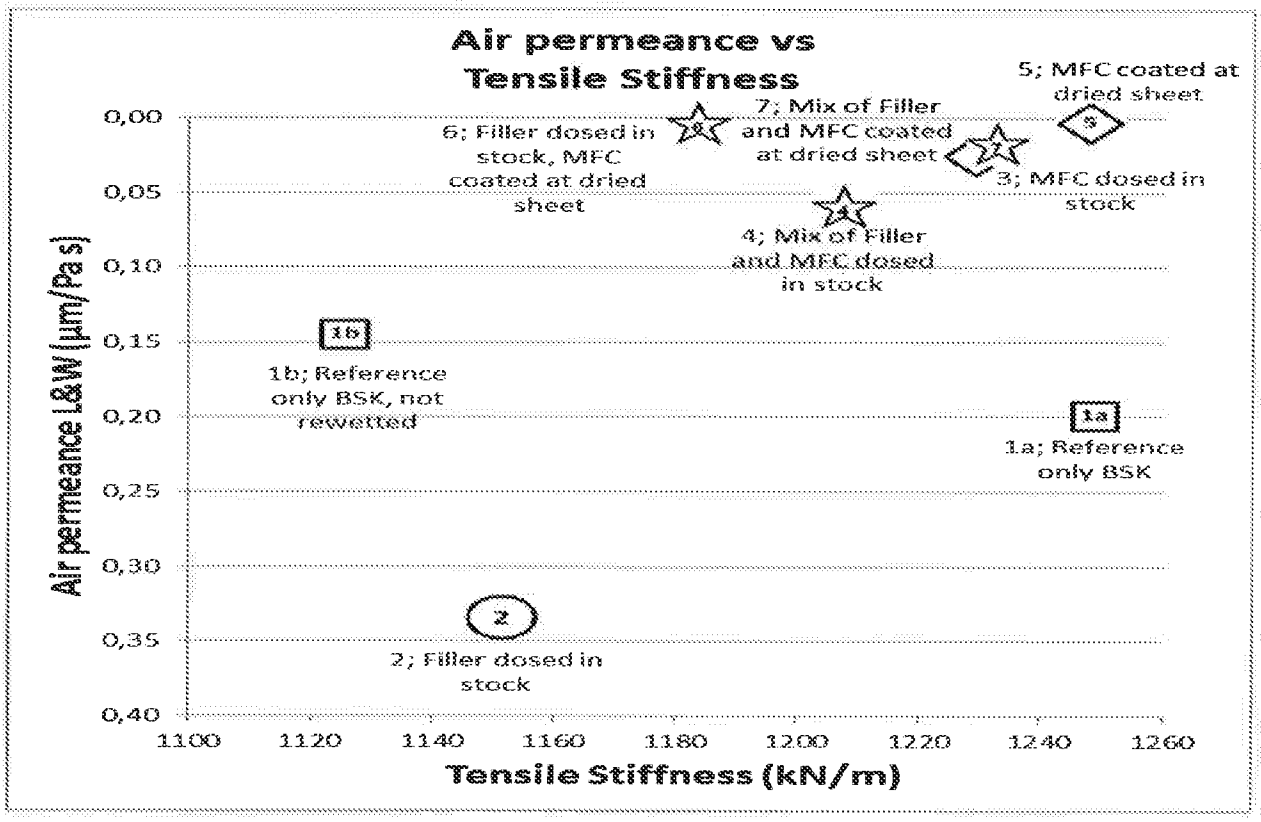
Air permeance vs
Tensile Stiffness
Air permeance L&W (µm/Pa s)
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
0,40
1100
1120
1140
1160
1180
1200
1220
1240
1260
Tensile Stiffness (kN/m)
1b; Reference only BSK, not rewetted
1a; Reference only BSK
2; Filler dosed in stock
3; MFC dosed in stock
4; Mix of Filler and MFC dosed in stock
5; MFC coated at dried sheet
6; Filler dosed in stock, MFC coated at dried sheet
7; Mix of Filler and MFC coated at dried sheet

Fig. 8

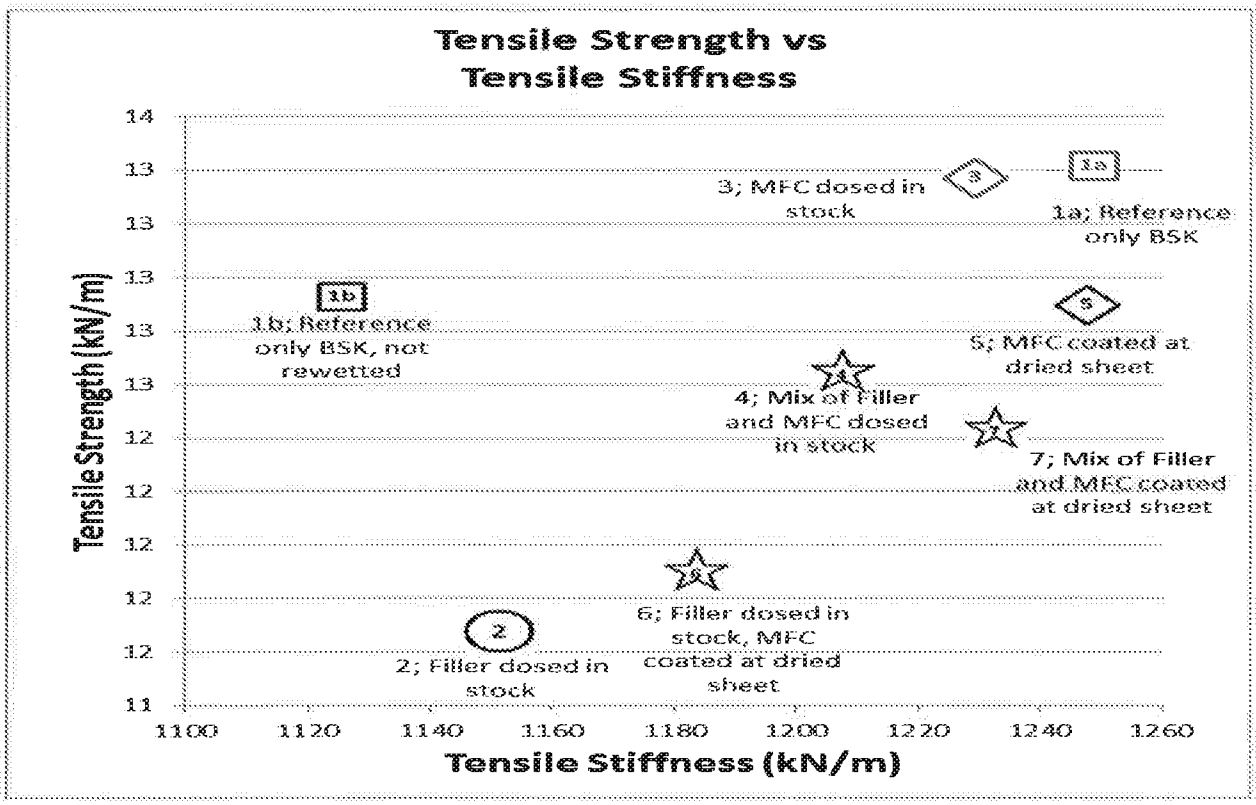
Tensile Strength vs
Tensile Stiffness
Tensile Strength (kN/m)
14
13
13
13
13
13
12
12
12
12
12
11
1100
1120
1140
1160
1180
1200
1220
1240
1260
Tensile Stiffness (kN/m)
3; MFC dosed in stock
1a; Reference only BSK
1b; Reference only BSK, not rewetted
5; MFC coated at dried sheet
4; Mix of Filler and MFC dosed in stock
7; Mix of Filler and MFC coated at dried sheet
6; Filler dosed in stock, MFC coated at dried sheet
2; Filler dosed in stock

Fig. 9

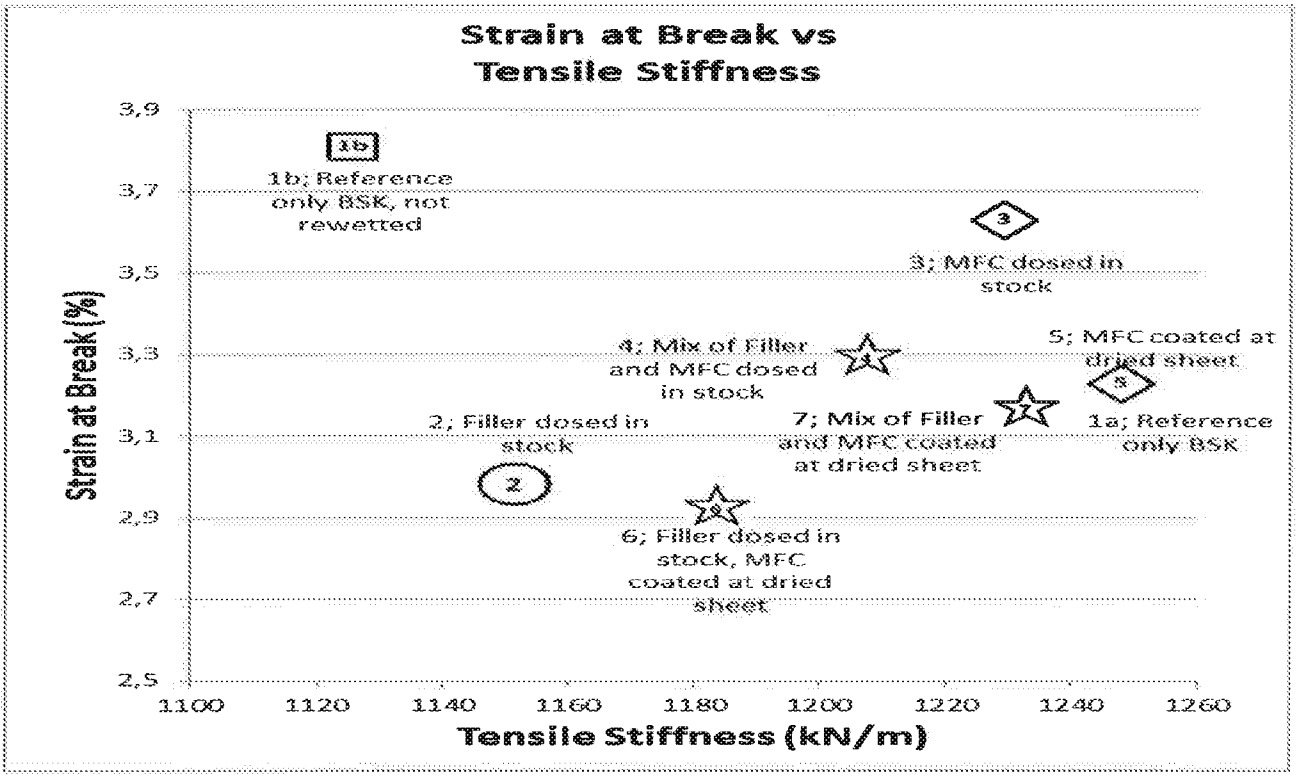
Strain at Break vs
Tensile Stiffness
Strain at Break (%)
3,9
3,7
3,5
3,3
3,1
2,9
2,7
2,5
1100
1120
1140
1160
1180
1200
1220
1240
1260
Tensile Stiffness (kN/m)
1b; Reference only BSK, not rewetted
3; MFC dosed in stock
4; Mix of Filler and MFC dosed in stock
5; MFC coated at dried sheet
2; Filler dosed in stock
7; Mix of Filler and MFC coated at dried sheet
1a; Reference only BSK
6; Filler dosed in stock, MFC coated at dried sheet

Fig. 10

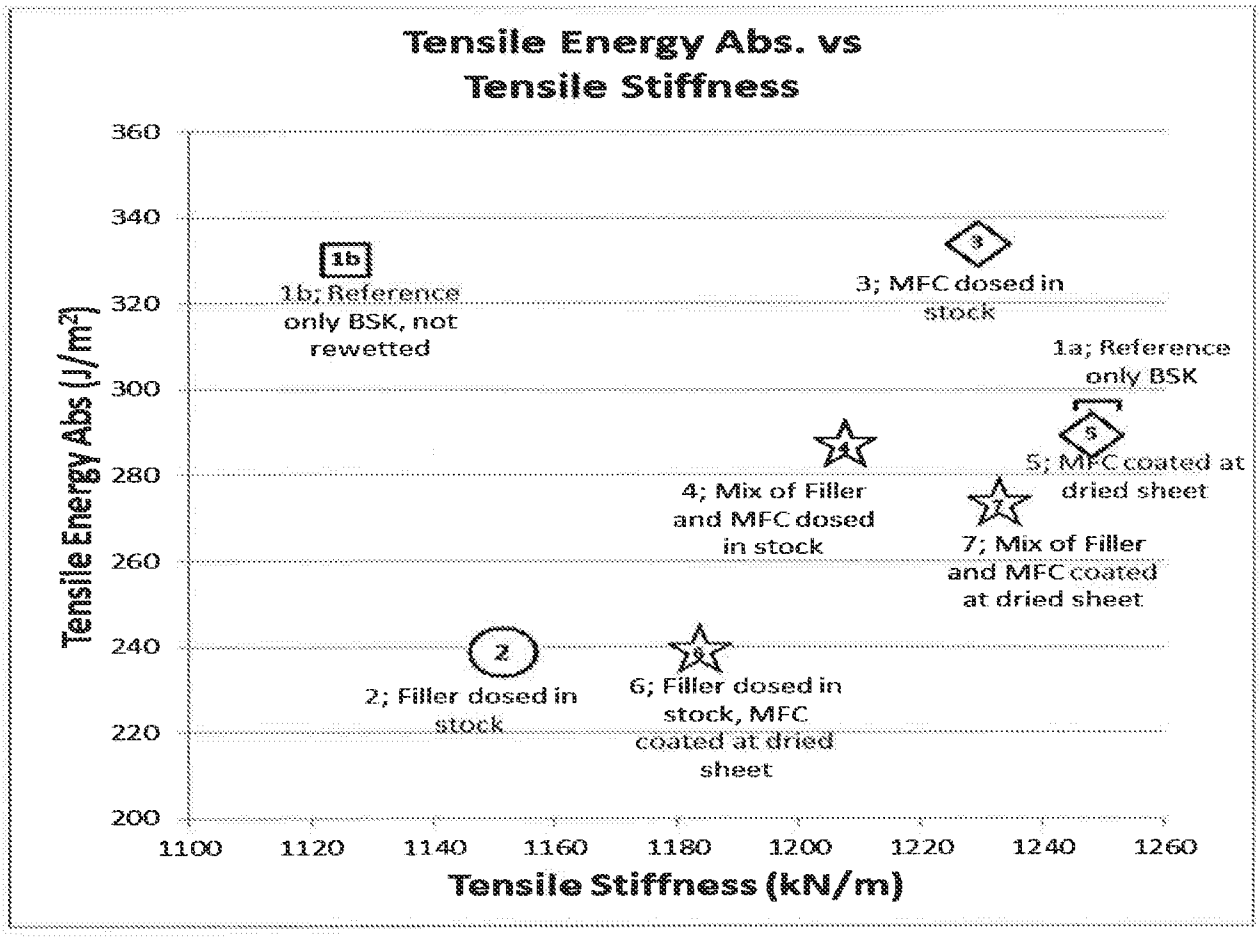
Tensile Energy Abs. vs
Tensile Stiffness
Tensile Energy Abs (J/m²)
360
340
320
300
280
260
240
220
200
1100
1120
1140
1160
1180
1200
1220
1240
1260
Tensile Stiffness (kN/m)
1b
1b; Reference only BSK, not rewetted
3
3; MFC dosed in stock
1a; Reference only BSK
5
5; MFC coated at dried sheet
4
4; Mix of Filler and MFC dosed in stock
7
7; Mix of Filler and MFC coated at dried sheet
2
2; Filler dosed in stock
6
6; Filler dosed in stock, MFC coated at dried sheet

Fig. 11

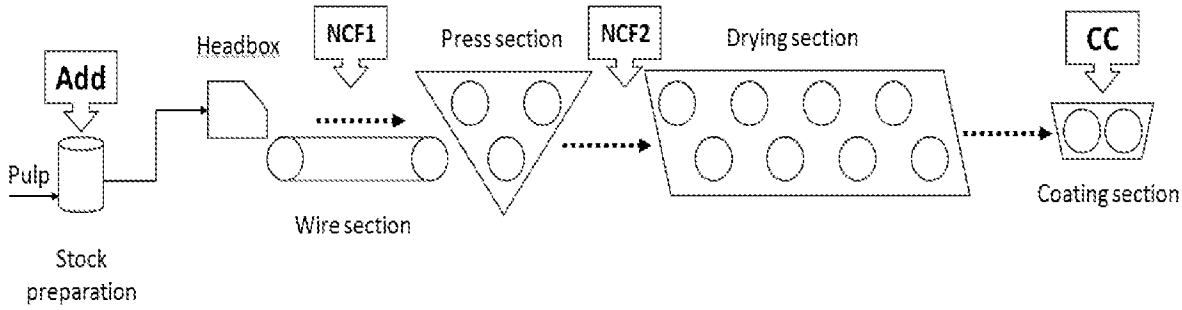

Fig. 12

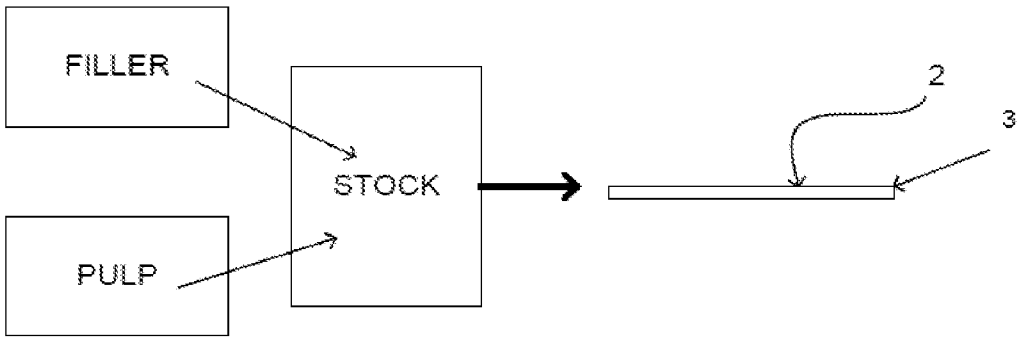

Fig. 13a

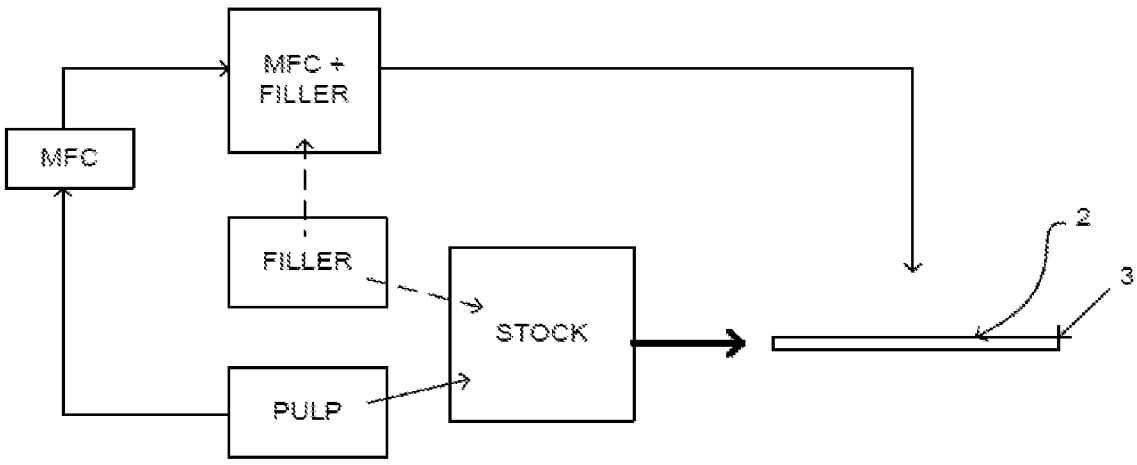

Fig. 13b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2016/052738

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: B32B, C08L, D21C, D21H

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, BIOSIS, COMPENDEX, MEDLINE, PUBCHEM, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010131016 A2 (IMERYS MINERALS LTD ET AL), 18 November 2010 (2010-11-18); page 22, line 14 - page 24, line 30; page 25, line 13 - page 25, line 25; page 26, line 11 - page 26, line 13; page 27, line 18 - page 27, line 30; page 28, line 9 - page 28, line 11; page 32, line 14 - page 32, line 27	1-4, 7, 9-15
Y	--	5, 6, 8
X	WO 2012066308 A2 (IMERYS MINERALS LTD ET AL), 24 May 2012 (2012-05-24); claims 1,9,15	1-4, 7, 9-15
	--	
X	WO 2011059398 A1 (BERGLUND LARS ET AL), 19 May 2011 (2011-05-19); page 8, line 30 - page 9, line 2; claims 1,15	1-4, 7, 9-15
	--	

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24-08-2016	26-08-2016
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer John Sjöberg Telephone No. + 46 8 782 28 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2016/052738

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004055267 A1 (KORSNAES AB PUBL ET AL), 1 July 2004 (2004-07-01); claims --	1-4, 7, 9-15
X	WO 2011056135 A1 (STORA ENSO OYJ ET AL), 12 May 2011 (2011-05-12); page 9, line 8 - page 9, line 15; claims --	1-4, 7, 9-15
X	DIMIC-MISIC K., et al. "Comparing the rheological properties of novel nanofibrillar cellulose-formulated pigment coating colours with those using traditional thickener", 2014, Nordic Pulp and Paper Research Journal, Vol. 29, No. 2, pp. 253-270, ISSN 0283-2631; whole document --	1-4, 7, 9-15
Y	US 3560334 A (ARLEDTER HANNS F), 2 February 1971 (1971-02-02); column 1, line 25 - column 2, line 20; column 4, line 13 - column 4, line 19 --	5, 6, 8
Y	WO 8503316 A1 (SVENSKA TRAEFORSKNINGSINST), 1 August 1985 (1985-08-01); page 2 --	5, 6, 8
X	US 20140050922 A1 (F CHIN YUNGCHANG ET AL), 20 February 2014 (2014-02-20); claims --	1-4, 7, 9-15
X	WO 2010113805 A1 (JUJO PAPER CO LTD ET AL), 7 October 2010 (2010-10-07); claims --	1-4, 7, 9-15
X	US 6183596 B1 (MATSUDA YUJI ET AL), 6 February 2001 (2001-02-06); column 9, line 62 - column 10, line 7 --	1-4, 7, 9-15
X	HAMADA H., et al. "Nanofibrillated cellulose with fine clay as a coating agent to improve print quality", 2010, In: Paper Conference and Trade Show 2010 (PaperCon 2010), Vol. 1, pp. 854-880, ISBN 978-1-61738-789-0; whole document --	1-4, 7, 9-15

International application No.
PCT/IB2016/052738

Continuation of: second sheet

International Patent Classification (IPC)

D21H 19/52 (2006.01)
D21H 11/18 (2006.01)
B32B 29/00 (2006.01)
C08L 1/02 (2006.01)
D21C 9/00 (2006.01)
D21H 19/84 (2006.01)
D21H 27/30 (2006.01)

WO	2010131016	A2	18/11/2010	AU	2010247184	B2 10/01/2013
				CA	2748137	C 07/07/2015
				CN	102753752	A 24/10/2012
				CN	105332306	A 17/02/2016
				DK	2557225	T3 18/07/2016
				EP	3040475	A2 06/07/2016
				EP	2350387	A2 03/08/2011
				ES	2535645	T3 13/05/2015
				JP	2012514137	A 21/06/2012
				JP	5572169	B2 13/08/2014
				JP	2014198930	A 23/10/2014
				KR	101378720	B1 27/03/2014
				KR	20110091025	A 10/08/2011
				KR	101569122	B1 16/11/2015
				KR	20150126727	A 12/11/2015
				KR	20130023398	A 07/03/2013
				RU	2011139570	A 20/06/2013
				RU	2505635	C2 27/01/2014
				TW	201544655	A 01/12/2015
				TW	I530605	B 21/04/2016
				US	20160053437	A1 25/02/2016
				US	20120012031	A1 19/01/2012
				US	20110259537	A1 27/10/2011
				US	9127405	B2 08/09/2015
				US	8231764	B2 31/07/2012
				ZA	201104857	B 31/08/2011
WO	2012066308	A2	24/05/2012	AU	2016202328	A1 05/05/2016
				AU	2011330981	A1 02/05/2013
				CA	2817635	A1 24/05/2012
				CN	103210144	B 06/04/2016
				EP	2640893	A2 25/09/2013
				JP	2014503696	A 13/02/2014
				KR	20130096755	A 30/08/2013
				TW	201241268	A 16/10/2012
				US	20130280545	A1 24/10/2013

WO	2011059398	A1	19/05/2011	CA	2780478	A1	19/05/2011
				CN	103025813	A	03/04/2013
				EP	2501753	A1	26/09/2012
				JP	5796016	B2	21/10/2015
				JP	2013510963	A	28/03/2013
				RU	2567855	C2	10/11/2015
				RU	2012124267	A	27/12/2013
				US	8658287	B2	25/02/2014
				US	20120216718	A1	30/08/2012
WO	2004055267	A1	01/07/2004	AT	527411	T	15/10/2011
				AU	2003288850	A1	09/07/2004
				EP	1573129	A1	14/09/2005
WO	2011056135	A1	12/05/2011	BR	112012010610	A2	22/03/2016
				CN	102686802	B	22/06/2016
				EP	2496766	A4	05/11/2014
				JP	5883393	B2	15/03/2016
				JP	2013510249	A	21/03/2013
				KR	20120091162	A	17/08/2012
				US	20120219816	A1	30/08/2012
				US	9175441	B2	03/11/2015
US	3560334	A	02/02/1971	NONE			
WO	8503316	A1	01/08/1985	DE	198837	T1	26/02/1987
				EP	0198837	A1	29/10/1986
				FI	862288	A	29/05/1986
				JP	61500448	A	13/03/1986
				NO	853662	A	18/09/1985
				SE	441109	B	09/09/1985
				SE	8400258	L	20/07/1985
US	20140050922	A1	20/02/2014	CN	103590283	B	02/12/2015
WO	2010113805	A1	07/10/2010	NONE			
US	6183596	B1	06/02/2001	US	6214163	B1	10/04/2001