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(54) **PROCESS FOR THE PRODUCTION OF PAPER**

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(57) **ABSTRACT**

The invention relates to a process for the production of paper which comprises

- (i) providing a main aqueous flow containing cellulosic fibers;
- (i) introducing one or more retention components into the main aqueous flow to form a main aqueous flow containing one or more retention components;
- (iii) providing a diluting aqueous flow;
- (iv) introducing a low molecular weight cationic organic polymer into the diluting aqueous flow to form a diluting aqueous flow containing a low molecular weight cationic organic polymer, the low molecular weight cationic organic polymer having a weight average molecular weight up to 5,000,000;
- (v) introducing the diluting aqueous flow containing a low molecular weight cationic organic polymer into the main aqueous flow containing one or more retention components to form a resulting aqueous flow; and then
- (vi) ejecting the resulting aqueous flow onto a wire and dewatering the resulting aqueous flow to form a web of paper.

PROCESS FOR THE PRODUCTION OF PAPER

RELATED APPLICATION

[0001] This application claims priority based on U.S. Provisional Patent Application No. 60/469,010, filed May 9, 2003.

FIELD OF THE INVENTION

[0002] The present invention relates to a process for the production of paper in which papermaking additives are introduced into a cellulosic stock before it is ejected from a headbox onto a wire and dewatered to form a web of paper.

BACKGROUND OF THE INVENTION

[0003] In the papermaking art, an aqueous suspension containing cellulosic fibers and optional fillers and additives, referred to as stock, is fed into a headbox which ejects the stock onto a forming wire. Water is drained from the stock so that a wet web of paper is formed on the wire, and the web is further dewatered and dried in the drying section of the paper machine.

[0004] Retention agents are usually introduced into the stock in order to increase adsorption of fine particles, e.g. fine fibers and filler particles, onto the cellulosic fibers so that they are retained with the fibers on the wire. A wide variety of retention agents are known in the art, examples of which include anionic, non-ionic, amphoteric and cationic organic polymers of different molecular weights, inorganic materials, and combinations thereof. Due to incomplete retention, the water obtained by dewatering the stock and the wet web, referred to as white water, contains fine particles not being retained on the wire and the white water is usually recirculated in different flow circuits.

[0005] In paper machines having a dilution headbox, white water is used to dilute the stock within the headbox. Hereby the flow of high consistency stock is diluted with a low consistency flow originating from the white water. The headbox can have a series of mixing sections or dilution lines distributed over the width of the headbox. White water is injected into the mixing sections to locally control the stock dilution thereby forming a variable consistency profile leaving the slice opening at a constant volume flow. The dilution headbox design provides better control of paper properties; by adjusting the amount of dilution, i.e. the ratio of high consistency flow to low consistency flow, at a plurality of points of the dilution headbox across the machine, the basis weight of the web can be controlled in an improved manner and rendered essentially uniform in a cross machine direction. However, notably when using high performance retention agents, it has been experienced that the papermaking process and the properties of the paper produced are still not completely satisfactory, which has been attributed to inadequate pitch deposition control.

[0006] Problems caused by pitch build-up on papermaking machinery and formation of pitch globules in the final paper in the production of all types of paper has previously been recognized. Pitch generally refers to emulsified hydrophobic organic compounds. Pitch can be defined as the sticky, resinous materials that are released from wood during the pulping process. Pitch has also come to include sticky materials which arise from components of coated broke and

recycled fibers, such as adhesives, and are often referred to as stickies and tackies. In paper mill process waters, pitch exists as unstable, colloidal dispersions of hydrophobic particles. Therefore, typical papermaking process conditions, such as hydrodynamical and mechanical shear forces and abrupt changes of temperature as well as chemical environment and equilibrium, may cause the colloidal pitch particles to agglomerate within the cellulosic suspension or deposit on the surfaces of the wire or other equipment. This may lead to quality defects in the finished product, such as formation of spots or holes and a poor quality paper surface, and shortened equipment life, runnability problems, paper machine downtime and, ultimately, lost profit for the mill. These problems are magnified in paper mills with high level of process water closure, such as extensive white water recirculation.

SUMMARY OF THE INVENTION The present invention is generally directed to a process for the production of paper which comprises:

[0007] (i) providing a main aqueous flow containing cellulosic fibers;

[0008] (ii) introducing one or more retention components into said main aqueous flow to form a main aqueous flow containing one or more retention components;

[0009] (iii) providing a diluting aqueous flow;

[0010] (iv) introducing a low molecular weight cationic organic polymer into said diluting aqueous flow to form a diluting aqueous flow containing a low molecular weight cationic organic polymer, said low molecular weight cationic organic polymer having a weight average molecular weight up to 5,000,000;

[0011] (v) introducing said diluting aqueous flow containing a low molecular weight cationic organic polymer into said main aqueous flow containing one or more retention components to form a resulting aqueous flow; and then

[0012] (vi) ejecting said resulting aqueous flow onto a wire and dewatering said resulting aqueous flow to form a web of paper.

[0013] The present invention is further directed to a process for the production of paper on a paper machine containing a dilution headbox, the process comprising:

[0014] (i) introducing one or more retention components into a main aqueous flow containing cellulosic fibers, and feeding the obtained main aqueous flow into the dilution headbox;

[0015] (ii) introducing low molecular weight cationic organic polymer having a weight average molecular weight up to 5,000,000 into a diluting aqueous flow and feeding the obtained diluting aqueous flow into the dilution headbox;

[0016] (iii) mixing the obtained main aqueous flow with the obtained diluting aqueous flow in the headbox to form a resulting aqueous flow; and

[0017] (iv) ejecting the resulting aqueous flow onto a wire and dewatering the resulting aqueous flow to form a web of paper.

[0018] The invention is also directed to a process for the production of paper from an aqueous suspension containing cellulosic fibers, and optional filler, which comprises introducing one or more retention components into the suspension followed by introducing into the suspension a low molecular weight cationic organic polymer having a weight average molecular weight up to 5,000,000, and thereafter forming and draining the suspension on a wire.

DETAILED DESCRIPTION OF THE INVENTION

[0019] According to the present invention it has been found that pitch problems can be reduced by the introduction of additives into a stock in a certain manner before it is dewatered on a wire to form the web of paper. This finding is particularly applicable to papermaking processes where paper is produced on a paper machine with a dilution headbox. It has also been found that pitch deposition in the papermaking system can be better controlled according to the present invention. It has further been found that the process of this invention renders possible production of paper with improved properties.

[0020] Dilution headboxes generally can be described as devices comprising at least one inlet for a first partial volume flow, at least one inlet for a second partial volume flow, at least one section for mixing the partial volume flows to form a mixture volume flow, and at least one outlet for ejecting the mixture volume flow. Preferably the dilution headbox comprises a plurality of such inlets, sections and outlets across its working width. Examples of suitable dilution headboxes include those disclosed in U.S. Pat. Nos. 4,909,904; 5,196,091; 5,316,383; 5,545,293; and 5,549,793.

[0021] The term "main aqueous flow", as used herein, refers to the main flow of stock containing cellulosic fibers, and optional filler, entering the headbox which has a high consistency (hereafter HC), i.e. a high solids content, HC stock, thereby representing the high consistency flow (hereafter HC flow). The consistency of the HC flow can be within the range of from 0.1% to 3.5% by weight, preferably from 0.3% to 2.2% and more preferably from 0.4% to 1.9%. The term "diluting aqueous flow", as used herein, refers to the aqueous flow which is used to dilute the HC flow and which, in relation to the HC flow, has a low consistency (LC), i.e. a low solids content, LC stock, thereby representing the low consistency flow (hereafter LC flow). The consistency of the LC flow can be within the range of from 0-1.5% by weight, preferably 0.002-0.9%, and more preferably 0.005-0.8%, with the proviso that the consistency of the LC flow is lower than that of the HC flow. Preferably, in the headbox, the HC flow is mixed and diluted with the LC flow, for example just before the turbulence generator, to form a resulting flow which is discharged onto the wire for dewatering. The volume ratio of HC flow to LC flow can be within the range of from 99:1 to 50:50, preferably from 97:3 to 60:40, more preferably from 95:5 to 75:25 and typically about 85:15. As conventional in dilution headbox designs, the volume ratio of HC flow to LC flow preferably is varying at a plurality of points of the headbox across its width in order to adjust the amount of dilution, thereby enabling better control of the basis weight cross profile of the paper web formed. Preferably the partial volume flows, i.e. the HC flow and the LC flow, are mixed in the headbox to form a

resulting HC/LC mixture volume flow which is ejected from the headbox and which is essentially constant in a cross-machine direction.

[0022] The aqueous LC flow used for dilution can be selected from fresh water, white water and other types of aqueous flows that are recycled in the process. The diluting LC flow may contain fiber fines and filler, and it may be treated by means of any purification step before being fed into the headbox. Examples of suitable steps that can be used for purifying or clarifying aqueous flows of these types include filtration, flotation, sedimentation, anaerobic and aerobic treatment. Preferably, the LC flow is white water containing, for example, cellulosic fines, extractives and other materials released from wood during the pulping process as well as filler and other additives introduced into the HC flow but not retained on the wire. The white water used is preferably obtained by dewatering the stock and/or the wet web on the wire, and it may be clarified as mentioned above before being fed into the dilution headbox. The LC flow usually has a composition that is different from that of the HC flow. When filler is used in the process the filler content of the LC flow usually differs from that of the HC flow; the LC flow normally has a higher filler content, expressed as percentage of the dry substance of the flow, than the HC flow.

[0023] In addition to the HC flow and the LC flow entering the headbox as described above, there can be at least one additional flow entering the headbox in accordance with the present invention. The additional flow is preferably a flow that contains water alone. The additional flow may also be a flow of stock or pulp, the consistency and/or composition of which differs from that of the HC flow.

[0024] The retention component(s) to be introduced into the HC flow according to this invention may be a single retention agent or a retention system, for example any of those defined hereinafter. The single component can be any component functioning as a retention agent, preferably a cationic polymer such as, for example, any of those defined herein. In this embodiment, the amount of the component introduced into the main aqueous flow should be sufficient so as to give better retention than is obtained when not adding the component.

[0025] In a preferred embodiment of this invention, there is used a retention system. The term "retention system", as used herein, refers to two or more components, or agents which, when being added to a stock, give better retention than is obtained when not adding the two or more components, or agents. The components of retention systems are preferably selected from two or more organic polymers and one or more organic polymers in combination with aluminium compounds and/or inorganic microparticles.

[0026] In a preferred embodiment of the invention, there is used a microparticle retention system. The term "microparticle retention system", as used herein, refers to a retention system comprising a microparticulate material, or microparticles, such as, for example, anionic inorganic particles, cationic inorganic particles and organic microparticles, as defined herein. The microparticulate material is used in combination with at least one further component, usually at least one organic polymer, herein also referred to as a main polymer, preferably a cationic, amphoteric or anionic polymer. Anionic microparticles are preferably used

in combination with at least one amphoteric and/or cationic polymer, whereas cationic microparticles are preferably used in combination with at least one amphoteric and/or anionic polymer. Preferably the microparticles are anionic inorganic particles. It is further preferred that the microparticles are in the colloidal range of particle size. The retention system, e.g. systems comprising microparticles, can comprise more than two components; for example, it can be a three- or four-component retention system. Examples of suitable additional components of this type include, for example, aluminium compounds and low molecular weight cationic organic polymers. Usually retention systems, including microparticle retention systems, also give better dewatering than is obtained when not adding the components, and the systems are commonly referred to as retention and dewatering systems.

[0027] In another preferred embodiment of the invention, there is used a retention system comprising one or more cationic organic polymers and one or more anionic organic polymers. Preferably such a retention system includes a cationic organic polymer having one or more aromatic groups and/or an anionic organic polymer having one or more aromatic groups, as defined herein.

[0028] Anionic inorganic particles that can be used according to the invention include anionic silica-based particles and clays of the smectite type. Anionic silica-based particles, i.e. particles based on SiO_2 or silicic acid, including colloidal silica and different types of poly-silicic acid and polysilicates, are preferably used. Anionic silica-based particles are usually supplied in the form of aqueous colloidal dispersions, so called sols. Examples of suitable silica-based sols according to the invention may also contain other elements, for example nitrogen, aluminium and boron. Such elements may be present as a result of modification using organic nitrogen-containing organic compounds, aluminium-containing compounds and boron-containing compounds, respectively. These compounds may be present in the aqueous sol and/or in the silica-based particles. Examples of suitable retention and dewatering systems comprising anionic silica-based particles are disclosed in U.S. Pat. Nos. 4,388,150; 4,927,498; 4,954,220; 4,961,825; 4,980,025; 5,127,994; 5,176,891; 5,368,833; 5,447,604; 5,470,435; 5,543,014; 5,571,494; 5,584,966; 5,603,805; and 6,379,500, which are all hereby incorporated herein by reference.

[0029] Anionic silica-based particles preferably have an average particle size below about 50 nm, preferably below about 20 nm and more preferably in the range of from about 1 to about 10 nm. As conventional in silica chemistry, the particle size refers to the average size of the primary particles, which may be aggregated or non-aggregated. The specific surface area of the silica-based particles is preferably above 50 m^2/g and more preferably above 100 m^2/g . Usually, the specific surface area is up to about 1700 m^2/g and preferably up to 1000 m^2/g . The specific surface area is measured by means of titration with NaOH in known manner, e.g. as described by Sears in Analytical Chemistry 28(1956):12, 1981-1983 and in U.S. Pat. No. 5,176,891, after appropriate removal of or adjustment for any elements or compounds present in the sample that may disturb the titration like aluminium and boron species. The given area thus represents the average specific surface area of the particles.

[0030] In a preferred embodiment of the invention, the anionic inorganic particles are silica-based particles having a specific surface area within the range of from 50 to 1000 m^2/g and preferably from 100 to 950 m^2/g . Preferably, the anionic inorganic particles are present in a silica-based sol having an S-value in the range of from 8 to 45%, preferably from 10 to 35%, containing silica-based particles with a specific surface area in the range of from 300 to 1000 m^2/g , preferably from 500 to 950 m^2/g , which particles can be non-aluminium-modified or aluminium-modified, preferably surface-modified with aluminium. The S-value is measured and calculated as described by Ier & Dalton in J. Phys. Chem. 60(1956), 955-957. The S-value indicates the degree of aggregate or microgel formation and a lower S-value is indicative of a higher degree of aggregation.

[0031] In yet another preferred embodiment of the invention, the anionic inorganic particles are selected from poly-silicic acid, optionally reacted with aluminium, having a high specific surface area, preferably above about 1000 m^2/g . The specific surface area can be within the range of from 1000 to 1700 m^2/g and preferably from 1050 to 1600 m^2/g . In the art, polysilicic acid is also referred to as polymeric silicic acid, polysilicic acid microgel, polysilicate and polysilicate microgel, which are all encompassed by the term polysilicic acid used herein. Aluminium-containing polysilicic acid is commonly referred to as polyaluminosilicate and poly-aluminosilicate microgel, which are both encompassed by the term polysilicic acid used herein.

[0032] Clays of the smectite type that can be used in the process of the invention are known in the art and include naturally occurring, synthetic and chemically treated materials. Examples of suitable smectite clays include montmorillonite/bentonite, hectorite, beidelite, nontronite and saponite, preferably bentonite and especially such which after swelling preferably has a surface area of from 400 to 800 m^2/g . Examples of suitable clays include those disclosed in U.S. Pat. Nos. 4,753,710; 5,071,512; and 5,607,552, which are hereby incorporated herein by reference, the latter patent disclosing mixtures of anionic silica-based particles and smectite clays, preferably natural bentonites. Cationic inorganic particles that can be used include cationic silica-based particles, cationic alumina, and cationic zirconia.

[0033] Examples of suitable organic polymers for use as a retention agent or part of a retention system according to this invention include anionic, non-ionic, amphoteric, or cationic polymers, they can be derived from natural or synthetic sources and they can be linear, branched or cross-linked, e.g. in the form of microparticles. Preferably the polymer is water-soluble or water-dispersible.

[0034] Examples of suitable cationic polymers include cationic polysaccharides, e.g. starches, guar gums, celluloses, chitins, chitosans, glycans, galactans, glucans, xanthan gums, pectins, mannans, dextrans, preferably starches and guar gums; examples of suitable starches including potato, corn, wheat, tapioca, rice, waxy maize, barley, etc.; cationic synthetic organic polymers such as cationic chain-growth polymers, e.g. cationic vinyl addition polymers like acrylate-, acrylamide-, vinylamine-, vinylamide- and allylamine-based polymers, and cationic step-growth polymers, e.g. cationic polyamidoamines, polyethylene imines, polyamines and polyurethanes. Cationic starches and cationic acrylamide-based polymers are particularly preferred

cationic polymers, both as single retention components as well as in retention systems with and without anionic inorganic particles. Examples of suitable cationic organic polymers having one or more aromatic groups include those disclosed in WO 02/12626. The weight average molecular weight of the cationic organic polymer can vary within wide limits depending on, inter alia, the type of polymer used, and usually it is above 2,000,000, more often above 3,000,000, preferably above 5,000,000. The upper limit is not critical; it can be about 600,000,000, usually 150,000,000, and preferably 100,000,000.

[0035] Examples of further suitable cationic polymers that can be introduced into the HC flow according to the invention include cationic organic polymers having a low molecular weight. Such cationic organic polymers include those commonly referred to as anionic trash catcher (hereafter ATC). The weight average molecular weight of the ATC cationic organic polymer is usually at least 2,000, preferably at least 10,000 and more preferably at least 50,000, and it is usually up to 2,000,000 and often up to 1,500,000. Examples of suitable ATC's include linear, branched and cross-linked polymers, usually highly charged, which can be derived from natural and synthetic sources. Examples of suitable ATC's include low molecular weight degraded polysaccharides, e.g. those based on starches, guar gums, celluloses, chitins, chitosans, glycans, galactans, glucans, xanthan gums, pectins, mannans, dextrans, preferably starches and guar gums; examples of suitable starches including potato, corn, wheat, tapioca, rice, waxy maize, barley, etc.; cationic synthetic organic polymers such as cationic chain-growth polymers, e.g. cationic vinyl addition polymers like acrylate-, acrylamide-, vinylamine-, vinylamide- and allylamine-based polymers, for example homo- and copolymers based on diallyldialkyl ammonium halide, e.g. diallyldimethyl ammonium chloride, as well as (meth)acrylamides and (meth)acrylates; and cationic step-growth polymers, e.g. cationic polyamidoamines, polyethylene imines, polyamines, e.g. dimethylamine-epichlorhydrin copolymers, and polyurethanes.

[0036] Examples of suitable anionic organic polymers according to the invention can be selected from step-growth polymers, chain-growth polymers, polysaccharides, naturally occurring aromatic polymers and modifications thereof. Examples of suitable anionic step-growth polymers include anionic benzene-based and naphthalene-based condensation polymers, preferably naphthalene-sulphonic acid based and naphthalene-sulphonate based condensation polymers; and addition polymers, i.e. polymers obtained by step-growth addition polymerization, e.g. anionic polyurethanes. Examples of suitable anionic chain-growth polymers include anionic vinyl addition polymers, e.g. acrylate- and acrylamide-based polymers comprising anionic or potentially anionic monomers like (meth)acrylic acid and paravinyl phenol (hydroxy styrene). Examples of suitable naturally occurring aromatic polymers and modifications thereof, i.e. modified naturally occurring aromatic anionic polymers, according to the invention include lignin-based polymers, preferably sulphonated lignins, e.g. lignosulphonates, kraft lignin, sulphonated kraft lignin, and tannin extracts. Examples of other suitable anionic organic polymers having one or more aromatic groups include those disclosed in WO 02/12626. The weight average molecular weight of the anionic polymer can vary within wide limits dependent on, inter alia, the type of polymer used, and usually it is at least

about 500, preferably above about 2,000 and more preferably above about 5,000. The upper limit is not critical; it can be about 600,000,000, usually 150,000,000, preferably 100,000,000 and more preferably 10,000,000.

[0037] The term "step-growth polymer", as used herein, refers to a polymer obtained by step-growth polymerization, also being referred to as step-reaction polymer and step-reaction polymerization, respectively. The term "chain-growth polymer", as used herein, refers to a polymer obtained by chain-growth polymerization, also being referred to as chain reaction polymer and chain reaction polymerization, respectively.

[0038] Aluminium compounds that can be used according to the invention include alum, aluminates, aluminium chloride, aluminium nitrate and polyaluminium compounds, such as polyaluminium chlorides, polyaluminium sulphates, polyaluminium compounds containing both chloride and sulphate ions, polyaluminium silicate-sulphates, and mixtures thereof. The polyaluminium compounds may also contain other anions, for example anions from phosphoric acid, sulphuric acid, organic acids such as citric acid and oxalic acid.

[0039] Preferred retention systems according to the invention comprise:

- [0040]** (i) anionic silica-based particles in combination with cationic starch, cationic guar gum or cationic acrylamide-based polymer, optionally in combination with anionic organic particles and/or ATC and/or aluminium compound;
- [0041]** (ii) anionic silica-based particles in combination with anionic chain-growth polymer, preferably anionic acrylamide-based polymer in combination with cationic organic polymer and/or ATC;
- [0042]** (iii) bentonite in combination with cationic acrylamide-based polymer, optionally in combination with ATC and/or aluminium compound;
- [0043]** (iv) cationic polysaccharide, preferably cationic starch, in combination with anionic step-growth polymer, preferably anionic naphthalene-based condensation polymer; optionally in combination with ATC and/or aluminium compound;
- [0044]** (v) cationic polysaccharide, preferably cationic starch, in combination with naturally occurring aromatic anionic polymer and modifications thereof, preferably sulphonated lignin, optionally in combination with ATC and/or aluminium compound;
- [0045]** (vi) cationic chain-growth polymer, preferably cationic acrylamide-based polymer, in combination with anionic step-growth polymer, preferably anionic naphthalene-based condensation polymer, optionally in combination with ATC and/or aluminium compound; and
- [0046]** (vii) cationic chain-growth polymer, preferably cationic acrylamide-based polymer, in combination with naturally occurring aromatic anionic polymer and modifications thereof, preferably sulphonated lignin, optionally in combination with ATC and/or aluminium compound;

[0047] (viii) cationic chain-growth polymer, preferably cationic acrylamide-based polymer, in combination with ATC; and

[0048] (ix) cationic chain-growth polymer, preferably cationic acrylamide-based polymer, in combination with anionic organic particles.

[0049] In the process of the invention, the retention component(s) is/are introduced into the HC flow which is to be mixed with the LC flow, preferably in the headbox, thereby introducing the component(s) into the resulting aqueous flow in the dilution process. When using a retention system comprising more than one component, the components can be added to the stock flow in conventional manner, preferably at different points and in any order. When using a retention system comprising anionic inorganic particles and a cationic polymer, it is preferred to add the cationic polymer to the HC stock flow before adding the microparticulate material, even if the opposite order of addition may be used. When using a retention system comprising cationic and anionic organic polymers, it is preferred to add the cationic polymer to the HC stock flow before adding the anionic polymer, even if the opposite order of addition may be used. It is further preferred to add the first component, e.g. the cationic polymer, before a shear stage, which can be selected from pumping, mixing, cleaning, etc., and to add the second component, e.g. the anionic inorganic microparticles or organic polymer, after that shear stage. When using a low molecular weight cationic organic polymer as an ATC, it is preferably introduced into the HC stock flow prior to or simultaneous with other retention component(s). When using an aluminium compound, it is preferably introduced into the HC stock flow prior to or simultaneous with other retention component(s).

[0050] The components of the retention system are introduced into the stock to be dewatered in amounts which can vary within wide limits depending on, inter alia, type and number of components, type of stock, type of filler, filler content, point of addition, etc. Generally the components are added in amounts that give better retention than is obtained when not adding the components. When using anionic inorganic particles as a microparticulate material, the total amount added is usually at least 0.001% by weight, often at least 0.005% by weight, based on dry substance of the stock. The upper limit is usually 1.0% and preferably 0.6% by weight. When using anionic silica-based particles, the total amount is preferably within the range of from 0.005 to 0.5% by weight, calculated as SiO₂ and based on dry stock substance, preferably within the range of from 0.01 to 0.2% by weight. Organic polymers, e.g. cationic and anionic polymers, are usually added in total amounts of at least 0.001%, often at least 0.005% by weight, based on dry stock substance. The upper limit is usually 3% and preferably 1.5% by weight. When using a low molecular weight cationic organic polymer as an ATC, it can be introduced into the HC stock flow in an amount of at least 0.01%, based on dry stock substance, preferably the amount is in the range from 0.05% to 0.5%. When using an aluminium compound in the process, the total amount introduced into the stock to be dewatered is dependent on the type of aluminium compound used and on other effects desired from it. It is for instance well-known in the art to utilize aluminium compounds as precipitants for rosin-based sizing agents. The total amount added is usually at least 0.05%, calculated as

Al₂O₃ and based on dry stock substance. Preferably the amount is in the range of from 0.08 to 2.8%, more preferably in the range from 0.1 to 2.0%.

[0051] According to the present invention, a low molecular weight cationic organic polymer is introduced into the LC flow to be mixed with the HC flow, preferably in the dilution headbox. Examples of suitable low molecular weight (hereafter LMW) cationic organic polymers include linear, branched and cross-linked polymers, usually highly charged, which can be derived from natural and synthetic sources. Examples of suitable LMW cationic organic polymers include LMW degraded polysaccharides, e.g. those based on starches, guar gums, celluloses, chitins, chitosans, glycans, galactans, glucans, xanthan gums, pectins, mannan, dextrans, preferably starches and guar gums; examples of suitable starches including potato, corn, wheat, tapioca, rice, waxy maize, barley, etc.; LMW cationic synthetic organic polymers such as cationic chain-growth polymers, e.g. cationic vinyl addition polymers like acrylate-, acrylamide-, vinylamine-, vinylamide- and allylamine-based polymers, for example homo- and copolymers based on diallyldialkyl ammonium halide, e.g. diallyldimethyl ammonium chloride, as well as (meth)acrylamides and (meth)acrylates; and LMW cationic step-growth polymers, e.g. cationic polyamidoamines, polyethylene imines, polyamines, e.g. dimethylamine-epichlorhydrin copolymers, and polyurethanes. The weight average molecular weight of the LMW cationic organic polymer is usually at least 100,000, preferably at least 500,000 and more preferably at least 1,000,000, and it is usually up to 5,000,000, preferably up to 3,000,000 and more preferably up to 2,000,000. Usually, in case a cationic organic polymer is added to the HC flow as a retention agent or part of a retention system, the weight average molecular weight of the LMW cationic organic polymer added to the LC flow is lower than that of the cationic organic polymer added to the HC flow.

[0052] The LMW cationic organic polymer is usually added to the LC flow in an amount of at least 0.01%, based on dry substance of the stock to be dewatered. Preferably, the amount is in the range of from 0.05 to 1.0%, more preferably in the range from 0.1 to 0.5%.

[0053] In a preferred embodiment of this invention, subsequent to introducing the LC flow containing the LMW cationic organic polymer into the HC flow containing one or more retention components to form the resulting aqueous flow, no further retention components are introduced into the resulting aqueous flow. The formation of the resulting aqueous flow preferably takes in the dilution headbox, but may also take place outside the headbox.

[0054] The process of this invention is applicable to all papermaking processes and cellulosic suspensions, and it is particularly useful in the manufacture of paper from a stock that has a high conductivity. In such cases, the conductivity of the stock that is dewatered on the wire is usually at least about 1.5 mS/cm, preferably at least 3.5 mS/cm, and more preferably at least 5.0 mS/cm. Conductivity can be measured by standard equipment such as, for example, a WTW LF 539 instrument supplied by Christian Berner. The values referred to above are determined by measuring the conductivity of the resulting aqueous flow that is ejected onto the wire to be dewatered. High conductivity levels mean high contents of salts (electrolytes) which are usually derived from materials

used to form the stock, from various additives introduced into the stock, from the fresh water supplied to the process, etc. Further, the content of salts is usually higher in processes where white water is extensively recirculated, which may lead to considerable accumulation of salts in the water circulating in the process.

[0055] The present invention further encompasses paper-making processes where white water is extensively recycled, or recirculated, i.e. with a high degree of white water closure, for example where from 0 to 30 tons of fresh water are used per ton of dry paper produced, usually less than 20, preferably less than 15, more preferably less than 10 and notably less than 5 tons of fresh water per ton of paper. Fresh water can be introduced in the process at any stage; for example, fresh water can be mixed with cellulosic fibers in order to form a suspension, and fresh water can be mixed with a thick suspension containing cellulosic fibers to dilute it so as to form a thin suspension that is fed into the headbox as a high consistency flow.

[0056] The process according to the invention is used for the production of paper. The term "paper", as used herein, of course include not only paper and the production thereof, but also other web-like products, such as for example board and paperboard, and the production thereof. The process can be used in the production of paper from different types of suspensions of cellulosic fibers, and the suspensions should preferably contain at least 25% and more preferably at least 50% by weight of such fibers, based on dry substance. The suspensions can be based on fibers from chemical pulp, such as sulphate and sulphite pulp, thermomechanical pulp, chemo-thermomechanical pulp, organosolv pulp, refiner pulp or groundwood pulp from both hardwood and softwood, or fibers derived from one year plants like elephant grass, bagasse, flax, straw, etc., and can also be used for suspensions based on recycled fibers. The invention is preferably applied to processes for making paper from wood-containing suspensions. The suspension also contain mineral fillers of conventional types, such as, for example, kaolin, clay, titanium dioxide, gypsum, talc and both natural and synthetic calcium carbonates, such as, for example, chalk, ground marble, ground calcium carbonate, and precipitated calcium carbonate. The stock can of course also contain papermaking additives of conventional types, such as wet-strength agents, stock sizes, such as those based on rosin, ketene dimers, ketene multimers, alkenyl succinic anhydrides, etc.

[0057] Preferably the invention is applied on paper machines producing wood-containing paper and paper based on recycled fibers, such as SC, LWC and different types of book and newsprint papers, and on machines producing wood-free printing and writing papers, the term wood-free meaning less than about 15% of wood-containing fibers. The invention is also applicable for the production of board on single layer machines as well as on machines producing paper or board in multilayered headboxes, and on machines with several headboxes, in which one or more of the layers essentially consist of recycled fibers. In machines using multi layer headboxes, or several headboxes, in which one or more of the layers are produced with a headbox of the dilution type, the invention can be applied to one or more of these layers. Preferably the invention is applied on paper machines running at a speed of from 300 to 2500 m/min and more preferably from 1000 to 2000 m/min.

[0058] The invention is further illustrated in the following example which, however, is not intended to limit the same. Parts and % relate to parts by weight and % by weight, respectively, unless otherwise stated.

EXAMPLE

[0059] The process of this invention was tested using different LMW cationic organic polymers as additive to the LC stock.

[0060] Paper was produced from a cellulosic suspension on a paper machine utilizing a dilution headbox to make SC grades. Retention agents were added to the HC stock; first 0.8 kg/ton based on dry furnish of dimethylamine-epichlorhydrin copolymer with a weight average molecular weight of about 1 million and then 0.36 kg/ton based on dry furnish of cationic polyacrylamide with a weight average molecular weight of 4.6 million. The LC stock was obtained by draining the stock.

[0061] 500 ml of LC stock was added to a Dynamic Drainage Jar and mixed at 1000 rpm for 15 seconds, and then LMW cationic organic polymer was added to the stock and mixed for 30 seconds. For blank tests, the LC stock was added to a Dynamic Drainage Jar and mixed at 1000 rpm for 45 seconds without the addition of LMW cationic organic polymer. The obtained LC stock was then drained and the filtrate was collected and passed through a 1 micron filter. An Ocean Optics S2000 UV spectrophotometer with a fast scanning rate was used to measure the UV absorption as a representation of the pitch content of the filtered fraction.

[0062] Several LMW cationic organic polymers were tested at the same dry dosage (4 kg/ton based on LC stock dry substance, corresponding to about 2 kg/ton based on total dry substance reel tonnage) and the results outlined below.

[0063] LMW-1 was a dimethylamine-epichlorhydrin copolymer with a weight average molecular weight of about 120,000;

[0064] LMW-2 was a dimethylamine-epichlorhydrin copolymer with a weight average molecular weight of about 1,000,000;

[0065] LMW-3 was a polydiallyldimethylammonium chloride with a weight average molecular weight of about 680,000; and

[0066] LMW-4 was a polydiallyldimethylammonium chloride with a weight average molecular weight of about 1,800,000.

[0067] Compared to the blank test, all the processes according to the invention showed a reduction in UV absorbance. The most effective process according to the invention was the one employing the polydiallyldimethylammonium chloride with a weight average molecular weight of about 1,800,000.

[0068] The tests are summarised in Table 1, showing UV absorbance at different wavelengths for the processes according to the invention and the blank corresponding to the prior art.

TABLE 1

UV absorbance at different wavelengths.					
Wavelength nm	UV Absorbance				
	Blank	LMW-1	LMW-2	LMW-3	LMW-4
241.21	2.68	2.656	2.683	2.636	2.647
244.96	2.707	2.744	2.707	2.671	2.657
248.7	2.705	2.61	2.603	2.499	2.454
252.44	2.586	2.427	2.403	2.296	2.243
256.18	2.555	2.345	2.352	2.228	2.156
259.91	2.575	2.376	2.37	2.255	2.181
263.64	2.607	2.454	2.441	2.328	2.293
267.37	2.692	2.545	2.567	2.488	2.438
271.1	2.728	2.666	2.649	2.588	2.575
274.82	2.71	2.682	2.66	2.642	2.623
278.54	2.687	2.706	2.666	2.64	2.633
282.26	2.654	2.653	2.639	2.621	2.596
285.97	2.634	2.59	2.582	2.534	2.496
289.68	2.476	2.331	2.318	2.212	2.164
293.39	2.05	1.838	1.823	1.715	1.661
297.09	1.672	1.463	1.453	1.359	1.31
300.8	1.433	1.239	1.23	1.144	1.101
304.49	1.284	1.104	1.096	1.017	0.98
308.19	1.172	1.005	0.998	0.927	0.892
311.88	1.073	0.916	0.91	0.844	0.813
315.57	0.97	0.826	0.817	0.757	0.73
319.26	0.868	0.733	0.727	0.673	0.648
322.94	0.768	0.643	0.638	0.589	0.567
326.62	0.672	0.558	0.553	0.509	0.49
330.3	0.576	0.473	0.468	0.431	0.415

1. A process for the production of paper which comprises

(i) providing a main aqueous flow containing cellulosic fibers;

(ii) introducing one or more retention components into the main aqueous flow to form a main aqueous flow containing one or more retention components;

(iii) providing a diluting aqueous flow;

(iv) introducing a low molecular weight cationic organic polymer into the diluting aqueous flow to form a diluting aqueous flow containing a low molecular weight cationic organic polymer, the low molecular weight cationic organic polymer having a weight average molecular weight up to 5,000,000;

(v) introducing the diluting aqueous flow containing a low molecular weight cationic organic polymer into the main aqueous flow containing one or more retention components to form a resulting aqueous flow; and then

(vi) ejecting the resulting aqueous flow onto a wire and dewatering the resulting aqueous flow to form a web of paper.

2. The process of claim 1, wherein the main aqueous flow has a higher consistency than the diluting aqueous flow.

3. The process of claim 1, wherein the diluting aqueous flow is white water obtained by dewatering the resulting aqueous flow.

4. The process of claim 1, wherein the retention components are selected from the group consisting of microparticle retention systems and retention systems comprising at least two organic polymers.

5. The process of claim 4, wherein the retention components comprise at least one cationic organic polymer and anionic silica-based particles.

6. The process of claim 5, wherein the cationic organic polymer is cationic starch or cationic acrylamide-based polymer.

7. The process of claim 1, wherein the low molecular weight cationic organic polymer has a weight average molecular weight within the range from 500,000 to 3,000,000:

8. The process of claim 1, wherein the low molecular weight cationic organic polymer is a chain-growth polymer.

9. The process of claim 1, wherein the low molecular weight cationic organic polymer is a homopolymer or copolymer based on diallyldimethylammonium chloride.

10. A process for the production of paper on a paper machine containing a dilution headbox which comprises

(i) introducing one or more retention components into a main aqueous flow containing cellulosic fibers, and feeding the obtained main aqueous flow into the dilution headbox;

(ii) introducing low molecular weight cationic organic polymer having a weight average molecular weight up to 5,000,000 into a diluting aqueous flow and feeding the obtained diluting aqueous flow into the dilution headbox;

(iii) mixing the obtained main aqueous flow with the obtained diluting aqueous flow in the headbox to form a resulting aqueous flow; and

(iv) ejecting the resulting aqueous flow onto a wire and dewatering the resulting aqueous flow to form a web of paper.

11. The process of claim 10, wherein the retention components comprise two or more components which, when used in combination, give better retention than is obtained when not adding the components.

12. The process of claim 10, wherein the retention components are selected from the group consisting of organic polymers, organic polymers in combination with aluminium compounds, and organic polymers in combination with inorganic microparticles.

13. The process of claim 10, wherein the low molecular weight cationic organic polymer has a weight average molecular weight within the range from 500,000 to 3,000,000.

14. The process of claim 10, wherein the diluting aqueous flow is white water obtained by dewatering the resulting aqueous flow.

15. The process of claim 10, wherein the paper machine produces paper at a speed of from 300 to 2500 m/min.

16. The process of claim 10, wherein it comprises recycling of white water and introduction of from 0 to 30 tons of fresh water per ton of dry paper produced.

17. The process of claim 10, wherein the retention components comprise at least one organic polymer containing one or more aromatic groups.

18. The process of claim 10, wherein the low molecular weight cationic organic polymer is a homopolymer or copolymer based on diallyldimethylammonium chloride.