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(54) **SOFT TISSUE PAPER HAVING A CHEMICAL SOFTENING AGENT APPLIED ONTO A SURFACE THEREOF**

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(57) **ABSTRACT**

A tissue paper product having at least one ply, wherein only one outer surface of the tissue paper product has an aqueous chemical softening agent applied and substantially affixed thereto is disclosed. The chemical softening agent is applied to a web substrate at a concentration ranging from about 0.45% to about 0.25%. The chemical softening agent provides the tissue paper product with a raw dispensing dust value of less than about 4893.

SOFT TISSUE PAPER HAVING A CHEMICAL SOFTENING AGENT APPLIED ONTO A SURFACE THEREOF

PRIORITY

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 11/799,890 filed May 3, 2007.

FIELD OF THE INVENTION

[0002] This invention relates, in general, to tissue paper products. More specifically, it relates to tissue paper products having chemical softening agent(s) applied thereon.

BACKGROUND OF THE INVENTION

[0003] Sanitary paper tissue products such as facial tissues, toilet tissues and absorbent towels share a common need, specifically to be soft to the touch. Softness is a complex tactile impression elicited by a product when it is stroked against the skin. The purpose of being soft is so that these products can be used to cleanse the skin without being irritating. Effectively cleansing the skin is a persistent personal hygiene problem for many people. Objectionable discharges of urine, menses, and fecal matter from the perineal area or otorhinolaryngogical mucus discharges do not always occur at a time convenient for one to perform a thorough cleansing, as with soap and copious amounts of water for example. As a substitute for thorough cleansing, a wide variety of tissue and toweling products are offered to aid in the task of removing from the skin and retaining the before mentioned discharges for disposal in a sanitary fashion. Not surprisingly, the use of these products does not approach the level of cleanliness that can be achieved by the more thorough cleansing methods, and producers of tissue and toweling products are constantly striving to make their products compete more favorably with thorough cleansing methods.

[0004] Accordingly, making soft tissue and toweling products which promote comfortable cleaning without performance impairing sacrifices has long been the goal of the engineers and scientists who are devoted to research into improving tissue paper. There have been numerous attempts to reduce the abrasive effect, i.e., improve the softness of tissue products.

[0005] One area that has been exploited in this regard has been to select and modify cellulose fiber morphologies and engineer paper structures to take optimum advantages of the various available morphologies. Applicable art in this area include in U.S. Pat. Nos. 5,228,954; 5,405,499; 4,874,465; and 4,300,981.

[0006] Another area which has received a considerable amount of attention is the addition of chemical softening agents (also referred to herein as "chemical softeners") to tissue and toweling products.

[0007] As used herein, the term "chemical softening agent" refers to any chemical ingredient which improves the tactile sensation perceived by the consumer who holds a particular paper product and rubs it across the skin. Although somewhat desirable for towel products, softness is a particularly important property for facial and toilet tissues. Such tactile perceivable softness can be characterized by, but is not limited to, friction, flexibility, and smoothness, as well as subjective descriptors, such as lubricious, velvet, silk or flannel, which imparts a lubricious feel to tissue. This includes, for exemplary purposes only, basic waxes such as paraffin and beeswax and oils such as mineral oil and silicone oil as well as petrolatum and more complex lubricants and emollients such as quaternary ammonium compounds with long alkyl chains, functional silicones, fatty acids, fatty alcohols and fatty esters.

[0008] Thus, it would be advantageous to provide for the addition of chemical softeners to already-dried paper webs either at the so-called dry end of the papermaking machine or in a separate converting operation subsequent to the papermaking step. Exemplary art from this field includes U.S. Pat. Nos. 5,215,626; 5,246,545; and 5,525,345. While each of these references could represent advances over the previous so-called wet end methods particularly with regard to eliminating the degrading effects on the papermaking process, none are able to completely address the overall reduction of dust that accompanies such applications to the dry paper web.

[0009] One of the most important physical properties related to softness is generally considered by those skilled in the art to be the strength of the web. Strength is the ability of the product, and its constituent webs, to maintain physical integrity and to resist tearing, bursting, and shredding under use conditions. Achieving a high softening potential without degrading strength has long been an object of workers in the field of the present invention.

[0010] Accordingly, it is an object of the present invention to provide a soft tissue paper that emits less dust during use without performance impairing sacrifices such as in the strength of the paper.

SUMMARY OF THE INVENTION

[0011] The present invention provides for a tissue paper product having at least one ply wherein only one outer surface of the tissue paper product has an aqueous chemical softening agent applied and substantially affixed thereto at a concentration ranging from about 0.45% to about 0.25%. The chemical softening agent provides the tissue paper product with a raw dispensing dust value. The raw dispensing dust value is less than about 4893.

[0012] The present invention also provides for a tissue paper product having at least one ply wherein only one outer surface of said tissue paper product has an aqueous chemical softening agent applied and substantially affixed thereto at a concentration ranging from about 0.45% to about 0.25%. The chemical softening agent provides the tissue paper product with a raw dust per raw lint value. The raw dust per raw lint value is less than about 804.8.

[0013] The present invention also provides for a tissue paper product having at least one ply wherein only one outer surface of said tissue paper product has an aqueous chemical softening agent applied and substantially affixed thereto at a concentration ranging from about 0.45% to about 0.25%. The chemical softening agent provides the tissue paper product with a geometric mean of dust×lint (GM D×L) value. The GM D×L value is less than about 176.5.

DETAILED DESCRIPTION OF THE INVENTION

[0014] As used herein, the term "water soluble" refers to materials that are soluble in water to at least 3%, by weight, at 25° C.

[0015] As used herein, the terms "tissue paper web, paper web, web, paper sheet and paper product" are all used interchangeably to refer to sheets of paper made by a process comprising the steps of forming an aqueous papermaking

furnish, depositing this furnish on a foraminous surface, such as a Fourdrinier wire, and removing the water from the furnish as by gravity or vacuum-assisted drainage, forming an embryonic web, transferring the embryonic web from the forming surface to a transfer surface traveling at a lower speed than the forming surface. The web is then transferred to a fabric upon which it is through air dried to a final dryness after which it is wound upon a reel.

[0016] The terms "multi-layered tissue paper web, multi-layered paper web, multi-layered web, multi-layered paper sheet and multi-layered paper product" are all used interchangeably in the art to refer to sheets of paper prepared from two or more layers of aqueous paper making furnish which are preferably comprised of different fiber types, the fibers typically being relatively long softwood and relatively short hardwood fibers as used in tissue paper making. The layers are preferably formed from the deposition of separate streams of dilute fiber slurries upon one or more endless foraminous surfaces. If the individual layers are initially formed on separate foraminous surfaces, the layers can be subsequently combined when wet to form a multi-layered tissue paper web.

[0017] As used herein, the term "single-ply tissue product" means that it is comprised of one ply of un-creped tissue; the ply can be substantially homogeneous in nature or it can be a multi-layered tissue paper web. As used herein, the term "multi-ply tissue product" means that it is comprised of more than one ply of un-creped tissue. The plies of a multi-ply tissue product can be substantially homogeneous in nature or they can be multi-layered tissue paper webs.

[0018] As used herein, the term "substantively affixed chemical softening agent" is defined as a chemical agent which imparts lubricity or emolliency to tissue paper products and also possesses permanence with regard to maintaining the fidelity of its deposits without substantial migration when exposed to the environmental conditions to which products of this type are ordinarily exposed during their typical life cycle. Waxes and oils for example are capable of imparting lubricity or emolliency to tissue paper, but they suffer from a tendency to migrate because they have little affinity for the cellulose pulps which comprise the tissue papers of the present invention. While not wishing to be bound by theory, the substantively affixed chemical softeners of the present invention are believed to interact with the cellulose by covalent, ionic, or hydrogen bonding any of which are sufficiently potent to stem migration under normal environmental conditions.

[0019] Preferably, the substantively affixed chemical softening agents comprise quaternary ammonium compounds. Preferred quaternary compounds have the formula:

$$(R_1)_{4-m}—N^+—[R_2]_mX^-$$

[0020] wherein:

[0021] m is 1 to 3;

[0022] R_1 is a C_1-C_6 alkyl group, hydroxyalkyl group, hydrocarbyl or substituted hydrocarbyl group, alkoxylated group, benzyl group, or mixtures thereof;

[0023] R_2 is a C_{14}-C_{22} alkyl group, hydroxyalkyl group, hydrocarbyl or substituted hydrocarbyl group, alkoxylated group, benzyl group, or mixtures thereof; and

[0024] X^- is any softener-compatible anion are suitable for use in the present invention.

[0025] Preferably, each R_1 is methyl and X^- is chloride or methyl sulfate. Preferably, each R_2 is C_{16}-C_{18} alkyl or alkenyl, most preferably each R_2 is straight-chain C_{1-8} alkyl or alkenyl. Optionally, the R_2 substituent can be derived from vegetable oil sources.

[0026] Such structures include the well-known dialkyldimethylammonium salts (e.g. ditallowedimethylammonium chloride, ditallowedimethylammonium methyl sulfate, di(hydrogenated tallow)dimethyl ammonium chloride, etc.), in which R_1 are methyl groups, R_2 are tallow groups of varying levels of saturation, and X^- is chloride or methyl sulfate.

[0027] As discussed in Swern, Ed. in Bailey's Industrial Oil and Fat Products, Third Edition, John Wiley and Sons (New York 1964) tallow is a naturally occurring material having a variable composition. Table 6.13 in the above-identified reference edited by Swern indicates that typically 78% or more of the fatty acids of tallow contain 16 or 18 carbon atoms. Typically, half of the fatty acids present in tallow are unsaturated, primarily in the form of oleic acid. Synthetic as well as natural "tallows" fall within the scope of the present invention. It is also known that depending upon the product characteristic requirements the saturation level of the ditallow can be tailored from non hydrogenated (soft) to touch, partially or completely hydrogenated (hard). All of above-described levels of saturations are expressly meant to be included within the scope of the present invention.

[0028] Particularly preferred variants of these softening agents are what are considered to be mono or diester variations of these quaternary ammonium compounds having the formula:

$$(R_1)_{4-m}—N^+—[(CH_2)_n—Y—R_3]_mX^-$$

[0029] wherein:

[0030] Y is —O—(O)C—, or —C(O)—O—, or —NH—C(O)—, or —C(O)—NH—;

[0031] m is 1 to 3;

[0032] n is 0 to 4;

[0033] each R_1 is a C_1-C_6 alkyl group, hydroxyalkyl group, hydrocarbyl or substituted hydrocarbyl group, alkoxylated group, benzyl group, or mixtures thereof;

[0034] each R_3 is a $C_{13}C_{121}$ alkyl group, hydroxyalkyl group, hydrocarbyl or substituted hydrocarbyl group, alkoxylated group, benzyl group, or mixtures thereof; and

[0035] X^- is any softener-compatible anion.

[0036] Preferably, Y=—O—(O)C—, or —C(O)—O—; m=2; and n=2. Each R_1 substituent is preferably a C_1-C_3, alkyl group, with methyl being most preferred. Preferably, each R_3 is C_{13}-C_{17} alkyl and/or alkenyl, more preferably R_3 is straight chain C_{15}-C_{17} alkyl and/or alkenyl, C_{15}-C_{17} alkyl, most preferably each R_3 is straight-chain C_{17} alkyl. Optionally, the R_3 substituent can be derived from vegetable oil sources.

[0037] As mentioned above, X^- can be any softener-compatible anion, for example, acetate, chloride, bromide, methylsulfate, formate, sulfate, nitrate and the like. Preferably X^- is chloride or methyl sulfate.

[0038] Specific examples of ester-functional quaternary ammonium compounds having the structures detailed above and suitable for use in the present invention may include the diester dialkyl dimethyl ammonium salts such as diester ditallow dimethyl ammonium chloride, monoester ditallow dimethyl ammonium chloride, diester ditallow dimethyl ammonium methyl sulfate, diester di(hydrogenated)tallow dimethyl ammonium methyl sulfate, diester di(hydrogenated)tallow dimethyl ammonium chloride, and mixtures

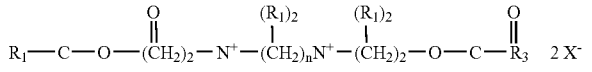
thereof. Diester ditallow dimethyl ammonium chloride and diester di(hydrogenated)tallow dimethyl ammonium chloride are particularly preferred. These particular materials are available commercially from Witco Chemical Company Inc. of Dublin, Ohio under the tradename "ADOGEN SDMC".

[0039] Typically, half of the fatty acids present in tallow are unsaturated, primarily in the form of oleic acid. Synthetic as well as natural "tallows" fall within the scope of the present invention. It is also known that depending upon the product characteristic requirements, the saturation level of the ditallow can be tailored from non hydrogenated (soft) to touch, partially or completely hydrogenated (hard). All of above-described levels of saturations are expressly meant to be included within the scope of the present invention.

[0040] It will be understood that substituents R_1, R_2 and R_3 may optionally be substituted with various groups such as alkoxyl, hydroxyl, or can be branched. As mentioned above, preferably each R_1 is methyl or hydroxyethyl. Preferably, each R_2 is C_{12}-C_{18} alkyl and/or alkenyl, most preferably each R_2 is straight-chain C_{16}-C_{18} alkyl and/or alkenyl, most preferably each R_2 is straight-chain C_{18} alkyl or alkenyl. Preferably R_3 is C_{13}-C_{17} alkyl and/or alkenyl, most preferably R_3 is straight chain C_{15}-C_{17} alkyl and/or alkenyl. Preferably, X^- is chloride or methyl sulfate. Furthermore the ester-functional quaternary ammonium compounds can optionally contain up to about 10% of the mono(long chain alkyl) derivatives, e.g., $(R_2)_2$—N^+—$((CH_2)_2OH)((CH_2)_2OC(O)R_3)X^-$ as minor ingredients. These minor ingredients can act as emulsifiers and can be useful in the present invention.

[0041] Other types of suitable quaternary ammonium compounds for use in the present invention are described in U.S. Pat. Nos. 5,543,067; 5,538,595; 5,510,000; 5,415,737; and European Patent Application No. 0 688 901 A2.

[0042] Di-quat variations of the ester-functional quaternary ammonium compounds can also be used, and are meant to fall within the scope of the present invention. These compounds have the formula:



[0043] In the structure named above each R_1 is a C_1-C_6 alkyl or hydroxyalkyl group, R_3 is C_{11}-C_{21} hydrocarbyl group, n is 2 to 4 and X^- is a suitable anion, such as a halide (e.g., chloride or bromide) or methyl sulfate. Preferably, each R_3 is C_{13}-C_{17} alkyl and/or alkenyl, most preferably each R_3 is straight-chain C_{15}-C_{17} alkyl and/or alkenyl, and R_1 is a methyl.

[0044] While not wishing to be bound by theory, it is believed that the ester moiety(ies) of the quaternary compounds provides a measure of biodegradability. It is believed the ester-functional quaternary ammonium compounds used herein biodegrade more rapidly than do conventional dialkyl dimethyl ammonium chemical softeners.

[0045] The use of quaternary ammonium ingredients before is most effectively accomplished if the quaternary ammonium ingredient is accompanied by an appropriate plasticizer. The plasticizer can be added during the quaternizing step in the manufacture of the quaternary ammonium ingredient or it can be added subsequent to the quaternization but prior to the application as a chemical softening agent. The plasticizer is characterized by being substantially inert during the chemical synthesis, but acts as a viscosity reducer to aid in the synthesis and subsequent handling, i.e. application of the quaternary ammonium compound to the tissue paper product. Preferred pasticizers are comprised of a combination of a non-volatile polyhydroxy compound and a fatty acid. Preferred polyhydroxy compounds include glycerol and polyethylene glycols having a molecular weight of from about 200 to about 2000, with polyethylene glycol having a molecular weight of from about 200 to about 600 being particularly preferred. Preferred fatty acids comprise C_6-C_{23} linear or branched and saturated or unsaturated analogs with isostearic acid being the most preferred.

[0046] While not wishing to be bound by theory, it is believed that a synergism results from the relationship of the polyhydroxy compound and the fatty acid in the mixture. While the polyhydroxy compound performs the essential function of viscosity reduction, it can be quite mobile after being laid down thus detracting from one of the objects of the present invention, i.e. that the deposited softener be substantively affixed. The inventors have now found that the addition of a small amount of the fatty acid is able to stem the mobility of the polyhydroxy compound and further reduce the viscosity of the mixture so as to increase the processability of compositions of a given quaternary ammonium compound fraction.

[0047] Alternative embodiments of preferred substantively affixed chemical softening agents comprise well-known organo-reactive polydimethyl siloxane ingredients, including the most preferred—amino functional polydimethyl siloxane.

[0048] A most preferred form of the substantively affixed softening agent is to combine the organo-reactive silicone with a suitable quaternary ammonium compound. In this embodiment the organo-reactive silicone is preferred to be an amino polydimethyl siloxane and is used at an amount ranging from 0 up to about 50% of the composition by weight, with a preferred usage being in the range of about 5% to about 15% by weight based on the weight of the polysiloxane relative to the total substantively affixed softening agent.

[0049] The soft tissue paper of the present invention preferably has a basis weight ranging from between about 5 g/m^2 and about 120 g/m^2, more preferably between about 10 g/m^2 and about 55 g/m^2, and even more preferably between about 10 g/m^2 and about 30 g/m^2. The soft tissue paper of the present invention preferably has a density ranging from between about 0.01 g/m^3 and about 0.19 g/cm^3, more preferably between about 0.03 g/m^3 and about 0.6 g/cm^3, and even more preferably between about 0.1 g/cm^3 and 0.2 g/cm^3.

[0050] The soft tissue paper of the present invention further comprises papermaking fibers of both hardwood and softwood types wherein at least about 50% of the papermaking fibers are hardwood and at least about 10% are softwood. The hardwood and softwood fibers are most preferably isolated by relegating each to separate layers wherein the tissue comprises an inner layer and at least one outer layer.

[0051] The tissue paper product of the present invention is preferably creped, i.e., produced on a papermaking machine culminating with a Yankee dryer to which a partially dried papermaking web is adhered and upon which it is dried and from which it is removed by the action of a flexible creping blade.

[0052] Creping is a means of mechanically compacting paper in the machine direction. The result is an increase in basis weight (mass per unit area) as well as dramatic changes

in many physical properties, particularly when measured in the machine direction. Creping is generally accomplished with a flexible blade, a so-called doctor blade, against a Yankee dryer in an on machine operation.

[0053] A Yankee dryer is a large diameter, generally 8-20 foot drum which is designed to be pressurized with steam to provide a hot surface for completing the drying of papermaking webs at the end of the papermaking process. The paper web which is first formed on a foraminous forming carrier, such as a Fourdrinier wire, where it is freed of the copious water needed to disperse the fibrous slurry is generally transferred to a felt or fabric in a so-called press section where de-watering is continued either by mechanically compacting the paper or by some other de-watering method such as through-drying with hot air, before finally being transferred in the semi-dry condition to the surface of the Yankee for the drying to be completed.

[0054] While the characteristics of the creped paper webs, particularly when the creping process is preceded by methods of pattern densification, are preferred for practicing the present invention, uncreped tissue paper is also a satisfactory substitute and the practice of the present invention using uncreped tissue paper is specifically incorporated within the scope of the present invention. Uncreped tissue paper, a term as used herein, refers to tissue paper which is non-compressively dried, most preferably by through-drying. Resultant through air dried webs are pattern densified such that zones of relatively high density are dispersed within a high bulk field, including pattern densified tissue wherein zones of relatively high density are continuous and the high bulk field is discrete.

[0055] To produce un-creped tissue paper webs, an embryonic web is transferred from the foraminous forming carrier upon which it is laid, to a slower moving, high fiber support transfer fabric carrier. The web is then transferred to a drying fabric upon which it is dried to a final dryness. Such webs can offer some advantages in surface smoothness compared to creped paper webs.

[0056] Tissue paper webs are generally comprised essentially of papermaking fibers. Small amounts of chemical functional agents such as wet strength or dry strength binders, retention aids, surfactants, size, chemical softeners, crepe facilitating compositions are frequently included but these are typically only used in minor amounts. The papermaking fibers most frequently used in tissue papers are virgin chemical wood pulps. Additionally, filler materials may also be incorporated into the tissue papers of the present invention.

[0057] Embodiments of the present invention wherein the substantively affixed softening agent comprises a quaternary ammonium compound further comprise from about 1% to about 50% of a polyhydroxy compound and from about 0.1% to about 10% of a fatty acid, each as a percentage of the weight of the quaternary ammonium compound.

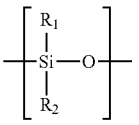
[0058] Polyhydroxy compounds useful in this embodiment of the present invention include polyethylene glycol, polypropylene glycol and mixtures thereof.

[0059] Fatty acids useful in this embodiment of the present invention comprises C_6-C_{23} linear, branched, saturated, or unsaturated analogs. The most preferred form of such a fatty acid is isostearic acid.

[0060] One particularly preferred chemical softening agent contains from about 0.1% to about 70% of a polysiloxane compound.

[0061] Polysiloxanes which are applicable to chemical softening compositions of the present invention include polymeric, oligomeric, copolymeric, and other multiple monomeric siloxane materials. As used herein, the term polysiloxane shall include all of such polymeric, oligomeric, copolymeric, and other multiple-monomeric materials. Additionally, the polysiloxane can be straight chained, branched chain, or have a cyclic structure.

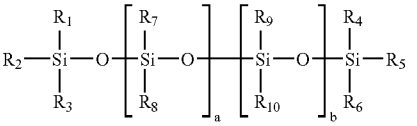
[0062] Preferred polysiloxane materials include those having monomeric siloxane units of the following structure:



wherein, R_1 and R_1 for each siloxane monomeric unit can independently be any alkyl, aryl, alkenyl, alkaryl, aralkyl, cycloalkyl, halogenated hydrocarbon, or other radical. Any of such radicals can be substituted or unsubstituted. R_1 and R_2 radicals of any particular monomeric unit may differ from the corresponding functionalities of the next adjoining monomeric unit. Additionally, the radicals can be either a straight chain, a branched chain, or have a cyclic structure. The radicals R_1 and R_2 can, additionally and independently be other silicone functionalities such as, but not limited to siloxanes, polysiloxanes, and polysilanes. The radicals R_1 and R_2 can also contain any of a variety of organic functionalities including, for example, alcohol, carboxylic acid, and amine functionalities.

[0063] Reactive, organo-functional silicones, especially amino-functional silicones are preferred for the present invention.

[0064] Preferred polysiloxanes include straight chain organopolysiloxane materials of the following general formula:



wherein each R_1-R_9 radical can independently be any C_1-C_{10} unsubstituted alkyl or aryl radical, and R_{10} of any substituted C_1-C_{10} alkyl or aryl radical. Preferably each R_1-R_9 radical is independently any C_1-C_4 unsubstituted alkyl group those skilled in the art will recognize that technically there is no difference whether, for example, R_9 or R_{10} is the substituted radical. Preferably the mole ratio of b to (a+b) is between 0 and about 20%, more preferably between 0 and about 10%, and most preferably between about 1% and about 5%.

[0065] In one particularly preferred embodiment, R_1-R_9 are methyl groups and R_{10} is a substituted or unsubstituted alkyl, aryl, or alkenyl group. Such material shall be generally described herein as polydimethylsiloxane which has a particular functionality as may be appropriate in that particular case. Exemplary polydimethylsiloxane include, for example, polydimethylsiloxane having an alkyl hydrocarbon R_{10} radical and polydimethylsiloxane having one or more amino, carboxyl, hydroxyl, ether, polyether, aldehyde, ketone, amide, ester, thiol, and/or other functionalities including alkyl and alkenyl analogs of such functionalities. For example, an amino functional alkyl group as R_{10} could be an

amino functional or an aminoalkyl-functional polydimethylsiloxane. The exemplary listing of these polydimethylsiloxanes is not meant to thereby exclude others not specifically listed.

[0066] Viscosity of polysiloxanes useful for this invention may vary as widely as the viscosity of polysiloxanes in general vary, so long as the polysiloxane can be rendered into a form which can be applied to the tissue paper product herein. This includes, but is not limited to, viscosity as low as about 25 centistokes to about 20,000,000 centistokes or even higher. High viscosity polysiloxanes which themselves are resistant to flowing can be effectively deposited by emulsifying with a surfactant or dissolution into a vehicle, such as hexane, listed for exemplary purposes only.

[0067] While not wishing to be bound by theory, it is believed that the tactile benefit efficacy is related to average molecular weight and that viscosity is also related to average molecular weight. Accordingly, due to the difficulty of measuring molecular weight directly, viscosity is used herein as the apparent operative parameter with respect to imparting softness to tissue paper.

[0068] References disclosing polysiloxanes include U.S. Pat. Nos. 2,826,551; 3,964,500; 4,364,837; 5,059,282; 5,529,665; 5,552,020; and British Patent 849,433.

[0069] It is anticipated that wood pulp in all its varieties will normally comprise the tissue papers with utility in this invention. However, other cellulose fibrous pulps, such as cotton linters, bagasse, rayon, etc., can be used and none are disclaimed. Wood pulps useful herein include chemical pulps such as, sulfite and sulfate (sometimes called Kraft) pulps as well as mechanical pulps including for example, ground wood, ThermoMechanical Pulp (TMP) and Chemi-ThermoMechanical Pulp (CTMP). Pulps derived from both deciduous and coniferous trees can be used.

[0070] Hardwood pulps and softwood pulps, as well as combinations of the two, may be employed as papermaking fibers for the tissue paper of the present invention. The term "hardwood pulps" as used herein refers to fibrous pulp derived from the woody substance of deciduous trees (angiosperms), whereas "softwood pulps" are fibrous pulps derived from the woody substance of coniferous trees (gymnosperms). Blends of hardwood Kraft pulps, especially eucalyptus, and northern softwood Kraft (NSK) pulps are particularly suitable for making the tissue webs of the present invention. A preferred embodiment of the present invention comprises the use of layered tissue webs wherein, most preferably, hardwood pulps such as eucalyptus are used for outer layer(s) and wherein northern softwood Kraft pulps are used for the inner layer(s). Also applicable to the present invention are fibers derived from recycled paper, which may contain any or all of the above categories of fibers.

[0071] In one preferred embodiment of the present invention, which utilizes multiple papermaking furnishes, the furnish containing the papermaking fibers which will be contacted by the particulate filler is predominantly of the hardwood type, preferably of content of at least about 80% hardwood.

Optional Chemical Additives

[0072] Other materials can be added to the aqueous papermaking furnish or the embryonic web to impart other characteristics to the product or improve the papermaking process so long as they are compatible with the chemistry of the substantively affixed softening agent and do not significantly and adversely affect the softness, strength, or low dusting character of the present invention. The following materials are expressly included, but their inclusion is not offered to be all-inclusive. Other materials can be included as well so long as they do not interfere or counteract the advantages of the present invention.

[0073] It is common to add a cationic charge biasing species to the papermaking process to control the zeta potential of the aqueous papermaking furnish as it is delivered to the papermaking process. These materials are used because most of the solids in nature have negative surface charges, including the surfaces of cellulosic fibers and fines and most inorganic fillers. One traditionally used cationic charge biasing species is alum. More recently in the art, charge biasing is done by use of relatively low molecular weight cationic synthetic polymers preferably having a molecular weight of no more than about 500,000 and more preferably no more than about 200,000, or even about 100,000. The charge densities of such low molecular weight cationic synthetic polymers are relatively high. These charge densities range from about 4 to about 8 equivalents of cationic nitrogen per kilogram of polymer. One example material is Cypro 514®, a product of Cytec, Inc. of Stamford, Conn. The use of such materials is expressly allowed within the practice of the present invention.

[0074] The use of high surface area, high anionic charge microparticles can improve the formation, drainage, strength, and retention of the product. Exemplary high anionic charge microparticles would be known to those of skill in the art. By way of non-limiting example, common materials for this purpose could include silica colloid, or bentonite clay. The incorporation of such materials is expressly included within the scope of the present invention.

[0075] If permanent wet strength is desired, the group of chemicals: including polyamide-epichlorohydrin, polyacrylamides, styrene-butadiene latices; insolubilized polyvinyl alcohol; urea-formaldehyde; polyethyleneimine; chitosan polymers and mixtures thereof can be added to the papermaking furnish or to the embryonic web. Polyamide-epichlorohydrin resins are cationic wet strength resins which have been found to be of particular utility. Suitable types of such resins are described in U.S. Pat. Nos. 3,700,623 and 3,772,076. One commercial source of useful polyamide-epichlorohydrin resins is Hercules, Inc. of Wilmington, Del., which markets such resin under the mark Kymene 557H®).

[0076] Many paper products must have limited strength when wet because of the need to dispose of them through toilets into septic or sewer systems. If wet strength is imparted to these products, it is preferred to be fugitive wet strength characterized by a decay of part or all of its potency upon standing in presence of water. If fugitive wet strength is desired, the binder materials can be chosen from the group consisting of dialdehyde starch or other resins with aldehyde functionality such as Co-Bond 1000® offered by National Starch and Chemical Company, Parez 750® offered by Cytec of Stamford, Conn. and the resin described in U.S. Pat. No. 4,981,557.

[0077] If enhanced absorbency is needed, surfactants may be used to treat the tissue paper webs of the present invention. The level of surfactant, if used, is preferably from about 0.01% to about 2.0% by weight, based on the dry fiber weight of the tissue paper. The surfactants preferably have alkyl chains with eight or more carbon atoms. Exemplary anionic surfactants are linear alkyl sulfonates, and alkylbenzene sulfonates. Exemplary nonionic surfactants are alkylglycosides

including alkylglycoside esters such as Crodesta SL-40® which is available from Croda, Inc. (New York, N.Y.); alkylglycoside ethers as described in U.S. Pat. No. 4,011,389, issued to W. K. Langdon, et al. on Mar. 8, 1977; and alkylpolyethoxylated esters such as Pegosperse 200 mL available from Glyco Chemicals, Inc. (Greenwich, Conn.) and IGEPAL RC-520® available from Rhone Poulenc Corporation (Cranbury, N.J.).

[0078] The present invention is further applicable to the production of multi-layered tissue paper webs. Multilayered tissue structures and methods of forming multilayered tissue structures are described in U.S. Pat. Nos. 3,994,771; 4,300,981; 4,166,001; and European Patent Publication No. 0 613 979 A1. The layers preferably comprise different fiber types, the fibers typically being relatively long softwood and relatively short hardwood fibers as used in multi-layered tissue paper making. Multi-layered tissue paper webs resultant from the present invention comprise at least two superposed layers, an inner layer and at least one outer layer contiguous with the inner layer. Preferably, the multi-layered tissue papers comprise three superposed layers, an inner or center layer, and two outer layers, with the inner layer located between the two outer layers. The two outer layers preferably comprise a primary filamentary constituent of relatively short paper making fibers having an average fiber length between about 0.5 and about 1.5 mm, preferably less than about 1.0 mm. These short paper making fibers typically comprise hardwood fibers, preferably hardwood Kraft fibers, and most preferably derived from eucalyptus. The inner layer preferably comprises a primary filamentary constituent of relatively long paper making fiber having an average fiber length of least about 2.0 mm. These long paper making fibers are typically softwood fibers, preferably, northern softwood Kraft fibers. Preferably, the majority of the particulate filler of the present invention is contained in at least one of the outer layers of the multi-layered tissue paper web of the present invention. More preferably, the majority of the particulate filler of the present invention is contained in both of the outer layers.

[0079] The tissue paper products made from single-layered or multi-layered un-creped tissue paper webs can be single-ply tissue products or multi-ply tissue products.

[0080] The term "dust" is used herein to refer to the tendency of a tissue paper web to release fibers or particulate fillers as measured in a controlled abrasion test, described infra. Dust can be related to strength since the tendency to release fibers or particles is directly related to the degree to which such fibers or particles are anchored into the structure. As the overall level of anchoring is increased, the strength will be increased. However, it is possible to have a level of strength which is regarded as acceptable but have an unacceptable level of dust. This is because dust can be localized. For example, the surface of a tissue paper web can be prone to dust, while the degree of bonding beneath the surface can be sufficient to raise the overall level of strength to quite acceptable levels. In another case, the strength can be derived from a skeleton of relatively long papermaking fibers, while fiber fines or the particulate filler can be insufficiently bound within the structure. The tissue paper webs of the present invention are relatively low in lint. Levels of lint below about 12 are preferable, and below about 10 are more preferable.

[0081] The multi-layered tissue paper webs of to the present invention can be used in any application where soft, absorbent multi-layered tissue paper webs are required. Particularly advantageous uses of the multi-layered tissue paper web of this invention are in toilet tissue and facial tissue products. Both single-ply and multi-ply tissue paper products can be produced from the webs of the present invention.

Application of a Chemical Softening Agents to Paper Webs

[0082] In accordance with the present invention, chemical softening agents may be applied to a paper web by any application method known in the industry such as, for example, spraying, printing, extrusion, brushing, by means of permeable or impermeable rolls and/or pads. In a first embodiment, the claimed softening agent may be applied to a paper web with a slot die. Specifically, the chemical softening agent may be extruded onto the surface of a paper web via a heated slot die. The slot die may be any suitable slot die or other means for applying chemical softening agent to the paper web. The slot die or other glue application means may be supplied by any suitable apparatus. For example, the slot die may be supplied by a heated hopper or drum and a variable speed gear pump through a heated hose. The chemical softening agent is preferably extruded onto the surface of the paper web at a temperature that permits the chemical softening agent to bond to the paper web. Depending on the particular embodiment, the chemical softening agent can be at least partially transferred to rolls in a metering stack (if used) and then to the paper web.

[0083] Additionally, the chemical softening agent may be applied to a paper web by an apparatus comprising a fluid transfer component. The fluid transfer component preferably comprises a first surface and a second surface. The fluid transfer component further preferably comprises pores connecting the first surface and the second surface. The pores are disposed upon the fluid transfer component in a non-random pre-selected pattern. A fluid supply is operably (or fluidly) connected to the fluid transfer component such that a fluid (such as the chemical softening agent) may contact the first surface of the fluid transfer component. The apparatus further comprises a fluid motivating component. The fluid motivating component provides an impetus for the fluid to move from the first surface to the second surface via the pores. The apparatus further comprises a fluid receiving component comprising a paper web. The paper web comprises a fluid receiving (or outer) surface. The fluid receiving surface may contact droplets of fluid formed upon the second surface. Fluid may pass through pores from the first surface to the second surface and may transfer to the fluid receiving surface.

[0084] The fluid transfer component may comprise a hollow cylindrical shell. The cylindrical shell may be sufficiently structural to function without additional internal bracing. The cylindrical shell may comprise a thin outer shell and structural internal bracing to support the cylindrical shell. The cylindrical shell may comprise a single layer of material or may comprise a laminate. The laminate may comprise layers of a similar material or may comprise layers dissimilar in material and structure. In one embodiment the cylindrical shell comprises a stainless steel shell having a wall thickness of about 0.125 inches (3 mm). In another embodiment (not shown) the fluid transfer component may comprise a flat plate. In another embodiment the fluid transfer component may comprise a regular or irregular polygonal prism.

[0085] The fluid application width of the apparatus may be adjusted by providing a single fluid transfer component of appropriate width. Multiple individual fluid application components may be combined in a series to achieve the desired width. In a non-limiting example, a plurality of stainless steel

cylinders each having a shell thickness of about 0.125 inches (3 mm) and a width of about 6 inches (about 15 cm) may be coupled end to end with an appropriate seal—such as an o-ring seal between each pair of cylinders. In this example, the number of shells combined may be increased until the desired application width is achieved.

[0086] The fluid transfer component preferably further comprises pores connecting the first surface and the second surface. Connecting the surfaces refers to the pores each providing a pathway for the transport of a fluid from the first surface to the second surface. In one embodiment, the pores may be formed by the use of electron beam drilling as is known in the art. Electron beam drilling comprises a process whereby high energy electrons impinge upon a surface resulting in the formation of holes through the material. In another embodiment, the pores may be formed using a laser. In another embodiment, the pores may be formed by using a drill bit. In yet another embodiment, the pores may be formed using electrical discharge machining as if known in the art.

[0087] In one embodiment, an array of pores may be disposed to provide a uniform distribution of fluid droplets to maximize the ratio of fluid surface area to applied fluid volume. In one embodiment, this may be used to apply a chemical softening agent in a pattern of dots to maximize the potential for adhesion between two surfaces for any volume of applied chemical softening agent.

[0088] The pattern of pores upon the second surface may comprise an array of pores having a substantially similar diameter or may comprise a pattern of pores having distinctly different pore diameters. In an alternative embodiment, the array of pores may comprise a first set of pores having a first diameter and arranged in a first pattern. The array further comprises a second set of pores having a second diameter and arranged in a second pattern. The first and second patterns may be arranged to interact each with the other.

[0089] Alternatively, the chemical softening agent may be sprayed directly onto the surface of a paper web using equipment suitable for such a purpose and as well known to those of skill in the art.

Analytical and Testing Procedures

[0090] A. Density

[0091] The density of multi-layered tissue paper, as that term is used herein, is the average density calculated as the basis weight of that paper divided by the caliper, with the appropriate unit conversions incorporated therein. Caliper of the multi-layered tissue paper, as used herein, is the thickness of the paper when subjected to a compressive load of 95 g/in^2 (15.5 g/cm^2).

[0092] B. Dispensing Dust Test Method

[0093] Dust is measured using a particle counter commercially available (Sympatec QICPIC, Sympatec GmbH, Am Pulverhaus 1, 38678 Clausthal-Zellerfeld, Germany). The instrument is used according to the manufacturer's recommendation and a frame rate of 400 frames/sec is selected. The particle size range is set to 20 to 10,000 micrometers. Sympatec's standard chute for guiding particles into the instrument was modified by removing the flights within the chute and by attaching a funnel to the top of the chute. The funnel is constructed of stainless steel and has 4 trapezoidal sides, 14 inches (35.6 cm) across the wide part (top), tapering to 2 inches (5.1 cm) wide at the bottom, i.e. point of attachment with the chute. The trapezoid sides are 12 inches (30.5 cm) long. A vacuum is attached to the exit of the instrument to create an air flow through the instrument, and consequently the chute and the funnel. The vacuum is sufficient to create an airspeed entering the funnel of 470 feet/min (14.3 Km/min). The airspeed is measured using an Extech Instruments ThermoAnemometer Model 407113 and Anemometer metal probe, SN Q138487. The probe was mounted in a plastic tube in a square of foam (necessitated by the square shape of the funnel). The probe assembly was placed in the funnel so that the foam sealed against the funnel walls and the anemometer was centered above the shaft opening. The linear flow was calculated for the bottom of the funnel where the drop shaft begins (the 2-inch×2-inch (5.08 cm×5.08 cm) opening).

[0094] To perform the dust test, sanitary tissue product is dispensed, i.e. pulled apart at the perforations, manually at the top of the funnel to release dust. The force to rupture the product at the perforations is a function of the dispensing tensile and the operator merely applies enough force directly in tension across the perforations to dispense the product in a manner typical of tissue dispensing. Care should be taken not to tear the product across any perforations, rather it should be dispensed by pulling directly in tension across the perforations. The dust fibers and/or particles so liberated are directed into a modified Sympatec chute and the chute delivers them to the measurement zone of the instrument by gravity and vacuum.

[0095] The QICPIC measures the number of particles passing through the measurement zone using dynamic image analysis. Five perforations are separated per measurement and the Raw Dispensing Dust value is simply the total number of particles counted.

[0096] The raw data needs to be normalized for width of the product at the perforations. The Raw Dispensing Dust value is multiplied by the width of the product at the perforations in inches and divided by 4.27. This result is the Dispensing Dust value. Products more than about 6 inches (15.24 cm) wide should be pre-cut in width with scissors to 4.27 inches (10.85 cm) wide prior to testing to prevent being too wide to dispense properly in tension.

[0097] The Normalized Dispensing Dust value is determined by any one of the following relationships: 1) Dispensing Dust value divided by Dispensing Tensile and multiplied by 150 yields the Tensile Normalized Dispensing Dust value; 2) Dispensing Dust Value divided by Lint test result and multiplied by 7 yields the Lint Normalized Dispensing Dust value; and 3) Dispensing Dust value divided by the product Density and multiplied by 0.08 yields the Density Normalized Dispensing Dust value.

[0098] The calculated dust valves as related to the application rate to the paper web (in lb/ton) and application method (spray, extrusion, or printing) compared to a non-treated paper web area provided in Table 1 below.

TABLE 1

Calculated Dust Valves (in # particles) Compared to Application Rate of Chemical Softening Agent to Substrate and Application Method and Dust Reduction

Application Rate of Chemical Softening Agent to Substrate	Spray (particles)	Extrusion (particles)	Print (particles)	None (particles)
10 lb/ton	6435	5080	6485	7510
Percent Dust Reduction	14.3%	32.4%	13.6%	—
20 lb/ton	5815	5325	—	7510
Percent Dust Reduction	22.6%	29.1%	—	—

[0099] C. Lint

[0100] The amount of lint generated from a tissue product is determined with a Sutherland Rub Tester. This tester uses a motor to rub a weighted felt 5 times over the stationary toilet tissue. The Hunter Color L value is measured before and after the rub test. The difference between these two Hunter Color L values is calculated as lint.

Sample Preparation

[0101] Prior to the lint rub testing, the paper samples to be tested should be conditioned according to Tappi Method #T4020M-88. Here, samples are preconditioned for 24 hours at a relative humidity level of 10 to 35% and within a temperature range of 22.degree. to 40.degree. C. After this preconditioning step, samples should be conditioned for 24 hours at a relative humidity of 48 to 52% and within a temperature range of 22.degree. to 24.degree. C. This rub testing should also take place within the confines of the constant temperature and humidity room.

[0102] The Sutherland Rub Tester may be obtained from Testing Machines, Inc. (Amityville, N.Y., 11701). The tissue is first prepared by removing and discarding any product which might have been abraded in handling, e.g. on the outside of the roll. For multi-ply finished product, three sections with each containing two sheets of multi-ply product are removed and set on the bench-top. For single-ply product, six sections with each containing two sheets of single-ply product are removed and set on the bench-top. Each sample is then folded in half such that the crease is running along the cross direction (CD) of the tissue sample. For the multi-ply product, make sure one of the sides facing out is the same side facing out after the sample is folded. In other words, do not tear the plies apart from one another and rub test the sides facing one another on the inside of the product. For the single-ply product, make up 3 samples with the wire side out and 3 with the non-wire side out. Keep track of which samples are wire side out and which are non-wire side out.

[0103] Obtain a 30-inch×40-inch (76.2 cm×101.6 cm) piece of Crescent #300 cardboard from Cordage Inc. (800 E. Ross Road, Cincinnati, Ohio, 45217). Using a paper cutter, cut out six pieces of cardboard having dimensions of 2.5 inches×6 inches (6.35 cm×15.24 cm). Puncture two holes into each of the six cards by forcing the cardboard onto the hold down pins of the Sutherland Rub tester.

[0104] If working with single-ply finished product center, and carefully place, each of the 2.5-inch×6-inch (6.35 cm×15.24 cm) cardboard pieces on top of the six previously folded samples. Make sure the 6-inch (15.24 cm) dimension of the cardboard is running parallel to the machine direction (MD) of each of the tissue samples. If working with multi-ply finished product, only three pieces of the 2.5-inch×6-inch (6.35 cm×15.24 cm) cardboard will be required. Center and carefully place each of the cardboard pieces on top of the three previously folded samples. Once again, make sure the 6-inch (15.24 cm) dimension of the cardboard is running parallel to the machine direction (MD) of each of the tissue samples.

[0105] Fold one edge of the exposed portion of tissue sample onto the back of the cardboard. Secure this edge to the cardboard with adhesive tape obtained from 3M Inc. (¾-inch (1.91 cm) wide Scotch Brand, St. Paul, Minn.). Carefully grasp the other over-hanging tissue edge and snugly fold it over onto the back of the cardboard. While maintaining a snug fit of the paper onto the board, tape this second edge to the back of the cardboard. Repeat this procedure for each sample.

[0106] Turn over each sample and tape the cross direction edge of the tissue paper to the cardboard. One half of the adhesive tape should contact the tissue paper while the other half is adhering to the cardboard. Repeat this procedure for each of the samples. If the tissue sample breaks, tears, or becomes frayed at any time during the course of this sample preparation procedure, discard and make up a new sample with a new tissue sample strip.

[0107] If working with multi-ply converted product, there will now be 3 samples on the cardboard. For single-ply finished product, there will now be 3 wire-side out samples on cardboard and 3 non-wire side out samples on cardboard.

Felt Preparation

[0108] Obtain a 30-inch×40-inch (76.2 cm×101.6 cm) piece of Crescent #300 cardboard from Cordage Inc. (800 E. Ross Road, Cincinnati, Ohio, 45217). Using a paper cutter, cut out six pieces of cardboard having dimensions of 2.25 inches×7.25 inches (5.72 cm×18.42 cm). Draw two lines parallel to the short dimension and down 1.125 inches (2.86 cm) from the top and bottom most edges on the white side of the cardboard. Carefully score the length of the line with a razor blade using a straight edge as a guide. Score it to a depth about half way through the thickness of the sheet. This scoring allows the cardboard/felt combination to fit tightly around the weight of the Sutherland Rub tester. Draw an arrow running parallel to the long dimension of the cardboard on this scored side of the cardboard.

[0109] Cut the six pieces of black felt (F-55 or equivalent from New England Gasket, 550 Broad Street, Bristol, Conn. 06010) to the dimensions of 2.25 inches×8.5 inches×0.0625 inches (5.72 cm×21.59 cm×0.16 cm). Place the felt on top of the unscored, green side of the cardboard such that the long edges of both the felt and cardboard are parallel and in alignment. Make sure the fluffy side of the felt is facing up. Also allow about 0.5 inch (1.27 cm) to overhang the top and bottom most edges of the cardboard. Snuggly fold over both overhanging felt edges onto the backside of the cardboard with Scotch brand tape. Prepare a total of six of these felt/cardboard combinations.

[0110] For best reproducibility, all samples should be run with the same lot of felt. Obviously, there are occasions where a single lot of felt becomes completely depleted. In those cases where a new lot of felt must be obtained, a correction factor should be determined for the new lot of felt. To determine the correction factor, obtain a representative single tissue sample of interest, and enough felt to make up 24 cardboard/felt samples for the new and old lots.

[0111] As described below and before any rubbing has taken place, obtain Hunter L readings for each of the 24 cardboard/felt samples of the new and old lots of felt. Calculate the averages for both the 24 cardboard/felt samples of the old lot and the 24 cardboard/felt samples of the new lot.

[0112] Next, rub test the 24 cardboard/felt boards of the new lot and the 24 cardboard/felt boards of the old lot as described below. Make sure the same tissue lot number is used for each of the 24 samples for the old and new lots. In addition, sampling of the paper in the preparation of the cardboard/tissue samples must be done so the new lot of felt and the old lot of felt are exposed to as representative as possible of a tissue sample. For the case of 1-ply tissue product, discard any product which might have been damaged or

abraded. Next, obtain 48 strips of tissue each two usable units (also termed sheets) long. Place the first two usable unit strip on the far left of the lab bench and the last of the 48 samples on the far right of the bench. Mark the sample to the far left with the number "1" in a 1 cm by 1 cm area of the corner of the sample. Continue to mark the samples consecutively up to 48 such that the last sample to the far right is numbered 48.

[0113] Use the 24 odd numbered samples for the new felt and the 24 even numbered samples for the old felt. Order the odd number samples from lowest to highest. Order the even numbered samples from lowest to highest. Now, mark the lowest number for each set with a letter "W." Mark the next highest number with the letter "N." Continue marking the samples in this alternating "W"/"N" pattern. Use the "W" samples for wire side out lint analyses and the "N" samples for non-wire side lint analyses. For 1-ply product, there are now a total of 24 samples for the new lot of felt and the old lot of felt. Of this 24, twelve are for wire side out lint analysis and 12 are for non-wire side lint analysis.

[0114] Rub and measure the Hunter Color L values for all 24 samples of the old felt as described below. Record the 12 wire side Hunter Color L values for the old felt. Average the 12 values. Record the 12 non-wire side Hunter Color L values for the old felt. Average the 12 values. Subtract the average initial un-rubbed Hunter Color L felt reading from the average Hunter Color L reading for the wire side rubbed samples. This is the delta average difference for the wire side samples. Subtract the average initial un-rubbed Hunter Color L felt reading from the average Hunter Color L reading for the non-wire side rubbed samples. This is the delta average difference for the non-wire side samples. Calculate the sum of the delta average difference for the wire side and the delta average difference for the non-wire side and divide this sum by 2. This is the uncorrected lint value for the old felt. If there is a current felt correction factor for the old felt, add it to the uncorrected lint value for the old felt. This value is the corrected Lint Value for the old felt.

[0115] Rub and measure the Hunter Color L values for all 24 samples of the new felt as described below. Record the 12 wire side Hunter Color L values for the new felt. Average the 12 values. Record the 12 non-wire side Hunter Color L values for the new felt. Average the 12 values. Subtract the average initial un-rubbed Hunter Color L felt reading from the average Hunter Color L reading for the wire side rubbed samples. This is the delta average difference for the wire side samples. Subtract the average initial un-rubbed Hunter Color L felt reading from the average Hunter Color L reading for the non-wire side rubbed samples. This is the delta average difference for the non-wire side samples. Calculate the sum of the delta average difference for the wire side and the delta average difference for the non-wire side and divide this sum by 2. This is the uncorrected lint value for the new felt.

[0116] Take the difference between the corrected Lint Value from the old felt and the uncorrected lint value for the new felt. This difference is the felt correction factor for the new lot of felt.

[0117] Adding this felt correction factor to the uncorrected lint value for the new felt should be identical to the corrected Lint Value for the old felt.

[0118] The same type procedure is applied to two-ply tissue product with 24 samples run for the old felt and 24 run for the new felt. But, only the consumer used outside layers of the plies are rub tested. As noted above, make sure the samples are prepared such that a representative sample is obtained for the old and new felts.

Care of 4-Pound (1.8 Kg) Weight

[0119] The four pound weight has four square inches of effective contact area providing a contact pressure of one pound per square inch. Since the contact pressure can be changed by alteration of the rubber pads mounted on the face of the weight, it is important to use only the rubber pads supplied by the manufacturer (Brown Inc., Mechanical Services Department, Kalamazoo, Mich.). These pads must be replaced if they become hard, abraded or chipped off.

[0120] When not in use, the weight must be positioned such that the pads are not supporting the full weight of the weight. It is best to store the weight on its side.

Rub Tester Instrument Calibration

[0121] The Sutherland Rub Tester must first be calibrated prior to use. First, turn on the Sutherland Rub Tester by moving the tester switch to the "cont" position. When the tester arm is in its position closest to the user, turn the tester's switch to the "auto" position. Set the tester to run 5 strokes by moving the pointer arm on the large dial to the "five" position setting. One stroke is a single and complete forward and reverse motion of the weight. The end of the rubbing block should be in the position closest to the operator at the beginning and at the end of each test.

[0122] Prepare a tissue paper on cardboard sample as described above. In addition, prepare a felt on cardboard sample as described above. Both of these samples will be used for calibration of the instrument and will not be used in the acquisition of data for the actual samples.

[0123] Place this calibration tissue sample on the base plate of the tester by slipping the holes in the board over the hold-down pins. The hold-down pins prevent the sample from moving during the test. Clip the calibration felt/cardboard sample onto the four pound weight with the cardboard side contacting the pads of the weight. Make sure the cardboard/felt combination is resting flat against the weight. Hook this weight onto the tester arm and gently place the tissue sample underneath the weight/felt combination. The end of the weight closest to the operator must be over the cardboard of the tissue sample and not the tissue sample itself. The felt must rest flat on the tissue sample and must be in 100% contact with the tissue surface. Activate the tester by depressing the "push" button.

[0124] Keep a count of the number of strokes and observe and make a mental note of the starting and stopping position of the felt covered weight in relationship to the sample. If the total number of strokes is five and if the end of the felt covered weight closest to the operator is over the cardboard of the tissue sample at the beginning and end of this test, the tester is calibrated and ready to use. If the total number of strokes is not five or if the end of the felt covered weight closest to the operator is over the actual paper tissue sample either at the beginning or end of the test, repeat this calibration procedure until 5 strokes are counted the end of the felt covered weight closest to the operator is situated over the cardboard at the both the start and end of the test.

[0125] During the actual testing of samples, monitor and observe the stroke count and the starting and stopping point of the felt covered weight. Recalibrate when necessary.

Hunter Color Meter Calibration

[0126] Adjust the Hunter Color Difference Meter for the black and white standard plates according to the procedures outlined in the operation manual of the instrument. Also run the stability check for standardization as well as the daily color stability check if this has not been done during the past eight hours. In addition, the zero reflectance must be checked and readjusted if necessary.

[0127] Place the white standard plate on the sample stage under the instrument port. Release the sample stage and allow the sample plate to be raised beneath the sample port.

[0128] Using the "L-Y", "a-X", and "b-Z" standardizing knobs, adjust the instrument to read the Standard White Plate Values of "L", "a", and "b" when the "L", "a", and "b" push buttons are depressed in turn.

Measurement of Samples

[0129] The first step in the measurement of lint is to measure the Hunter color values of the black felt/cardboard samples prior to being rubbed on the tissue. The first step in this measurement is to lower the standard white plate from under the instrument port of the Hunter color instrument. Center a felt covered cardboard, with the arrow pointing to the back of the color meter, on top of the standard plate. Release the sample stage, allowing the felt covered cardboard to be raised under the sample port.

[0130] Since the felt width is only slightly larger than the viewing area diameter, make sure the felt completely covers the viewing area. After confirming complete coverage, depress the L push button and wait for the reading to stabilize. Read and record this L value to the nearest 0.1 unit.

[0131] If a D25D2A head is in use, lower the felt covered cardboard and plate, rotate the felt covered cardboard 90 degrees so the arrow points to the right side of the meter. Next, release the sample stage and check once more to make sure the viewing area is completely covered with felt. Depress the L push button. Read and record this value to the nearest 0.1 unit. For the D25D2M unit, the recorded value is the Hunter Color L value. For the D25D2A head where a rotated sample reading is also recorded, the Hunter Color L value is the average of the two recorded values.

[0132] Measure the Hunter Color L values for all of the felt covered cardboards using this technique. If the Hunter Color L values are all within 0.3 units of one another, take the average to obtain the initial L reading. If the Hunter Color L values are not within the 0.3 units, discard those felt/cardboard combinations outside the limit. Prepare new samples and repeat the Hunter Color L measurement until all samples are within 0.3 units of one another.

[0133] For the measurement of the actual tissue paper/cardboard combinations, place the tissue sample/cardboard combination on the base plate of the tester by slipping the holes in the board over the hold-down pins. The hold-down pins prevent the sample from moving during the test. Clip the calibration felt/cardboard sample onto the four pound weight with the cardboard side contacting the pads of the weight. Make sure the cardboard/felt combination is resting flat against the weight. Hook this weight onto the tester arm and gently place the tissue sample underneath the weight/felt combination. The end of the weight closest to the operator must be over the cardboard of the tissue sample and not the tissue sample itself. The felt must rest flat on the tissue sample and must be in 100% contact with the tissue surface.

[0134] Next, activate the tester by depressing the "push" button. At the end of the five strokes the tester will automatically stop. Note the stopping position of the felt covered weight in relation to the sample. If the end of the felt covered weight toward the operator is over cardboard, the tester is operating properly. If the end of the felt covered weight toward the operator is over sample, disregard this measurement and recalibrate as directed above in the Sutherland Rub Tester Calibration section.

[0135] Remove the weight with the felt covered cardboard. Inspect the tissue sample. If torn, discard the felt and tissue and start over. If the tissue sample is intact, remove the felt covered cardboard from the weight. Determine the Hunter Color L value on the felt covered cardboard as described above for the blank felts. Record the Hunter Color L readings for the felt after rubbing. Rub, measure, and record the Hunter Color L values for all remaining samples.

[0136] After all tissues have been measured, remove and discard all felt. Felts strips are not used again. Cardboards are used until they are bent, torn, limp, or no longer have a smooth surface.

Calculations

[0137] Determine the delta L values by subtracting the average initial L reading found for the unused felts from each of the measured values for the wire side and the non-wire side of the sample. Recall, multi-ply-ply product will only rub one side of the paper. Thus, three delta L values will be obtained for the multi-ply product. Average the three delta L values and subtract the felt factor from this final average. This final result is termed the lint for the 2-ply product.

[0138] For the single-ply product where both wire side and non-wire side measurements are obtained, subtract the average initial L reading found for the unused felts from each of the three wire side L readings and each of the three non-wire side L readings. Calculate the average delta for the three wire side values. Calculate the average delta for the three non-wire side values. Subtract the felt factor from each of these averages. The final results are termed a lint unit for the non-wire side and a lint unit for the wire side of the single-ply product. By taking the average of these two values, an ultimate lint unit is obtained for the entire single-ply product.

[0139] D. Total Tensile

[0140] Insert the flat face clamps into the unit and calibrate the tester according to the instructions given in the operation manual of the Thwing-Albert Intelect II. Set the instrument crosshead speed to 4.00 in/min (10.2 cm/min) and the 1st and 2nd gauge lengths to 2.00 inches (5.1 cm). The break sensitivity should be set to 20.0 grams and the sample width should be set to 1.00 inch (2.54 cm) and the sample thickness at 0.025 inches (0.6 cm).

[0141] A load cell is selected such that the predicted tensile result for the sample to be tested lies between 25% and 75% of the range in use. For example, a 5000 gram load cell may be used for samples with a predicted tensile range of 1250 grams (25% of 5000 grams) and 3750 grams (75% of 5000 grams). The tensile tester can also be set up in the 10% range with the 5000 gram load cell such that samples with predicted tensiles of 125 grams to 375 grams could be tested.

[0142] Take one of the tensile strips and place one end of it in one clamp of the tensile tester. Place the other end of the paper strip in the other clamp. Make sure the long dimension of the strip is running parallel to the sides of the tensile tester.

[0143] After inserting the paper test strip into the two clamps, the instrument tension can be monitored. If it shows a value of 5 grams or more, the sample is too taut. Conversely, if a period of 2-3 seconds passes after starting the test before any value is recorded, the tensile strip is too slack.

[0144] Start the tensile tester as described in the tensile tester instrument manual. The test is complete after the crosshead automatically returns to its initial starting position. Read and record the tensile peak load in units of grams from the instrument scale or the digital panel meter to the nearest unit.

[0145] If the reset condition is not performed automatically by the instrument, perform the necessary adjustment to set the instrument clamps to their initial starting positions. Insert the next paper strip into the two clamps as described above and obtain a tensile reading in units of grams. Obtain tensile readings from all the paper test strips. It should be noted that readings should be rejected if the strip slips or breaks in or at the edge of the clamps while performing the test.

[0146] Unit of Measure: grams/inch per sample width (e.g. 1.0 inches (2.54 cm)); Total Dry Strength is the arithmetic sum of the MD+CD tensile

[0147] E. Measurement of Panel Softness of Tissue Papers

[0148] Ideally, prior to softness testing, the paper samples to be tested should be conditioned according to Tappi Method #T4020M-88. Here, samples are preconditioned for 24 hours at a relative humidity level of 10 to 35% and within a temperature range of 22° to 40° C. After this preconditioning step, samples should be conditioned for 24 hours at a relative humidity of 48 to 52% and within a temperature range of 22° C. to 24° C.

[0149] Ideally, the softness panel testing should take place within the confines of a constant temperature and humidity room. If this is not feasible, all samples, including the controls, should experience identical environmental exposure conditions.

[0150] Softness testing is performed as a paired comparison in a form similar to that described in "Manual on Sensory Testing Methods", ASTM Special Technical Publication 434, published by the American Society for Testing and Materials 1968 and is incorporated herein by reference. Softness is evaluated by subjective testing using what is referred to as a Paired Difference Test. The method employs a standard external to the test material itself. For tactile perceived softness two samples are presented such that the subject cannot see the samples, and the subject is required to choose one of them on the basis of tactile softness. The result of the test is reported in what is referred to as Panel Score Unit (PSU). With respect to softness testing to obtain the softness data reported herein in PSU, a number of softness panel tests are performed. In each test ten practiced softness judges are asked to rate the relative softness of three sets of paired samples. The pairs of samples are judged one pair at a time by each judge: one sample of each pair being designated X and the other Y. Briefly, each X sample is graded against its paired Y sample as follows:

[0151] 1. a grade of plus one is given if X is judged to may be a little softer than Y, and a grade of minus one is given if Y is judged to may be a little softer than X;

[0152] 2. a grade of plus two is given if X is judged to surely be a little softer than Y, and a grade of minus two is given if Y is judged to surely be a little softer than X;

[0153] 3. a grade of plus three is given to X if it is judged to be a lot softer than Y, and a grade of minus three is given if Y is judged to be a lot softer than X; and, lastly:

[0154] 4. a grade of plus four is given to X if it is judged to be a whole lot softer than Y, and a grade of minus 4 is given if Y is judged to be a whole lot softer than X.

[0155] The grades are averaged and the resultant value is in units of PSU. The resulting data are considered the results of one panel test. If more than one sample pair is evaluated then all sample pairs are rank ordered according to their grades by paired statistical analysis. Then, the rank is shifted up or down in value as required to give a zero PSU value to which ever sample is chosen to be the zero-base standard. The other samples then have plus or minus values as determined by their relative grades with respect to the zero base standard. The number of panel tests performed and averaged is such that about 0.2 PSU represents a significant difference in subjectively perceived softness.

[0156] E. Calculations

Geometric Mean

[0157] The values for geometric mean (GM) are determined by taking the square root of the product of the desired measured values. By way of non-limiting example, the GM of D×L is the square root of the product of D×L (dust×lint). Similarly, the GM of D×TT is the square root of the product of D×TT (dust×total tensile)

[0158] All results are in units of grams/inch. For purposes of this specification, the tensile strength should be converted into a "specific total tensile strength" defined as the sum of the tensile strength measured in the machine and cross machine directions, divided by the basis weight, and corrected in units to a value in meters.

EXAMPLES

[0159] Any suitable process for making fibrous structures, such as tissue paper products, known in the art may be used to form a fibrous web having substantially machine direction oriented linear channels in the present invention.

[0160] The following Example illustrates a non-limiting example for a preparation of a sanitary tissue product comprising a fibrous structure according to the present invention on a pilot-scale Fourdrinier fibrous structure making machine.

[0161] An aqueous slurry of Eucalyptus (Aracruz Brazilian bleached hardwood kraft pulp) pulp fibers is prepared at about 3% fiber by weight using a conventional repulper. This slurry is passed through a stock pipe toward a multi-layered, three-chambered headbox of a Fourdrinier wet laid papermaking machine.

[0162] Separately, an aqueous slurry of Eucalyptus fibers is prepared at about 3% by weight using a conventional re-pulper. This slurry is passed through a stock pipe toward the multi-layered, three-chambered headbox of a Fourdrinier wet laid papermaking machine.

[0163] Finally, an aqueous slurry of NSK (Northern Softwood Kraft) fibers of about 3% by weight is made up using a conventional re-pulper. This slurry is passed through a stock pipe toward the multi-layered, three-chambered headbox of a Fourdrinier wet laid papermaking machine.

[0164] In order to impart temporary wet strength to the finished fibrous structure, a 1% dispersion of temporary wet strengthening additive (e.g., Parez® 750) is prepared and is added to the NSK fiber stock pipe at a rate of about 3.0 lbs. per ton (1.36 Kg/908 Kg) of total fiber. The temporary wet strength agent is also added to each of the Eucalyptus thick stock pipe at a rate of about 0.5 lbs. per ton (0.23 Kg/908 Kg) of total fiber. The absorption of the temporary wet strengthening additive is enhanced by passing the treated slurry through an in-line mixer. The NSK and eucalyptus fiber slurries are diluted with white water at the inlet of their respective fan pumps to consistencies of about 0.15% based on the total weight of the respective slurries. The three slurries are spread over the width of the Fourdrinier, but maintained as separate streams in the multi-chambered headbox until they are deposited onto a forming wire on the Fourdrinier.

[0165] The fibrous structure making machine has a layered headbox having a top chamber, a center chamber, and a bottom chamber. The eucalyptus fiber slurry is pumped through the top headbox chamber, the eucalyptus fiber slurry is pumped through the bottom headbox chamber (i.e. the chamber feeding directly onto the forming wire) and, finally, the NSK fiber slurry is pumped through the center headbox chamber and delivered in superposed relation onto the Fourdrinier wire to form thereon a three-layer embryonic web, of which about 33% of the top side is made up of the eucalyptus blended fibers, 33% is made of the eucalyptus fibers on the bottom side and 33% is made up of the NSK fibers in the center. Dewatering occurs through the Fourdrinier wire and is assisted by a deflector and vacuum boxes. The Fourdrinier wire is of a 5-shed, satin weave configuration having 87 machine-direction and 76 cross-machine-direction monofilaments per inch, respectively. The speed of the Fourdrinier wire is about 750 feet (228.6 m) per minute (fpm).

[0166] The embryonic wet web is transferred from the Fourdrinier wire, at a fiber consistency of about 15% at the point of transfer, to a patterned drying fabric. The speed of the patterned drying fabric is the same as the speed of the Fourdrinier wire. The drying fabric is designed to yield a pattern of substantially machine direction oriented linear channels having a continuous network of high density (knuckle) areas. This drying fabric is formed by casting an impervious resin surface onto a fiber mesh supporting fabric. The supporting fabric is a 45×52 filament, dual layer mesh. The thickness of the resin cast is about 11 mils above the supporting fabric.

[0167] Further de-watering is accomplished by vacuum assisted drainage until the web has a fiber consistency of about 20% to 30%.

[0168] While remaining in contact with the patterned drying fabric, the web is pre-dried by air blow-through pre-dryers to a fiber consistency of about 65% by weight.

[0169] After the pre-dryers, the semi-dry web is transferred to the Yankee dryer and adhered to the surface of the Yankee dryer with a sprayed creping adhesive. The creping adhesive is an aqueous dispersion with the actives consisting of about 22% polyvinyl alcohol, about 11% CREPETROL A3025, and about 67% CREPETROL R6390. CREPETROL A3025 and CREPETROL R6390 are commercially available from Hercules Incorporated of Wilmington, Del. The creping adhesive is delivered to the Yankee surface at a rate of about 0.15% adhesive solids based on the dry weight of the web. The fiber consistency is increased to about 97% before the web is dry-creped from the Yankee with a doctor blade.

[0170] The doctor blade has a bevel angle of about 25 degrees and is positioned with respect to the Yankee dryer to provide an impact angle of about 81 degrees. The Yankee dryer is operated at a temperature of about 350° F. (177° C.) and a speed of about 750 fpm (228.6 m/min). The fibrous structure is wound in a roll using a surface driven reel drum having a surface speed of about 656 fpm (199.95 m/min). The fibrous structure may be subsequently converted into a two-ply sanitary tissue product having a basis weight of about 25.5 g/m^2. For each ply, the outer layer having the eucalyptus fiber furnish is oriented toward the outside in order to form the consumer facing surfaces of the two-ply sanitary tissue product. The resulting sanitary tissue paper product is very soft, flexible and absorbent.

Chemical Softening Agent Preparation

[0171] By way of non-limiting example, Karlinal (a quaternary ammonium compound that is a blend of cationic and nonionic surfactants in water (CAS #27344-41-8) and available from Calvary Industries 9233 Seward Road, Fairfield, Ohio) was provided at three specific percent active levels (0.25%, 0.30%, and 0.45%) in order to determine the optimum percent active level to achieve the target parametric variables. Karlinal at 0.45% active is generally the neat Karlinal as provided by the supplier. This solution was applied directly to the web substrate as provided by the supplier. Karlinal at 0.25% and 0.30% were prepared by dilution with water of the neat Karlinal solution. Water was added to the neat Karlinal in the following ratio to achieve the 0.25% active level: neat Karlinal—6250 ml, water—4750 ml. Water was added to the neat Karlinal in the following ratio to achieve the 0.30% active level: neat Karlinal—7500 ml, water—3500 ml. After the specific ratios of neat Karlinal and water were combined, the resulting solution was mixed by hand.

Application Methods

[0172] Extrusion coating (also known to those of skill in the art as slot die coating) is a liquid application method where a fluid, such as the Karlinal solution prepared supra, is forced through a die slot via a metering pump. The fluid is then transferred to a moving web through contact with the slot. Fluid add-on rates are controlled by varying the metering pump delivery rate.

[0173] Spray application is accomplished by the use of a spray header consisting of seven individual spray nozzles. Fluid, such as the Karlinal solution prepared supra, is forced through a manifold to each of the seven spray nozzles via a metering pump. Fluid flow out of the spray nozzles is aided by a steady flow of air. Additional streams of air are directed at the stream of fluid from the spray nozzle tips to atomize the fluid into small droplets. Fluid add-on rates are controlled by varying the metering pump delivery rate. Distribution of the small droplets of fluid across the web is controlled by varying the volume of air atomizing the fluid, and by varying the distance of the spray header to the web.

[0174] Tissue products produced by the above methods were measured for the parametric attributes discussed above. The resulting directly measured values and any resulting calculated values are provided in Tables 2 and 3 hereto.

TABLE 2

Raw Dust, Lint, Total Tensile, Geometric Mean (Dust × Lint, and Geometric Mean (Dust × Total Tensile) vs. Percent Solids - slot extrusion application

Solids Application %	Dust (# particles)	Lint	Dust/Lint	Total Tensile (g/in)	GM (D × L)	GM (D × TT)
0.25	4337	5.69	762.2	498.2	157.1	1470
0.25	4286	5.84	733.9	521.7	157.8	1495
0.30	3907	6.03	647.9	485.3	153.8	1377
0.45	4319	5.83	740.8	529.2	158.1	1512
0.45	4631	5.80	798.4	467.6	164.6	1471

TABLE 3

Raw Dust, Lint, Total Tensile, Geometric Mean (Dust × Lint, and Geometric Mean (Dust × Total Tensile) vs. Percent Solids - spray application

Solids Application %	Dust (# particles)	Lint	Dust/Lint	Total Tensile (g/in)	GM (D × L)	GM (D × TT)
0.25	4581	6.20	738.9	476.6	169.0	1478
0.25	4720	6.52	723.4	446.1	176.5	1451
0.30	4562	6.44	708.4	484.9	171.7	1487
0.30	4281	6.61	647.7	451.8	169.1	1391
0.45	4893	6.08	804.8	491.6	172.7	1551
0.45	4135	5.81	711.7	469.6	155.6	1394

[0175] The soft tissue paper having a substantively affixed chemical softening agent extruded thereon of the present invention preferably has the substantively affixed chemical softening agent extruded thereupon at a concentration (solids %) ranging from about 0.45% to about 0.23%, more preferably ranging from about 0.40% to about 0.29%, and most preferably at about 0.34%. The soft tissue paper having a substantively affixed chemical softening agent extruded thereon of the present invention preferably has a dust value of less than about 4557, more preferably ranges from about 4557 to about 3797, even more preferably from about 3956 to about 3797. Based upon the information provided in Tables 1 and 2, supra, the application of a substantively affixed softening agent to paper products of the present invention by extrusion of the chemical softening agent upon the surface of the paper product preferably provides a dust value that approximately satisfies the equation:

$$\text{Dust}=4069.8-(805.4\times\text{solids }\%)+(59446.3\times(\text{solids }\%-0.336)^2).$$

[0176] The soft tissue paper having a substantively affixed chemical softening agent extruded thereon of the present invention preferably has the substantively affixed chemical softening agent sprayed thereupon at a concentration (solids %) ranging from about 0.45% to about 0.25%, more preferably ranging from about 0.40% to about 0.30%, and most preferably at about 0.35%. The soft tissue paper having a substantively affixed chemical softening agent sprayed thereon of the present invention preferably has a dust value of less than about 4543, more preferably ranges from about 4543 to about 4318, even more preferably from about 4378 to about 4318. Based upon the information provided in Tables 1 and 2, supra, the application of a substantively affixed softening agent to paper products of the present invention by spray application of the chemical softening agent upon the surface of the paper product preferably provides a dust value that approximately satisfies the equation:

$$\text{Dust}=4803.9-(1388.9\times\text{solids }\%)+(25974.1\times(\text{solids }\%-0.336)^2).$$

[0177] The soft tissue paper having a substantively affixed chemical softening agent extruded thereon of the present invention preferably has a dust/raw lint value of less than about 808, more preferably ranges from about 808 to about 618, even more preferably from about 770 to about 618, yet more preferably ranging from about 671 to about 618, and most preferably ranging from about 651 to about 618. Based upon the information provided in Tables 1 and 2, supra, the application of a substantively affixed softening agent to paper products of the present invention by extrusion of the chemical softening agent upon the surface of the paper product preferably provides a value of dust per raw lint that approximately satisfies the equation:

$$\text{Dust/Raw Lint}=712.2-(276.4\times\text{solids }\%)+(14080.9\times(\text{solids }\%-0.336)^2).$$

[0178] The soft tissue paper having a substantively affixed chemical softening agent sprayed thereon of the present invention preferably has a dust/raw lint value of less than about 758, more preferably ranges from about 758 to about 665, even more preferably ranging from about 731 to about 665, yet more preferably ranging from about 691 to about 665, and most preferably ranging from about 678 to about 665. Based upon the information provided in Tables 1 and 2, supra, the application of a substantively affixed softening agent to paper products of the present invention by spray application of the chemical softening agent upon the surface of the paper product preferably provides a value of dust per raw lint that approximately satisfies the equation:

Dust/Raw Lint=692.6−(83.9×solids %)+(8010.3×(solids %−0.336)^2).

[0179] The soft tissue paper having a substantively affixed chemical softening agent extruded thereon of the present invention preferably has a geometric mean dust×total tensile (GM D×TT) value of less than about 1492, more preferably ranges from about 1492 to about 1343, even more preferably from about 1483 to about 1343, yet more preferably ranging from about 1381 to about 1343, and most preferably ranging from about 1377 to about 1343. Based upon the information provided in Tables 1 and 2, supra, the application of a substantively affixed softening agent to paper products of the present invention by extrusion of the chemical softening agent upon the surface of the paper product preferably provides a geometric mean of dust multiplied by total tensile strength value that approximately satisfies the equation:

$GM\ D{\times}TT$=1462.2−(347.7×solids %)+(14399.8×(solids %−0.336)^2).

[0180] The soft tissue paper having a substantively affixed chemical softening agent sprayed thereon of the present invention preferably has a geometric mean dust×total tensile (GM D×TT) value of less than about 1480, more preferably ranges from about 1480 to about 1432, even more preferably ranging from about 1472 to about 1432, yet more preferably ranging from about 1445 to about 1432, and most preferably ranging from about 1441 to about 1432. Based upon the information provided in Tables 1 and 2, supra, the application of a substantively affixed softening agent to paper products of the present invention by spray application of the softening agent upon the surface of the paper product preferably provides a geometric mean of dust multiplied by total tensile strength value that approximately satisfies the equation:

$GM\ D{\times}TT$=1452.1−(59.4×solids %)+(3635.0×(solids %−0.336)^2).

[0181] The soft tissue paper having a substantively affixed chemical softening agent extruded thereon of the present invention preferably has a geometric mean dust×lint (GM D×L) value of less than about 163, more preferably ranges from about 163 to about 153, even more preferably from about 161 to about 153, yet more preferably ranging from about 156 to about 153, and most preferably ranging from about 155 to about 153. Based upon the information provided in Tables 1 and 2, supra, the application of a substantively affixed softening agent to paper products of the present invention by extrusion of the softening agent upon the surface of the paper product preferably provides a geometric mean of dust multiplied by lint value that approximately satisfies the equation:

$GM\ D{\times}L$=152.2−(2.44×solids %)+(620.9×(solids %−0.336)^2).

[0182] The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact dimension and values recited. Instead, unless otherwise specified, each such dimension and/or value is intended to mean both the recited dimension and/or value and a functionally equivalent range surrounding that dimension nand/or value. For example, a dimension disclosed as "40 mm" is intended to mean "about 40 mm".

[0183] All documents cited in the Detailed Description of the Invention are, in relevant part, incorporated herein by reference; the citation of any document is not to be construed as an admission that it is prior art with respect to the present invention. To the extent that any meaning or definition of a term in this document conflicts with any meaning or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

[0184] While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

What is claimed is:

1. A tissue paper product having at least one ply, wherein only one outer surface of said tissue paper product has an aqueous chemical softening agent applied and substantially affixed thereto at a concentration ranging from about 0.45% to about 0.25%, said chemical softening agent providing said tissue paper product with a raw dispensing dust value, said raw dispensing dust value being less than about 4893.

2. The tissue paper product of claim **1**, wherein said raw dispensing dust value ranges from about 4893 to about 3907.

3. The tissue paper product of claim **1**, wherein said aqueous chemical softening agent is applied and substantially affixed to said at least one ply at a concentration ranging from about 0.30% to about 0.40%.

4. The tissue paper product of claim **3**, wherein said aqueous chemical softening agent is applied and substantially affixed to said at least one ply at a concentration of about 0.35%.

5. The tissue paper product of claim **3**, wherein said raw dispensing dust value is less than about 3907.

6. The tissue paper product of claim **1**, wherein said raw dispensing dust value is related to the concentration of said aqueous chemical softening agent applied and substantially affixed to said at least one ply by the equation:

Dust=4069.8−(805.4×solids %)+(59446.3×(solids %−0.336)^2)

Wherein:

Dust=raw dispensing dust value; and,

Solids %=concentration of aqueous chemical softening agent.

7. The tissue paper product of claim **6**, wherein said chemical softening agent is extruded upon said one outer surface of said tissue paper product.

8. The tissue paper product of claim **1**, wherein said raw dispensing dust value is related to the concentration of said aqueous chemical softening agent applied and substantially affixed to said at least one ply by the equation:

Dust=4803.9−(1388.9×solids %)+(25974.1×(solids %−0.336)^2)

Wherein:

Dust=raw dispensing dust value; and,

Solids %=concentration of aqueous chemical softening agent.

9. The tissue paper product of claim **8**, wherein said chemical softening agent is sprayed upon said one outer surface of said tissue paper product.

10. A tissue paper product having at least one ply, wherein only one outer surface of said tissue paper product has an aqueous chemical softening agent applied and substantially

affixed thereto at a concentration ranging from about 0.45% to about 0.25%, said chemical softening agent providing said tissue paper product with a raw dust per raw lint value, said raw dust per raw lint value being less than about 804.8.

11. The tissue paper product of claim **10**, wherein said raw dust per raw lint value ranges from about 804.8 to about 647.7.

12. The tissue paper product of claim **10**, wherein said aqueous chemical softening agent is applied and substantially affixed to said at least one ply at a concentration ranging from about 0.30% to about 0.40%.

13. The tissue paper product of claim **12**, wherein said aqueous chemical softening agent is applied and substantially affixed to said at least one ply at a concentration of about 0.35%.

14. The tissue paper product of claim **12**, wherein said raw dust per raw lint value is less than about 647.7.

15. A tissue paper product having at least one ply, wherein only one outer surface of said tissue paper product has an aqueous chemical softening agent applied and substantially affixed thereto at a concentration ranging from about 0.45% to about 0.25%, said chemical softening agent providing said tissue paper product with a geometric mean of dust×lint (GM D×L) value, said GM D×L value being less than about 176.5.

16. The tissue paper product of claim **15**, wherein said aqueous chemical softening agent is applied and substantially affixed to said at least one ply at a concentration of about 0.35%.

17. The tissue paper product of claim **15**, wherein said GM D×L value is related to the concentration of said aqueous chemical softening agent applied and substantially affixed to said at least one ply by the equation:

$$GM\ D\times L = 152.2 + (2.44 \times \text{solids}\ \%) + (620.9 \times (\text{solids}\ \% - 0.336)^2)$$

Wherein:

GM D×L=geometric mean of dust×lint value; and,

Solids %=concentration of aqueous chemical softening agent.

18. The tissue paper product of claim **17**, wherein said chemical softening agent is extruded upon said one outer surface of said tissue paper product.

19. The tissue paper product of claim **15**, wherein said GM D×L value is related to the concentration of said aqueous chemical softening agent applied and substantially affixed to said at least one ply by the equation:

$$GM\ D\times L = 183.5 - (43.75 \times \text{solids}\ \%) + (24.0 \times (\text{solids}\ \% - 0.336)^2)$$

Wherein:

GM D×L=geometric mean of dust×lint value; and,

Solids %=concentration of aqueous chemical softening agent.

20. The tissue paper product of claim **19**, wherein said chemical softening agent is sprayed upon said one outer surface of said tissue paper product.

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