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(54) METHOD OF TREATING A FIBER WEB AND A TREATMENT SYSTEM FOR TREATMENT OF A FIBER WEB

(57) The invention relates to a method of treating a fiber web, in which method the fiber web is sized in a sizer (10) by indirect curtain sizing in a curtain sizer (10), in which the sizing agent (TA, TB) is applied onto at least one side of the fiber web by two sizing rolls (11A,11B) with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 — 100 shoreD, advantageously 80 - 95 shoreD, in a sizing nip (N), in which the fiber web (W) is sized with high solids content sizing agent (TA, TB) having solids content of 10 — 60 %, preferably 20 — 40 %, and viscosity of 50 cP- 2000 cP, preferably 100 cP — 1500 cP, and the sizing agent (TA; TB) is applied onto the at least one side of the fiber web (W) by the two sizing rolls (11A,11N), in the sizing nip (N). After the sizing the fiber web (W) is directly guided to contactless and supported drying in an air-borne drying system (20) and the run of the fiber web (W) from the sizing nip (N) to beginning of the drying in the air-borne drying system (20) is not more than 2 m, advantageously not more than 0,5 m, and / or takes not more time than 0,5 s. The invention also relates to a treatment system for treatment of a fiber web, which treatment system comprises a sizer (10), which is a curtain sizer (10) with at least one curtain application device (12A; 12B) for indirect application of sizing agent (TA; TB) and comprises two hard sizing rolls (11A, 11B) with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 — 100 shoreD, advantageously 80 — 95 shoreD, and forming a sizing nip (N), which curtain sizer (10) with the indirect application of sizing agent (TA, TB) is configured to apply the sizing agent (TA, TB) in high solids content of 10 — 60 %, preferably 20 — 40 % and in viscosity of 100 cP or over, preferably 1050 cP— 2000 cP, more preferably 100 cP — 1500 cP. The treatment system further comprises an immediately after the sizer (10) located air-borne drying system (20) such, that the run of the fiber web (W) from the sizing nip (N) to beginning of the drying in the air-borne drying system (20) is not more than 2 m, advantageously not more than 0,5 m, and / or takes not more time than 0,5 s.

EP 3 988 713 A1

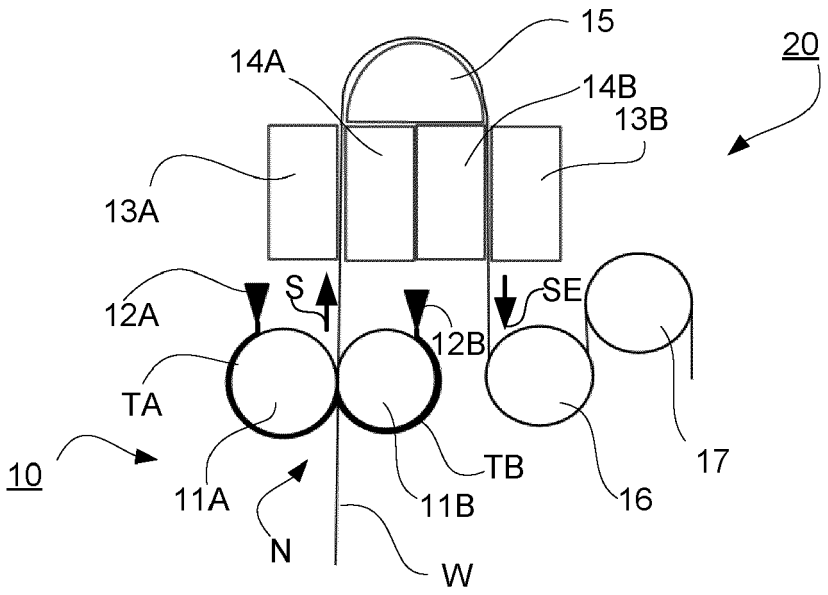

Fig. 1

Description

[0001] In general, present invention relates to treating of fiber webs in a fiber web production line. More especially the present invention relates to a method according to preamble part of the independent method claim and to a treatment system according to preamble part of the independent treatment system claim.

[0002] In this description and the following claims by fiber webs are meant for example a paper and board webs.

[0003] Fiber webs, such as paper and board webs are available in a wide variety of types and can be divided according to basis weight in two grades: papers with a single ply and a basis weight of 25-300 g/m^2 and boards manufactured in multi-ply technology and having a basis weight of 150-600 m/m^2. It should be noted that the borderline between paper and board is flexible since board grades with lightest basis weights are lighter than the heaviest paper grades. Generally speaking, paper is used for printing and board for packaging.

[0004] The subsequent descriptions are examples of values presently applied for fiber webs, and there may be considerable fluctuations from the disclosed values. The descriptions are mainly based on the source publication Papermaking Science and Technology, section Papermaking Part 3, edited by Rautiainen, P., and published by Paper Engineers' Association, Helsinki 2009, 404 pages.

[0005] Mechanical-pulp based, i.e. wood-containing printing papers include newsprint, uncoated magazine and coated magazine paper.

[0006] Today's newsprint furnishes mostly contain between 80 and 100 % deinked pulp (DIP). The rest of the furnish is mechanical pulp (typically TMP). However, there is also newsprint made of 100 % mechanical fiber furnishes. DIP based newsprint may contain up to 20 % filler. The filler content of a virgin-fiber based newsprint furnish is about 8 %.

[0007] General values for CSWO newsprint can be regarded as follows: basis weight 40-48.8 g/m^2, PPS s10 roughness (SCAN-P 76-95) 4.0-4.5 μm, Bendtsen roughness (SCAN-P21:67) 150 ml/min, density 600-750 kg/m^3, brightness (ISO 2470:1999) 58-59 %, and opacity (ISO 2470:1998) 92-95%.

[0008] Uncoated magazine paper (SC-supercalendered) grades usually contain 50 % - 75 % mechanical pulp, 5 % - 25 % chemical pulp, and 10 % - 35 % filler. The paper may also contain DIP. Typical values for calendered SC paper (containing e.g. SC-C, SC-B, and SC-A/A+) include basis weight 40-60 g/m^2, ash content (SCAN-P 5:63) 0-35%, Hunter gloss (ISO/DIS 8254/1) <20-50%, PPS s10 roughness (SCAN-P 76:95) 1.0-2.5 μm, density 700-1250 kg/m^3, brightness (ISO 2470:1999) 62-75%, and opacity (ISO 2470:1998) 90-95%.

[0009] Coated mechanical papers include for example MFC (machine finished coated), LWC (lightweight coated), MWC (medium weight coated), and HWC (heavy weight coated) grades. Coated mechanical papers usually contain 45 % -75 % mechanical or recycled fiber and 25 % - 55 % chemical pulp. Semi chemical pulps are typical in LWC paper grades made in the Far East. The filler content is about 5 % -10 %. The grammage is typically in the range 40-80 g/m2.

[0010] General values for LWC paper can be regarded as follows: basis weight 40-70 g/m^2, Hunter gloss 50-65%, PPS S10 roughness 1.0-1.5 μm (offset) and 0.6-1.0 μm (roto), density 1100-1250 kg/m^3, brightness 70-75%, and opacity 89-94%.

[0011] General values for MFC paper (machine finished coated) can be regarded as follows: basis weight 48-70 g/m^2, Hunter gloss 25-40%, PPS S10 roughness 2.2-2.8 μm, density 900-950 kg/ m^3, brightness 70-75%, and opacity 91-95%.

[0012] General values for MWC paper (medium weight coated) can be regarded as follows: basis weight 70-90 g/ m^2, Hunter gloss 65-70%, PPS S10 roughness 0.6-1.0 μm, density 1150-1250 kg/ m^3, brightness 70-75%, and opacity 89-94%.

[0013] Wood free paper is divided into two segments: uncoated and coated. Conventionally, the furnish of wood free papers consists of bleached chemical pulp, with less than 10 % mechanical pulp.

[0014] Typical values are for uncoated WFU Copy paper: grammage 70-80 g/m^2, Bendtsen roughness 150-250 ml/min and bulk > 1.3 cm3/g; for uncoated offset paper: grammage 60-240 g/m^2, Bendtsen roughness 100-200 ml/min and bulk 1.2-1.3 cm3/g; and for color copy paper: grammage 100 g/m^2, Bendtsen roughness < 50 ml/min and bulk 1.1 cm3/g.

[0015] In coated pulp-based printing papers (WFC), the amounts of coating vary widely in accordance with requirements and intended application. The following are typical values for once- and twice-coated, pulp-based printing paper: once-coated basis weight 90 g/ m^2, Hunter gloss 65-80%, PPS s10 roughness 0.75-1.1 μm, brightness 80-88%, and opacity 91-94%, and twice-coated basis weight 130 g/ m^2, Hunter gloss 70-80%, PPS S10 roughness 0.65-0.95 μm, brightness 83-90%, and opacity 95-97%.

[0016] Containerboard includes both linerboard and corrugating medium. Liners are divided according to their furnish base into Kraft liner, recycled liner and white top liner. Liners are typically 1- to 3-ply boards with grammage varying in the range 100-300 g/m^2.

[0017] Linerboards are generally uncoated, but the production of coated white-top liner is increasing to meet higher demands for printability.

[0018] The main cartonboard grades are folding boxboard (FBB), white-lined chipboard (WLC), solid bleached board (SBS) and liquid packaging board (LPB). In general, these grades are typically used for different kinds of packaging of consumer goods. Carton board grades vary from one- up to five-ply boards (150-400 g/m^2). The top side is usually coated with from one to

three layers (20-40 g/m^2); the back side has less coating or no coating at all. There is a wide range of different quality data for the same board grade. FBB has the highest bulk thanks to the mechanical or chemi mechanical pulp used in the middle layer of the base board. The middle layer of WLC consists mainly of recycled fiber, whereas SBS is made from chemical pulp, exclusively.

[0019] FBB's bulk typically is between 1.1-1.9 cm^3/g whereas WLC is on range 1.1-1.6 cm^3/g and SBS 0.95-1.3 cm^3/g. The PPS-s10-smoothess is respectively for FBB between 0.8 - 2.1 μm, for WLC 1.3- 4.5 μm and for SBS 0.7 - 2.1 μm.

[0020] Release paper is used in label base paper in various end-use applications, such as food packaging and office labels. The most common release paper in Europe is supercalendered glassine paper coated with silicone to provide good release properties.

[0021] Typical values for supercalendered release papers are basis weight 60 - 95 g/m^2, caliper 55-79 μm, IGT 12-15 cm, Cobb Unger for dense side 0.9-1.6 g/m^2 and for open side 1.2-2.5 g/m^2.

[0022] Coated label paper is used as face paper for release, but also for coated backing paper and flexible packings. Coated label paper has a grammage of 60-120 g/m^2 and is typically sized or pre-coated with a sizer and single-blade coated on one side. Some typical paper properties for coated and calendered label paper are basis weight 50-100 g/m^2, Hunter gloss 70-85%, PPS s10 roughness 0.6-1.0 μm, Bekk smoothness 1500-2000 s and caliper 45-90 μm.

[0023] The fiber webs are produced in a fiber web producing process. As known from the prior art in fiber web producing processes typically comprise an assembly formed by a number of apparatus arranged consecutively in the process line. A typical production and treatment line comprise a head box, a wire section and a press section as well as a subsequent drying section and a reel-up. The production and treatment line can further comprise other devices and/or sections for finishing the fiber web, for example, a pre-calender, a sizer, a final-calender, a coating section. The production and treatment line also typically comprise at least one slitter-winder for forming customer rolls as well as a roll packaging apparatus.

[0024] In production of fiber webs, for example in production of paper or board webs, sizing is used to alter the properties of a fiber web by adding sizing agents, for example starch. Sizing can be divided to internal sizing and surface sizing. In internal sizing the sizing agent is added to pulp in the wet end of the fiber web machine before forming. In surface sizing the sizing agent is added onto the surface of the fiber web typically at the dry end of the fiber web machine. Surface sizing is used in production of many fiber web grades, for example of uncoated fine papers and of several board grades. Sizing is used in order to improve paper web properties, in particular water resistance, water absorption properties, strength, internal strength, surface strength and bending stiffness, as well as to improve adherence of coating color to the surface of the fiber web. In addition, runnability as well as dusting tendency can be affected favorably.

[0025] An object of the invention is to create a method of treating a fiber web and a treatment system for treatment of a fiber web, in which disadvantages in treating a fiber web with high solids sizing agent are eliminated or at least minimized.

[0026] A particular object of the invention is to create a method and a system to treat the fiber web to improve the surface strength and/or to create non-porous, advantageously porous controlled, closed surface of the fiber web, which provides good basis for coating, especially for barrier coating, of the fiber web..

[0027] A particular object is to create a method and a system to treat the fiber web to improve the strength and/or stiffness of the fiber web.

[0028] A particular object is to create a method and a system to treat the fiber web such, that dusting of the fiber web is eliminated or at least minimized.

[0029] A particular object is to create a method and a system to treat the fiber web to improve printing properties of the fiber web.

[0030] To achieve the objects mentioned above and later the method according to the invention is mainly characterized by the features of the characterizing part of the independent method claim.

[0031] The treatment system for treatment of a fiber web according to the invention is mainly characterized by the features of the characterizing part of the independent treatment system claim.

[0032] Advantageous features and embodiments of the invention are defined in the dependent claims.

[0033] According to the invention in the method of treating a fiber web the fiber web is sized in a sizer by indirect curtain sizing in a curtain sizer, in which the sizing agent is applied onto at least one side of the fiber web by two sizing rolls with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD, in a sizing nip, in which the fiber web is sized with high solids content sizing agent having solids content of 10 - 60 %, preferably 20 - 40 %, and viscosity of 50 cP- 2000 cP, preferably 100 cP - 1500 cP, and the sizing agent is applied onto the at least one side of the fiber web by the two sizing rolls in the sizing nip, wherein after the sizing the fiber web is directly guided to contactless and supported drying in an air-borne drying system (20) and the run of the fiber web from the sizing nip to beginning of the drying in the air-borne drying system is not more than 2 m, advantageously not more than 0,5 m, and / or takes not more time than 0,5 s.

[0034] According to an advantageous aspect of the invention the drying is continuous until the moisture content of the fiber web is desired for the next treatment and the fiber web runs without open draws and contacts to rolls.

[0035] Advantageously, as the sizing roll is used a ceramic or metallic roll or advantageously, a roll with a pol-

ymeric roll cover (rubber, polyurethane or composite) having surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD. The hard sizing nip enhances the strength increase.

[0036] According to an advantageous feature of the invention in the method the fiber web is configured to have a substantially U-formed contactless run in the air-borne drying system or a substantially reversed U-formed contactless run in the air-borne drying system.

[0037] According to an advantageous aspect in the method the fiber web is supported by air blows of the air-borne drying system and by the shape of the U-formed/the reversed U-formed contactless run such, that bending of the fiber web around an imaginary axis in the machine direction is eliminated.

[0038] According to an advantageous feature of the invention in the method maximum blowing air temperature in the air-borne drying system is about 500°C and minimum blowing air temperature is 50°C, advantageously 140-400°C.

[0039] According to an advantageous feature of the invention in the method blowing air velocity in the air-borne drying system is at least 20 m/s, advantageously 40 - 60 m/s.

[0040] According to an advantageous feature of the invention the air-borne drying system comprises at least two, advantageously three air compartments forming chambers of the air-borne drying system and that advantageously temperature and/or velocity of blowing air from each air compartment is adjustable, advantageously such, that both sides of the fiber web can be treated individually.

[0041] According to an advantageous aspect of the invention temperature and/or velocity of blowing air of each air compartment is adjustable such, that by increasing the velocity and lowering the temperature, the temperature of the fiber web is lowered at the same drying efficiency. According to an alternative advantageous aspect of the invention temperature and/or velocity of blowing air of each air compartment is adjustable such, that by decreasing the velocity and increasing the temperature, the temperature of the fiber web is increased. Thus, the temperature of the fiber web is controlled.

[0042] According to an advantageous feature of the invention running direction of the fiber web in the sizer is substantially, vertically upwards and running direction of the fiber web from the air-borne drying system is substantially vertically downwards or substantially inclined in relation to vertical direction substantially inclined downwards. Alternatively, according to an advantageous feature of the invention running direction of the fiber web in the sizer is substantially, vertically downwards and running direction of the fiber web from the air-borne drying system is substantially vertically upwards or substantially inclined in relation to vertical direction substantially inclined upwards.

[0043] According to the invention the treatment system for treatment of a fiber web comprises a sizer, which is a curtain sizer with at least one curtain application device for indirect application of sizing agent and comprises two sizing rolls with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD, and forming a sizing nip, which curtain sizer with the indirect application of sizing agent is configured to apply the sizing agent in high solids content of 10 - 60 %, preferably 20 - 40 % and in viscosity of 50 cP- 2000 cP, preferably 100 cP - 1500 cP, wherein that the treatment system further comprises an immediately after the sizer located air-borne drying system such, that the run of the fiber from the sizing nip to beginning of the drying in the air-borne drying system is not more than 2 m, advantageously not more than 0,5 m, and / or takes not more time than 0,5 s.

[0044] Advantageously, as the sizing roll is used a ceramic or metallic roll or advantageously, a roll with a polymeric roll cover (rubber, polyurethane or composite) having surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD. The hard sizing nip enhances the strength increase.

[0045] According to an advantageous feature of the invention one of the sizing rolls is a deflection compensated roll.

[0046] According to an advantageous feature of the invention the air-borne drying system is configured to have a substantially U-formed contactless run for the fiber web or a substantially reversed U-formed contactless run in the air-borne drying system for the fiber web.

[0047] According to an advantageous feature of the invention the air-borne drying system comprises at least two, advantageously three air compartments forming chambers of the air-borne drying system and that advantageously temperature and/or velocity of blowing air from each air compartment is adjustable such, that the both sides of the web can be individually controlled.

[0048] According to an advantageous aspect of the invention drying of the fiber web can be optimized such, that sorption of water and sizing agent into the base of the fiber web is optimized, advantageously minimized.

[0049] According to an advantageous aspect of the invention the drying by the air-borne drying system is contactless. Thus, cleaning and other maintenance work is needed very seldom.

[0050] According to an advantageous feature of the invention maximum blowing air temperature in the air-borne drying system is about 500°C and minimum blowing air temperature is 50°C, advantageously 140-400°C. Thus, the run of the fiber web is dynamically air pressure supported such, that moisture and/or temperature differences of the fiber web do not cause curl in the cross direction of the fiber web.

[0051] According to an advantageous feature of the invention blowing air velocity in the air-borne drying system is at least 20 m/s, advantageously 40 - 60 m/s.

[0052] According to an advantageous feature of the invention running direction of the fiber web in the sizer is

substantially, vertically upwards and running direction of the fiber web from the air-borne drying system is substantially vertically downwards or substantially inclined in relation to vertical direction substantially inclined downwards. Alternatively, according to an advantageous feature of the invention running direction of the fiber web in the sizer is substantially, vertically downwards and running direction of the fiber web from the air-borne drying system is substantially vertically upwards or substantially inclined in relation to vertical direction substantially inclined upwards.

[0053] According to one advantageous aspect of the invention the method and the system the fiber web is sized in the curtain sizer and the sizing agent is applied to the fiber web indirectly, i.e. first applying the sizing agent onto a surface of a roll forming a sizing nip, i.e. onto a surface of a sizing roll, and then applying the sizing agent to the fiber web by the sizing roll.

[0054] According to an advantageous aspect of the invention the curtain sizer comprises a slot or a slide nozzle.

[0055] According to an advantageous aspect of the invention the sizing agent is starch based sizing agent (uncooked starch or modified starch), carboxy methyl cellulose (CMC) based sizing agent, a substance providing a barrier layer comprising PVA (polyvinyl acetate), PVOH (polyvinyl alcohol), PEF (polyethylene furanoate), PLA (polylactic acid), PET (polyethylene terephthalate), PVdC (polyvinylidene chloride), alginates, chitosan, zein protein or nano-(NFC) or micro-fibrillated cellulose (MFC), or other synthetic or bio-based polymer latexes.

[0056] According to an advantageous aspect of the invention the fiber web is sized with sizing agent comprising fiber suspension.

[0057] According to an advantageous aspect of the invention the fiber web is sized with sizing agent comprising natural fibers and/or synthetic fibers. Advantageously, the sizing agent comprises for example pulp and/or cotton and/or nylon and/or polyester and/or aramid fibers.

[0058] According to an advantageous aspect of the invention the fiber web is sized with sizing agent comprising fiber suspension with 0,5 % or less fiber consistency.

[0059] The fibers can be nanoscale fibers and/or microscale fibers, advantageously, length of a fiber in the sizing agent is 0,1 μm - 10 mm and width of a fiber in the sizing agent is 0.01 - 30 μm.

[0060] According to an advantageous aspect of the invention the fiber web is treated by first adding the high solids sizing agent in the sizer to the fiber web and by thereafter substantially immediately drying the sizing agent by the air-borne drying system and thus increasing the Young's modulus of at least surface parts of the fiber web. By this the strength of the fiber web, especially the surface strength of the fiber web, is improved as the Young's modulus of at least the surface parts of the fiber web with the sizing agent increases due to increased and/or enhanced bonding of fibers. The strength of the fiber web after the drying is improved 10 - 70%. Advantageously, schematical form of the strength variation in thickness direction of the fiber web corresponds to the form of an I-beam cross section form. Accordingly, also the bending stiffness of the fiber web is improved.

[0061] According to an advantageous aspect of the invention linear load in the sizing nip is 5 - 450 kN/m, more preferably the linear load in the sizing nip is 5 - 200 kN/m.

[0062] According to one advantageous aspect of the invention in the method of threating the fiber web and the treatment system the fiber web the high solids content of the sizing agent and the high viscosity of the sizing agent combined with the hard sizing nip of the sizer provide that the sizing agent remains on the surface/surfaces of the fiber web after the sizing in the sizer. The drying in the air-borne drying system configured to dry the sizing agent such, that the sizing agent substantially remains on the surface of the fiber web i.e. only minimally protrudes inside the fiber web provides strength to the surfaces: improved Youngs modulus and steep force-strain curve, which provides improved flexural strength of the fiber web.

[0063] According to one advantageous aspect of the invention in the method of threating the fiber web and the treatment system the fiber web the drying by the air-borne drying system with hot air blows is configured to provide circumstances, in which the moisture towards the surfaces and the high blow velocity of the hot air blows the moisture mass-transfer with lower partial steam pressure and removes moisture and thus decreases the partial steam pressure the air, which both factors increase diffusion outwards from the moist sizing agent on the surface of the fiber web and thus diffusion and capillary effect towards inside of the fiber web are reduced significantly. Thus, sizing agent transfer towards inside the fiber web is decreased. The continued drying and immediately after sizing beginning drying configured by the air-borne drying system significantly prevent moisture sorption by capillary effect.

[0064] According to the invention in the treatment system one of the sizing rolls is a deflection compensated roll by which the pressure distribution and speed of the sizing nip can be adjusted in cross-direction of the fiber web and thus substantially uniform speed and uniform pressure distribution in the sizing nip in cross-direction of the fiber web is achieved.

[0065] According to the invention in the treatment system the sizing nip is formed between two sizing rolls, one of which is a deflection compensated roll and due to the effect provided by the deflection compensated roll the sizing nip is substantially straight, by which the runnability of the fiber web is improved.

[0066] According to the invention the hard sizing nip is formed between the two sizing rolls with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD.

[0067] Advantageously, as the sizing roll is used a ceramic or metallic roll or advantageously, a roll with a hard-

polymeric roll cover (rubber, polyurethane or composite) having surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD. The hard sizing nip enhances the strength increase.

[0068] According to an advantageous aspect of the invention in the sizing nip of the sizer and thus during the sizing the run of the fiber web is substantially vertical.

[0069] According to one aspect of invention the system in accordance with the invention are to be by configurating an existing fiber web production line, for example by adding the treatment system to a fiber production line without a sizing section at a location after the drying section, as the sizing section with the air-borne drying system or by amending an existing sizing section to be in accordance with the treatment system comprising the hard nip sizer and the air-borne drying system in accordance with the invention.

[0070] In the method and in the system according to the invention either one or both sides of the fiber web are treated.

[0071] The method and the system according to an advantageous aspect of the invention are also well applicable in sizing with two-component sizing agent as in this type of curtain sizing there is no return circulation of sizing substance. In other types of sizing methods and systems with return circulation the two-component sizing agent may harden in the return circulation and thus cause problems in the return circulation.

[0072] The method and the system according to an advantageous aspect of the invention also sizing agents with platy particle shaped substance suspensions, for example kaolin, can be used as in curtain sizing no metering rods are needed for applicating the sizing substance. In types of sizing methods and systems, where metering rods are used, grooves of the metering rods would block if platy particle shaped substance suspensions would be used.

[0073] Thus, the sizing agent can also comprise two-component sizing agent, for example lignin with acidic activator, and/or polymers, for example polyethene and/or polypropylene, and/or mineral fillers and/or particles, for example kaolin in platy particle shape. Also, sizing agents comprising cross-linking substances can be used.

[0074] By the invention and its advantageous aspects and features many advantages are achieved, in particular the strength, especially the surface strength, of the fiber web is significantly improved. In particular during treatment of the fiber web according to the invention the fiber web is supported and without long free runs, which provides for good runnablility of the fiber web in the treatment section Additionally, the fiber web with high solids content sizing agent, advantageously with fiber suspension, has a stiff structure as the sizing agent tends to remain more in the surface parts of the fiber web and the surface pores close and thus need of calendering is decreased. Additionally, the air-borne drying provides for contactless drying and support of the surface sized fiber web and thus, adherence problems are avoided. Additionally, the fiber web sized with sizing agent comprising according to the advantageous feature of the invention fiber suspension improves the adherence of coating color to the surface of the fiber web. Further, sizing in the hard sizing nip between the two sizing rolls with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD, does not roughen the surface smoothness of the fiber web as is typical when the sizing nip has a soft sizing roll but instead the surface smoothness increases. The present invention also provides a compact layout of the treatment system.

[0075] In the following the invention is further explained in detail with reference to the accompanying drawing in which:

In figure 1 is schematically shown an advantageous example of the treatment system according to the invention,

In figure 2 is schematically shown another advantageous example of the treatment system according to the invention,

In figure 3 is schematically shown yet an advantageous example of the treatment system according to the invention and

In figure 4 is schematically shown yet another advantageous example of the treatment system according to the invention.

[0076] In the following description same reference signs designate for respective components etc. unless otherwise mentioned and it should be understood that the examples are susceptible of modification in order to adapt to different usages and conditions.

[0077] In the examples of figures 1-4 the treatment system comprises a sizer 10 and an air-borne drying system 20 for treating a fiber web W. The sizer 10 is a curtain sizer and comprises two rotating, hard sizing rolls 11A, 11B with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD, between of which a hard sizing nip N is formed. Advantageously, linear load in the sizing nip is 5 - 450 kN/m, more preferably the linear load in the sizing nip is 5 - 200 kN/m. One of the sizing rolls 11A;11B is advantageously a deflection compensated roll and thus a straight sizing nip N is formed. Advantageously, as the sizing rolls is used ceramic or metallic rolls or advantageously with a polymeric roll cover (rubber, polyurethane or composite) having surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD. The fiber web W is sized by indirect curtain sizing i.e. sizing agent TA, TB is first applied by a curtain sizing device 12A, 12B on the surface of the sizing roll 11A, 11B and guided on the surfaces of the rotating

sizing rolls 11A, 11B to the sizing nip N, in which the sizing agent TA, TB is applied on both sides of the fiber web W. The sizing agent TA, TB is thus via the surfaces of the sizing rolls 11A, 1B guided onto the surfaces of the fiber web W such that in the sizing nip N the sizing agent TA, TB is pressed to the fiber web surfaces. The sizing agent TA; TB may also be applied only on one of the sides of the fiber web W, in which case the sizer may comprise only one curtain sizing device 12A; 12B for applying the sizing agent TA; TB on the corresponding rotating, sizing roll 11A; 11B.

[0078] After the indirect sizing in the curtain sizer 10 by the curtain sizing devices 12A, 12B and the sizing nip N the fiber web W is directly guided to drying in the air-borne drying system 20. The run of the fiber web W from the sizing nip N to beginning of the drying in the air-borne drying system 20 is not more than 2 m, advantageously not more than 0,5 m, and / or takes not more than 0,5 s.

[0079] In figures 1-4 the air-borne drying system 20 is shown as a schematical cross-sectional. The air-borne drying system 20 extends substantially over the width of the fiber web W. In the air-borne drying system 20 the fiber web W is dried by contactless drying by hot air blows, which blows also support the run of the fiber web W such, that the fiber web W runs contactless through the air-borne drying system 20 supported by the hot, drying air blows. The air-borne drying system 20 comprises at least two, advantageously three in, the example five air compartments 13A, 13B, 14A, 14B, 15 forming chambers of the air-borne drying system 20. Each air compartment 13A, 13B, 14A, 14B, 15 is advantageously adjustable such, that the both sides of the web can be individually controlled, which provides possibility of planning and controlling the optimum drying strategy and also for the possibility of controlling curl of the fiber web. Advantageously, the drying is controlled one-sidedly such, that more effective drying is configured to be provided on one side of the fiber web W compared to the other side of the fiber web W. Thus, five drying temperature zones for drying the fiber web W can be provided. The fiber web W has a substantially U-formed contactless run in the air-borne drying system 20 (figs 2 and 3) or a substantially reversed U-formed contactless run in the air-borne drying system 20 (figs. 1 and 4). Two of the air compartments 13A, 13B, are rectangular, box-type air chambers and located outside the substantially straight branches of the U-form of the reversed U-form. Two of the air compartments 14A, 14B are rectangular (figs. 1-2), or at least partially oblique angled box-type air chambers and located inside the substantially straight branched of the U-form or of the reversed U-form and located next to each other with two longitudinal "back" sides towards each other i.e. the sides without nozzles are located towards each other and the sides with nozzles towards the passing fiber web W. The fifth air compartment 15 is a turning air compartment, as a substantially curved outer, advantageously semi-circular outer surface and located inside the curved part of the U-form or of the reversed U-form with the straight surface towards the surfaces of other two air compartments 14A, 14B inside the U-form or the reversed U-form. In the examples of figures 1-2 the branches of the U-form or of the reversed U-form are substantially parallel and in the examples of figure 3-4 the branches of the U-form or of the reversed U-form are substantially inclined and recede from each other from the curved part of the U-form or of the reversed U-form. Radius of the curved air compartment 15 is advantageously 800 - 1200 mm. The height of the box-type air compartments 13A, 13B, 14A, 14B in the running direction S, SE of the fiber web W is advantageously 800 - 1200 mm and have advantageously minimum width of 5 - 6 m in perpendicular direction in respect of the running direction S, SE of the fiber web W. The configuration of air-borne drying system 20 is thus such, that the fiber web W has first a longitudinal, straight run thereafter a semi-circular run and next another longitudinal, straight run. The air-borne drying system 20 comprises thus the straight portions and the curved, turning portion. In the air-borne drying system 20 each air compartment 13A, 13B, 14A, 14B, 15 is configured to blow hot drying air blows for drying the passing fiber web W. The air-borne drying system 20 is a double-pass dryer system configured to the U-shaped air dryer system. The drying air of the air-borne drying system 20 can also superheated steam or other gas than air, for ex. nitrogen. The maximum blowing air temperature is advantageously about 500°C and the minimum blowing air temperature is 50°C, advantageously 140-400°C. The blowing velocity of the hot air blows is at least 20 m/s, advantageously 40 - 60 m/s. Various types of nozzles can be used in connection with the air compartments, advantageously the nozzles are overpressure-nozzles.

[0080] In these advantageous examples the fiber web running in direction S in the sizer 10 and is sized with high solids content sizing agent, comprising advantageously fiber suspension, preferably 10-60 % solids content, more preferably 20 - 40 % solids content. Viscosity of the sizing agent is 50 cP - 2000 cP, preferably 100 cP - 1500 cP and surface tension of the sizing agent is advantageously 50 mN/m.

[0081] In the examples of figures 1 and 4 the running direction S of the fiber web W in the sizer 10 is substantially, vertically upwards. In the examples of figures 2 and 3 the running direction S of the fiber web W in the sizer 10 is substantially, vertically downwards.

[0082] In the examples of figures 1 and 2 the running direction SE of the fiber web W from the air-borne drying system 20 is substantially vertical. In the example of the figure 1 the running direction SE of the fiber web W from the air-borne drying system 20 is substantially vertically downwards and in the example of the figure 2 the running direction SE of the fiber web W from the air-borne drying system 20 is substantially vertically upwards.

[0083] In the examples of figures 3 and 4 the running direction SE of the fiber web W from the air-borne drying system 20 is substantially inclined in relation to vertical

direction. In the example of the figure 3 the running direction SE of the fiber web W from the air-borne drying system 20 is substantially inclined upwards and in the example of the figure 4 the running direction SE of the fiber web W from the air-borne drying system 20 is substantially vertically inclined downwards.

[0084] In the description in the foregoing, although some functions and elements have been described with reference to certain features, those functions and elements may be performable by other features whether described or not. Although features have been described with reference to certain embodiments or examples, those features may also be present in other embodiments or examples whether described or not. Above the invention has been described by referring to some advantageous examples only, to which the invention is not to be narrowly limited. Many modifications and alterations are possible within the inventive idea.

Reference signs used in the drawing:

[0085]

10	sizer
11A, 11B	sizing roll
12A, 12B	curtain sizer
13A, 13B	air-borne dryer chamber
14A, 14B	air-borne dryer chamber
15	air-borne dryer chamber
20	air-born dryer
16, 17	guide roll
N	sizing nip
TA, TB	sizing agent
S, SE	running direction
W	fiber web

Claims

1. Method of treating a fiber web, in which method the fiber web is sized in a sizer (10) by indirect curtain sizing in a curtain sizer (10), in which the sizing agent (TA, TB) is applied onto at least one side of the fiber web by two sizing rolls (11A, 11B) with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD, in a sizing nip (N), in which the fiber web (W) is sized with high solids content sizing agent (TA, TB) having solids content of 10 - 60 %, preferably 20 - 40 %, and viscosity of 50 cP- 2000 cP, preferably 100 cP - 1500 cP, and the sizing agent (TA; TB) is applied onto the at least one side of the fiber web (W) by the two sizing rolls (11A, 11N), in the sizing nip (N) **characterized in that** after the sizing the fiber web (W) is directly guided to contactless and supported drying in an air-borne drying system (20) and that the run of the fiber web (W) from the sizing nip (N) to beginning of the drying in the air-borne drying system (20) is not more than 2 m, advantageously not more than 0,5 m, and / or takes not more time than 0,5 s.

2. Method according to claim 1, **characterized in that** in the method the fiber web (W) is configured to have a substantially U-formed contactless run in the air-borne drying system (20) (figs. 2 and 3) or a substantially reversed U-formed contactless run in the air-borne drying system (20) (figs. 1 and 4).

3. Method according to claim 1 or 2, **characterized in that** in the method maximum blowing air temperature in the air-borne drying system (20) is about 500°C and minimum blowing air temperature is 50°C, advantageously 140-400°C.

4. Method according to any of claims 1 - 3, **characterized in that** in the method blowing air velocity in the air-borne drying system (20) is at least 20 m/s, advantageously 40 - 60 m/s.

5. Method according to any of claims 1 - 4, **characterized in that** the air-borne drying system (20) comprises at least two, advantageously three air compartments (13A, 13B, 14A, 14B, 15) forming chambers of the air-borne drying system (20) and that advantageously temperature and/or velocity of blowing air from each air compartment (13A, 13B, 14A, 14B, 15) is adjustable.

6. Method according to any of claims 1 - 5, **characterized in that** running direction (S) of the fiber web (W) in the sizer (10) is substantially, vertically upwards and running direction (SE) of the fiber web (W) from the air-borne drying system (20) is substantially vertically downwards or substantially inclined in relation to vertical direction substantially inclined downwards.

7. Method according to any of claims 1 - 5, **characterized in that** running direction (S) of the fiber web (W) in the sizer (10) is substantially, vertically downwards and running direction (SE) of the fiber web (W) from the air-borne drying system (20) is substantially vertically upwards or substantially inclined in relation to vertical direction substantially inclined up-

wards.

8. Treatment system for treatment of a fiber web, which treatment system comprises a sizer (10), which is a curtain sizer (10) with at least one curtain application device (12A; 12B) for indirect application of sizing agent (TA; TB) and comprises two sizing rolls (11A, 11B) with metallic or ceramic surface or with polymeric surface, which polymeric surface has surface hardness 60 - 100 shoreD, advantageously 80 - 95 shoreD, and forming a sizing nip (N), which curtain sizer (10) with the indirect application of sizing agent (TA, TB) is configured to apply the sizing agent (TA, TB) in high solids content of 10 - 60 %, preferably 20 - 40 % and in viscosity of 50 cP-2000 cP, preferably 100 cP - 1500 cP, **characterized in that** the treatment system further comprises an immediately after the sizer (10) located air-borne drying system (20) such, that the run of the fiber web (W) from the sizing nip (N) to beginning of the drying in the air-borne drying system (20) is not more than 2 m, advantageously not more than 0,5 m, and / or takes not more time than 0,5 s.

9. Treatment system according to claim 8, **characterized in that** one of the sizing rolls (11A; 11B) is a deflection compensated roll.

10. Treatment system according to claim 8 or 9, **characterized in that** the air-borne drying system is configure to have a substantially U-formed contactless run for the fiber web (W) (figs. 2 and 3) or a substantially reversed U-formed contactless run in the air-borne drying system (20) for the fiber web (W) (figs. 1 and 4).

11. Treatment system according to any of claims 8-10, **characterized in that** the air-borne drying system (20) comprises at least two, advantageously three air compartments (13A, 13B, 14A, 14B, 15) forming chambers of the air-borne drying system (20) and that advantageously temperature and/or velocity of blowing air from each air compartment (13A, 13B, 14A, 14B, 15) is adjustable.

12. Treatment system according to any of claims 8 - 11, **characterized in that** maximum blowing air temperature in the air-borne drying system (20) is about 500°C and minimum blowing air temperature is 50°C, advantageously 140-400°C.

13. Treatment system according to any of claims 8 - 12, **characterized in that** blowing air velocity in the air-borne drying system (20) is at least 20 m/s, advantageously 40 - 60 m/s.

14. Treatment system according to any of claims 8 - 13, **characterized in that** running direction (S) of the fiber web (W) in the sizer (10) is substantially, vertically upwards and running direction (SE) of the fiber web (W) from the air-borne drying system (20) is substantially vertically downwards or substantially inclined in relation to vertical direction substantially inclined downwards.

15. Treatment system according to any of claims 8 - 13, **characterized in that** running direction (S) of the fiber web (W) in the sizer (10) is substantially, vertically downwards and running direction (SE) of the fiber web (W) from the air-borne drying system (20) is substantially vertically upwards or substantially inclined in relation to vertical direction substantially inclined upwards.

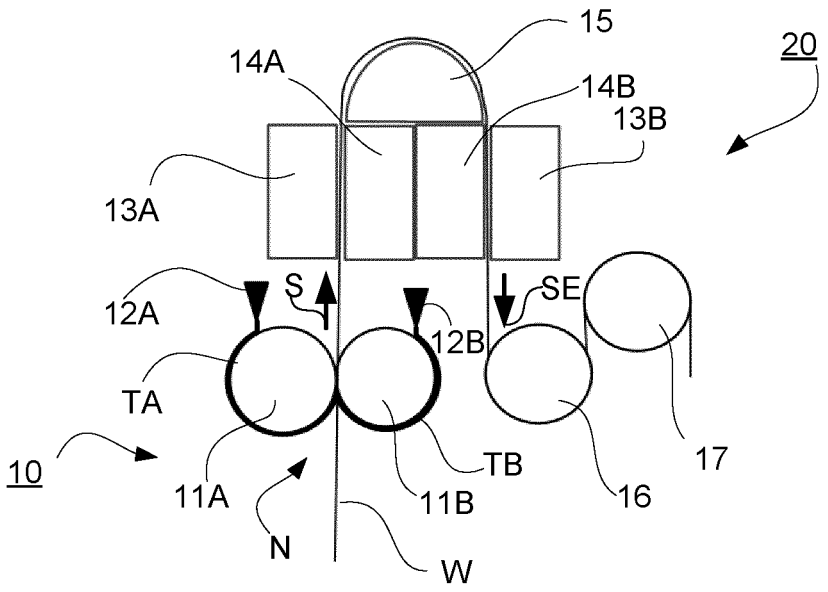
15
20
14A
14B
13B
13A
S
SE
12A
12B
TA
10
TB
17
11A
11B
16
N
W

Fig. 1

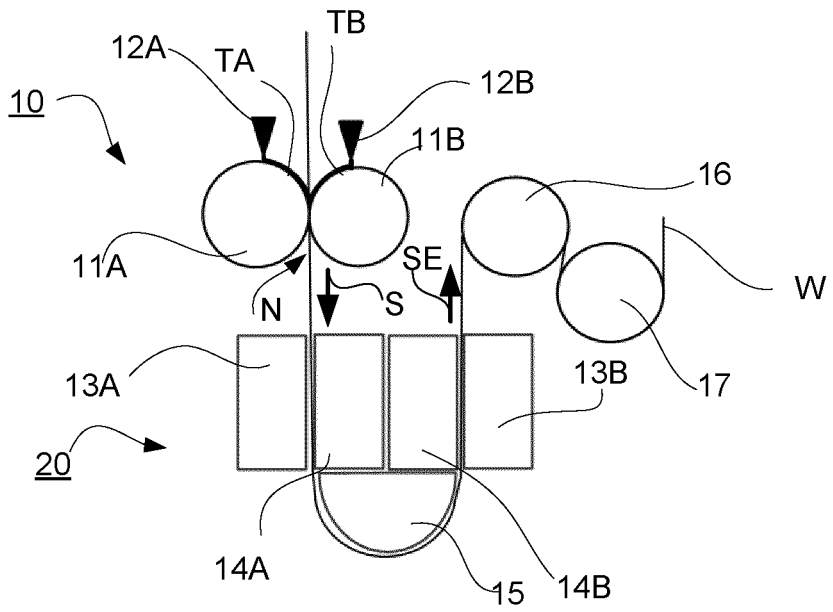
TB
12A
TA
12B
10
11B
16
11A
SE
W
N
S
13A
13B
17
20
14A
15
14B

Fig. 2

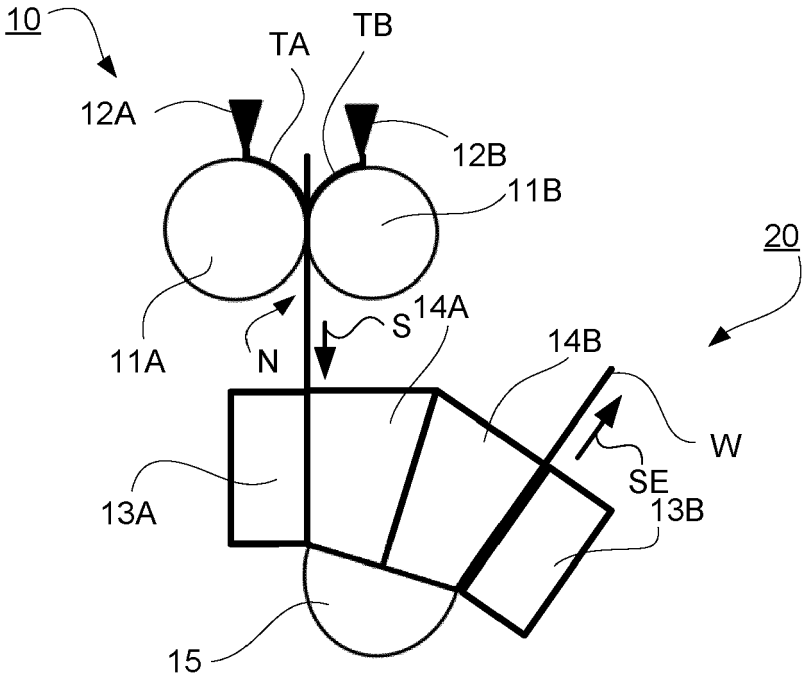
10
TA
TB
12A
12B
11B
20
11A
N
S
14A
14B
W
SE
13A
13B
15

Fig. 3

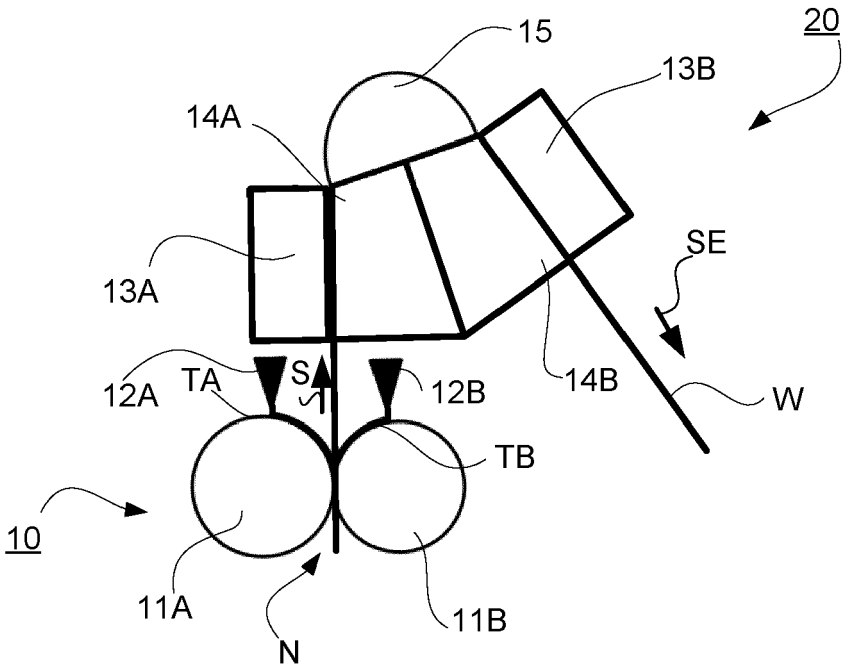
15
20
13B
14A
SE
13A
12A
TA
S
12B
14B
W
TB
10
11A
N
11B

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 21 19 6576

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D21H
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1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 February 2022	Ponsaud, Philippe

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