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(54) **SYSTEM FOR CONTROL OF STICKIES IN RECOVERED AND VIRGIN PAPER PROCESSING**

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(57) **ABSTRACT**

Enhanced removal and/or control of adhesives or sticky materials, "stickies", from recovered paper stock or virgin pulp fibers is achieved using a combination of enzyme treatment with adsorbents and/or absorbents. Pulp stock to be treated is typically obtained from old magazines, newspapers, household waste, but may include corrugated boxes and office waste. Virgin pulps may include mechanical, chemical, or semi-chemical pulps. Enzymes typically include hydrolases such as cellulases, hemicellulases, pectinases, amylases, and lipases such as esterases, lyases such as pectate lyases, and oxidoreductases. Adsorbents include activated bentonite, microparticles, talc, clay and modified silica. Adsorbents typically include water soluble polymers, dispersants, coagulatants and agglomerants.

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Effect of Polymers and Bentonite on Stickies

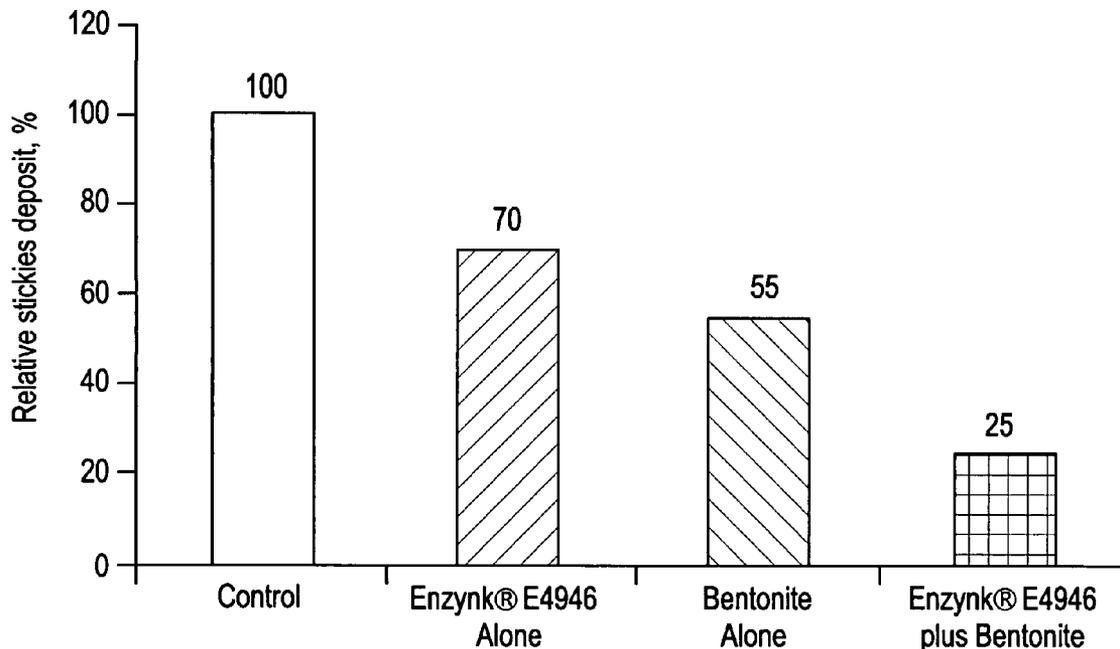


FIG. 1

Typical Recycling Plant Process Flow Sheet

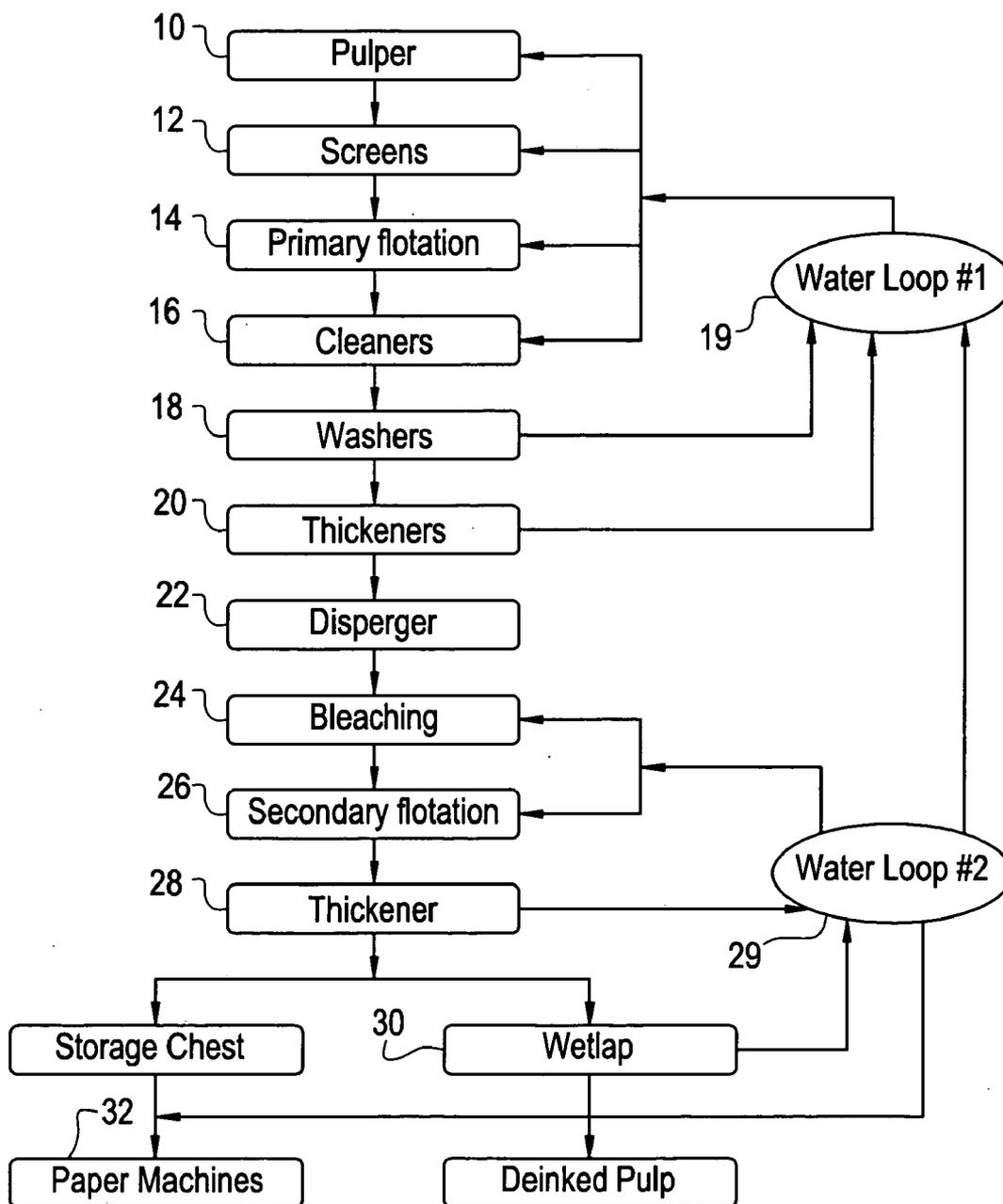


FIG. 2
Effect of Polymers and
Bentonite on Stickers

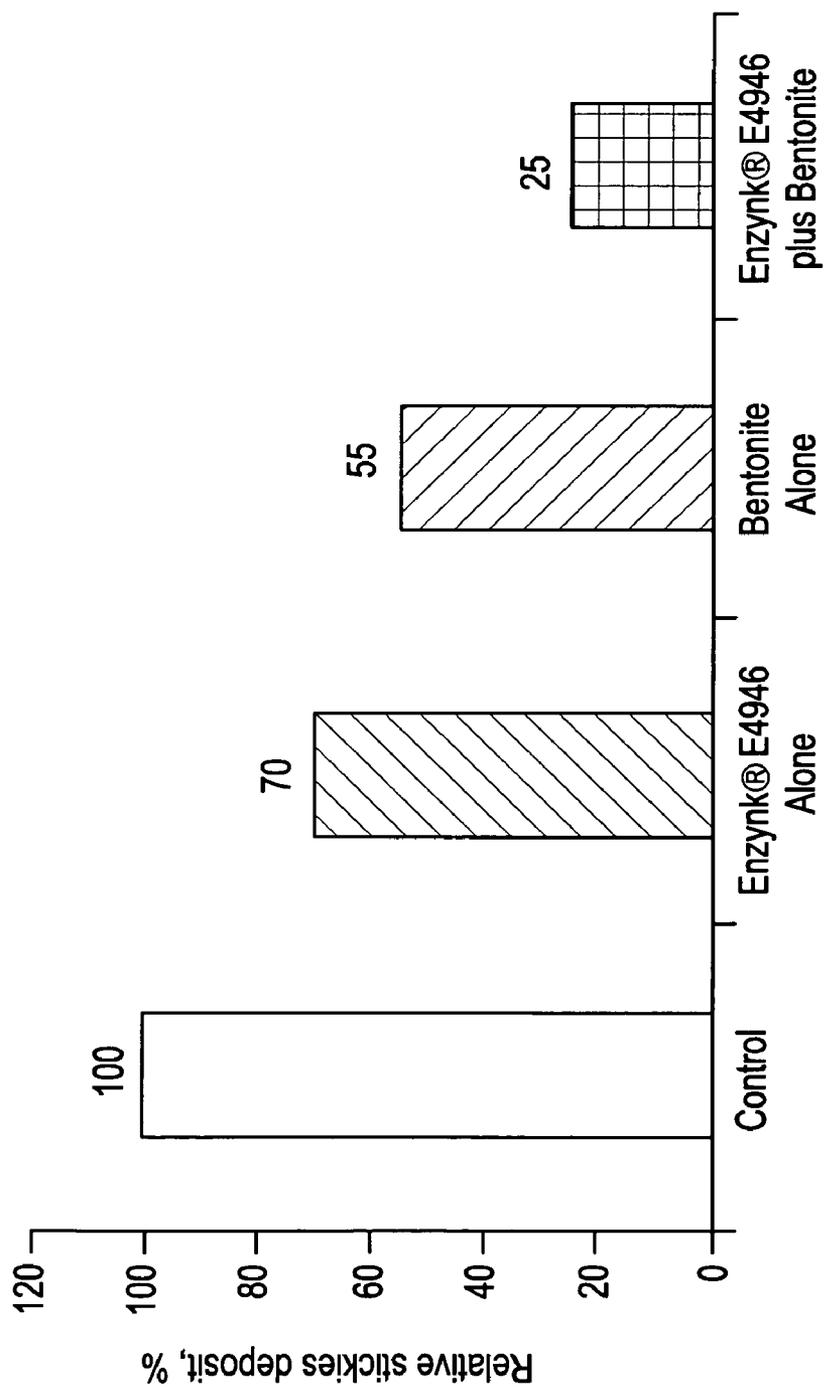
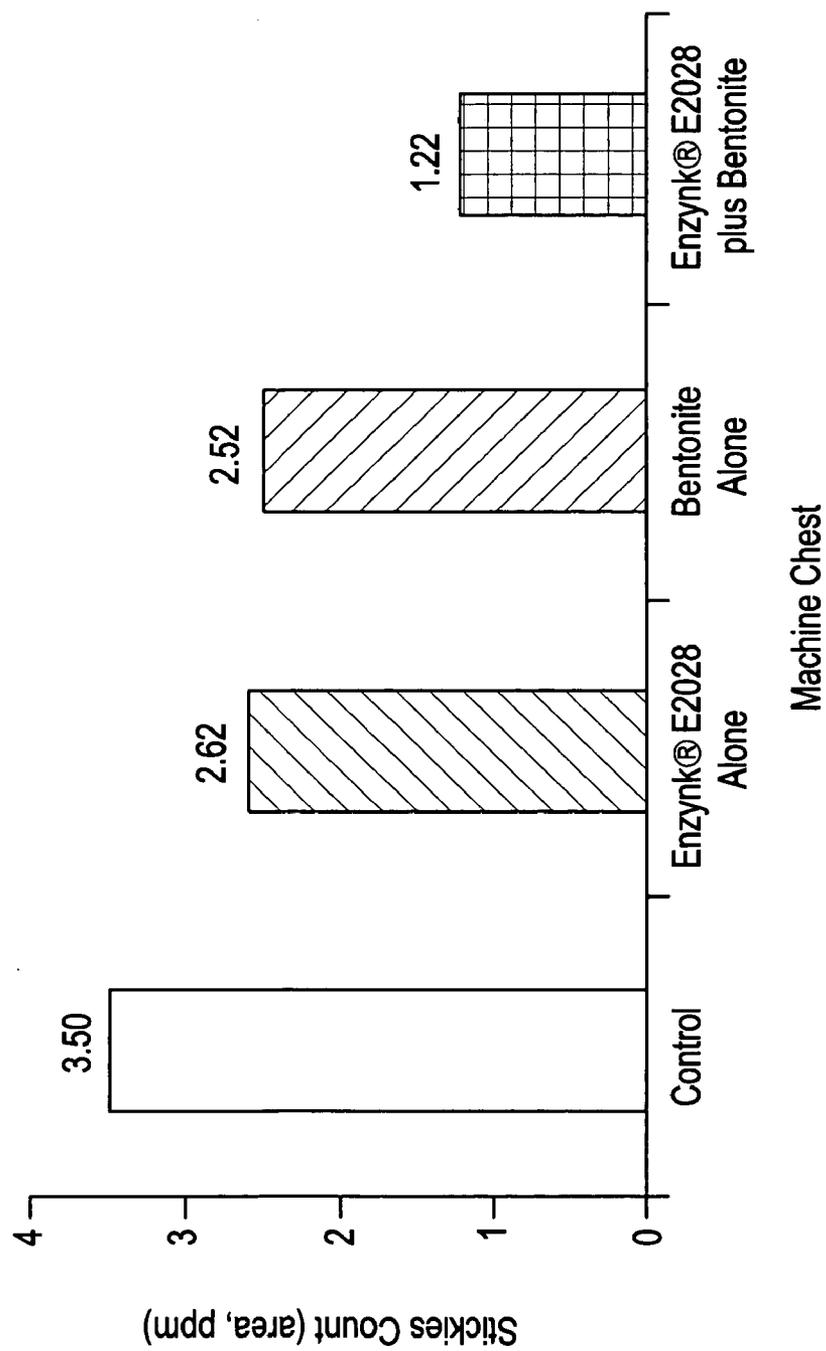


FIG. 3
Stickies Control
Application



SYSTEM FOR CONTROL OF STICKIES IN RECOVERED AND VIRGIN PAPER PROCESSING

BACKGROUND OF THE INVENTION

[0001] The present invention relates to paper making processes and more particularly relates to enhanced removal and the control of adhesive contaminants and stickies in recovered paper processing.

[0002] Conventional recycling of old paper products such as old newsprint, old corrugated containers, and mixed office waste is an important aspect of paper production today due to environmental demands that many paper grades have a portion of recycled fibers contained within the paper product. However, the recycling of the recovered paper generally requires additional processing steps in order to produce pulp, which is suitable for use in the final recycled paper product.

[0003] Conventional recycling of recovered paper to produce pulp comparable to that used to originally make the virgin sheet is known in the art as "de-inking," and typically involves pulping, soaking, screening, cleaning, washing, flotation, dispersion, thickening, and bleaching steps. Conventional recycling is usually conducted with surfactants, bleaching chemicals, chemicals for water treatment, and other polymeric treatments, and may use strong alkali treatments to solubilize insoluble contaminants. Generally, the first step in conventional recycling is to disassociate the paper into individual fibers with water to form a pulp slurry and to detach the ink and contaminants from the fibers, followed by removing ink and contaminants from the fibers by a combination of various process steps, such as screening, centrifugal cleaning, washing, dispersion, thickening, and flotation. The screening and centrifugal cleaning steps remove large contaminants, such as paperclips, staples, and plastics. The primary purpose of washing and flotation steps is to remove the ink and contaminants from the stock. Surfactants and alkaline agents such as caustic are added to facilitate the modification and separation of contaminants from the fibers. Alkaline agents may cause yellowing of the fibers, which must then be bleached. The fibers may or may not then be blended with virgin fibers and used in the papermaking process.

[0004] Recent developments in waste paper de-inking make use of enzymes to aid in the detachment and removal of inks and contaminants from the fibers. These processes describe the use of particular types of enzymes to facilitate ink removal without the negative effects of caustic treatment on brightness along with the use of flotation, washing, cleaning, and screening. In the past, chemical additives have been added to remove or make less problematic organic contaminants, known as "stickies." Stickies are generally adhesives, glues, hot melts, coatings, coating binders, ink residues, deinking chemicals, wood resins, rosin, pitch, and unpulped wet strength resins that typically are present with the fiber to be recycled. These organic contaminants typically must be removed or pacified in substantial quantities so that they do not detrimentally affect the subsequent processing steps in the deink plant, the paper machine, and with the printer or user of the final recycled sheet. Stickies have a broad range of glass transition temperatures and melting points and different degrees of tackiness depending upon the composition of the stickies. Temperature, pH, and compo-

sition can affect the tackiness of stickies. Recycled paper contains many components that, when repulped in recycled fiber plants, become stickies. Recycled furnishes may have as many as a dozen different types of stickies, each having its own characteristics. Sources of stickies may include any of the following: adhesives, glues, hot melts, coating binders, ink residues, deinking chemicals, wood resins, rosin, pitch, and wet strength resins. The actual tacky deposits found on paper machines may be a combination of several of these organic contaminants including fines, fibers, and ink particles as well as inorganic particles such as talc, clay, or calcium carbonate.

[0005] "Stickies" can generally be divided into two categories: synthetic and natural materials. Examples of synthetic materials include adhesives such as styrene-butadiene copolymer (SBR), polybutadiene (PBD), polyisoprene (PIP), polyacrylate, polyethylene (PE), and polypropylene (PP); hot melts such as waxes, resins, vinyl acrylates, and poly(vinyl acetate) (PVA); ink residues such as mineral oils, resin esters, alkyd resins, styrene-acrylates, polyacrylates, and epoxy acrylates; and wet-strength chemicals such as urea-formaldehyde and melamine-formaldehyde. Examples of natural materials include wood resins, resin and fatty acids or esters such as resin acids, fatty acids, and resin and fatty salts.

[0006] Stickies deposits on paper machine surfaces, fabrics, wires, felts, and rolls lead to problems such as wet end breaks, pressroom breaks, dryer section breaks, holes, sheet defects, high dirt counts, and difficulties in paper converting. These deposits and associated problems lead to a significant amount of downtime and waste. The cost of stickies is considerable, when factoring in the cost of downtime, chemical costs, production losses, scrap, rejected materials, and customer complaints.

[0007] Some mills control stickies by using wastepaper grades that contain less stickies. These grades are becoming more difficult to find and are sold at much higher prices. To manage the stickies present in the wastepaper, a number of different methods have been described for use in stickies control. The removal methods may be divided into two groups, mechanical methods such as cleaning, screening, and dispersion, and physicochemical methods such as flotation, washing, detackification, pacification, and coagulation and agglomeration. Stickies control strategies may use multiple approaches.

[0008] Screening typically removes larger or macro stickies (>1.0 mm²). Forward and reverse cleaners can be used based on density differences using centrifugal force. Forward cleaners remove contaminants heavier than water and reverse cleaners remove particles lighter than water. Cleaning removes more macro stickies than micro stickies. Flotation removes intermediate-size stickies (50-300 microns), which are troublesome because they are small enough to pass through screening and cleaning but too large to be removed by washing. In disperging, the stock is thickened, passing through a device at high temperature, pressure, and shear, which breaks organic contaminants, including stickies, into smaller pieces.

[0009] Physicochemical methods remove or control stickies by modifying the surface properties of stickies through either adsorption of adsorbents or addition of other chemicals or in combination, so that the stickies can be easily

removed or pacified. The methods include flotation, washing, addition of solid materials, treatment with surfactants and polymers.

[0010] For instance, in pacification, additives like talc, clay, nonionic organic polymers, other inorganic particles, and enzymes are used to render the stickies less tacky. Knudsen, et al., "Long-term Use of Enzymatic Deinking at Stora Dalum Plant, 7th International Conference on Biotechnology, in the Pulp Paper Ind., vol. A, June 1998, p. 1-4, generally refers to the use of enzymes to reduce stickies in recovered paper. Sykes, et al., "Enzymatic Removal of Stickie Contaminants" Pulping Conf. 1997, pp. 687-691 describes the use of cellulase, lipase or a mixture thereof to reduce stickies contaminants. See also Wong and Mansfield "Enzymatic processing for pulp and paper manufacture" APPITA J. 52(6):409-418 (1999) and U.S. Pat. No. 6,471,826. At various stages of the recycling process, dispersants, surfactants, and solvents are used to make stickies smaller. Some other approaches use chemicals to agglomerate the stickies to enhance their removal though stages such as screening. Still other chemical treatments aim to make the stickies more hydrophobic to enhance removal through flotation or more hydrophilic to enhance their removal through washing. With fixation treatments, the stickies are attached to the paper sheet by using a water soluble polymer, which adds charge to the stickies particles.

[0011] With dispersing and fixation treatments, a dispersant is added first to reduce the size of the stickies and then a cationic polymer is used to fix the stickies onto the sheet. With passivation, the use of dispersants, solvents, and low molecular weight cationic polymers makes the paper machine less susceptible to stickies.

[0012] Unfortunately, even with the best of all of these methods, too many of the stickies are still present in the final product to avoid problems.

[0013] It is therefore an object of the present invention to provide enhanced stickies removal and control from recycled paper systems and virgin fiber processing.

SUMMARY OF THE INVENTION

[0014] Enhanced removal and/or control of adhesives materials, "stickies", from recovered or recycled paper stock and virgin fiber processing is achieved using a combination of enzyme treatment with adsorbents and/or absorbents. Recovered paper stock to be treated is typically obtained from old magazines, newspapers, home waste or office waste, but may include corrugated cardboard boxes and other sources of recovered fiber. Enzymes typically include hydrolases such as cellulases, hemicellulases, amylases, proteases, β -glucosidase, lipases, esterases, and pectinases, lyases such as pectate lyase and oxidoreductases such as laccase, glucose oxidase, and peroxidases. Individual enzymes or any combinations of different varieties may be applied together with adsorbents or adsorbents. Adsorbents include bentonite, both activated and non-activated, micro-particles, talc, clay and modified silica gel. Absorbents typically include water soluble polymers, which can be either cationic or anionic. Dispersants may also be used.

[0015] Waste paper is initially treated in a pulper to make a slurry, which is screened mechanically and/or cleaned centrifugally and/or passed through a washer, flotation pro-

cess, or a disperger to remove large pieces. Enzymes may be added in the pulper or later in the system, including before the paper machine. Exemplary stages where enzymes may be applied include the dump chest, soaking tanks, flotation, washer, water treatment, and storage chests. Preferably the enzymes are selected so that they have optimal activity at the pH and temperature range where the pulp is to be treated. In the preferred embodiment, the adsorbent/absorbent is added to the pulp slurry, preferably in a 1%-5% slurry by weight at a dosage of between about 0.05 to 2.0% of solids per air dried ton of wastepaper. The adsorbent/absorbent can be added to the pulper, dump chest, flotation or washer, bleaching, disperger, water clarifier, prior to the paper machine, or prior to or in any stock storage tank. Good mixing is preferred to insure that the material is thoroughly mixed with the stock and that stickies come in contact with the enzymes, adsorbents and or adsorbents.

[0016] Examples demonstrate significantly more reduction with the combination of enzymes and adsorbents or absorbent, than treatment with either alone and is significantly more than an additive result.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a schematic of an example mill flow sheet showing points at which enzymes and adsorbent/absorbent can be added.

[0018] FIG. 2 is a graph of stickies count (relative stickies deposit, %), for a control test (100% is the stickies level with normal mill processing), enzyme treatment alone ("Enzynk® E4946"), activated bentonite treatment alone, and the combined enzyme treatment plus activated bentonite ("Enzynk® E4946 plus bentonite"). The furnish treated was a 60/40 blend of US mixed office white ledger waste and office pack. Treatment was made under highly controlled laboratory conditions. Stickies tests were made from mixing identical quantities of stock at 8% consistency in a Kitchen Aid mixer for 60 minutes followed by visual examination of the deposits on the mixer blades. The analysis is measured on the percent coverage of the leading blade by stickies.

[0019] FIG. 3 is a graph of the stickies count (area, ppm) for a control test, enzyme treatment alone ("Enzynk® E2028"), activated bentonite treatment alone, and the combined enzyme treatment plus activated bentonite ("Enzynk® E2028 plus bentonite"). A dosage of 1.5 kg Enzynk® E2028 per ton of wastepaper and 4.0 kg bentonite per ton mixed office wastepaper were added in the pulper. Analyses consisted of light microscope examination of filtrate of machine chest stock after having been passed through a machine fabric.

DETAILED DESCRIPTION OF THE INVENTION

[0020] A method to enhance removal and control of stickies from fibers has been developed. The fibers are typically cellulose fibers and more typically are recycled fibers from a variety of paper products or fiber containing products, such as old corrugated containers (OCC), old newsprint (ONP), mixed office waste (MOW), household waste (HW), other recovered paper varieties, or combinations thereof. These types of paper containing products typically include significant amounts of organic contaminants that are sticky in nature. When these types of paper products are recycled,

sticky organic contaminants are present along with the fibers during the pulping stage of a papermaking process. These organic contaminants, if not substantially removed or pacified, can severely interfere with the subsequent stages in the papermaking process or with the enduser by affecting the quality of the resulting sheets of paper formed and/or affecting the machinery used to produce the paper. Accordingly, the removal or pacification of such organic contaminants is important to the paper making process when such organic contaminants are present in fibers.

[0021] Examples of organic contaminants that are known in the industry as "stickies" include, but are not limited to, synthetic polymers resulting from adhesives, glues, hot melts, coatings, coating binders, ink residues, de-inking chemicals, wood resins, rosin, and wet strength resins. These types of materials are typically found in paper containing products, such as newsprint, corrugated containers, household waste, and/or mixed office waste. These organic contaminants typically will have polymers present, such as styrene butadiene rubber, vinyl acrylates, polyisoprene, polybutadiene, natural rubber, ethyl vinyl acetates, polyvinyl acetates, ethylvinyl alcohols, polyvinyl alcohols, styrene acrylates, and other synthetic types of polymers.

[0022] The enhanced removal is achieved through a combination of (1) enzyme treatment, using one or more enzymes and (2) treatment with adsorbent and/or absorbant.

[0023] As used herein, enhanced removal, pacification and/or control of stickies refers to a reduction in the size of particles and/or a reduction of the number or amount of measurable particles present, and/or a reduction of the tackiness of the organic contaminants.

[0024] Measurement of stickies can be done through many procedures. One procedure uses a fine slotted screen, such as a Pulmac Master Screen, to screen out large contaminants and then use multiple methods to separate and measure the stickies components. One such method uses heat and/or pressure to press the rejected contaminants against a surface, such as a sheet or clear overhead transparency such that the stickies are transferred to the sheet or transparency and the stickies can be counted manually or through image analysis. Variants on this approach use dyes to color the stickies prior to counting or scanning. A vibrating slotted screen, such as a Summerville Screen, can also be used to separate the contaminants from the stock. Still other tests use powders, either dark or light in color, which are transferred to the sticky reject contaminants with the resulting powder stuck on the stickies being scanned for area. Microscopic techniques can also be used to measure microstickies, such as visual inspection of pulp stock filtrates with an assessment by particle size of stickies viewed by light microscope. Stickies counts are usually measured as count or ppm area per fixed quantity of pulp (e.g., per 100 g air dried fiber).

I. Compositions and Systems for Reduction in Stickies

[0025] Compositions for removal or reduction in stickies are typically sold as a two component treatment system including at least two components: one or more enzymes and adsorbents/absorbents. Treatment systems may include other additives. Materials will typically be shipped together, but packaged separately, for administration in the appropriate amounts and in the optimal forms at different stages in the processing. For example, many of the inorganic mate-

rials are best added in low consistency slurries, so they are typically shipped to mills as a dry product. A typical process is depicted in FIG. 1.

[0026] A. Enzymes

[0027] Enzymes are used to modify stickies particles. Representative examples of useful enzymes include esterases, lipases, hydrolases such as cellulases, hemicellulases, amylases, pectinases, β -glucosidases, and proteases, lyases such as pectin lyase, and oxidoreductases such as laccases, glucose oxidases, and peroxidases, typically added in an amount of between 0.0005% and 0.5% based on air dried ton of fiber, more preferably between about 0.0025 and 0.25% based on air dried ton of fiber. These are commercially available from a number of different suppliers.

[0028] Lipases can be derived or isolated from pancreatic sources (e.g., pancreatic lipase) or from various fungi and/or bacteria, and/or other microorganisms. Examples include triacylglycerol acylhydrolase and triacyl glycerol lipase, lipases and esterases capable of hydrolyzing triglycerides to glycerol and fatty acids. Enzymes can be obtained from Enzymatic Deinking Technologies, Norcross, Ga., USA. Commercially available products containing esterase or lipase can be used such as Buzyme.RTM 2515 and Buzyme.RTM 2517, available from Buckman Laboratories International, Inc. Products containing such enzymes as Resinase A2X, Novocor ADL, Pancreatic Lipase 250, Lipase G-1000, Greasex 50L, and Greasex 100L products are available from such commercial sources as Genencor and Novo Nordisk. Esterases and lipases are described in U.S. Pat. Nos. 5,507,952 and 5,356,800. The esterase and lipase compositions can also be stabilized compositions using the formulations described in U.S. Pat. Nos. 5,356,800 and 5,780,283.

[0029] Enzymes can generally be used in any form, such as liquid form or solid form. They can either be added to the pulper in a preferred embodiment or later in the deink plant system, or even in the chest prior to the paper machine. Preferably, the amount of esterase, other lipase, other hydrolyase, or other enzyme variety used in the methods is in a sufficient amount to control the organic contaminants present in the fiber. Individual enzymes or any blends of these enzymes may be applied in an amount of between 0.0005% and 0.50% based on air dried fibers, preferably between 0.0025% and 0.25%, and most preferably between 0.05% to 0.15% based on air dried fibers, in an amount of sufficient quantity to provide a meaningful degree of reaction with the targeted substrate. Other enzymes used in this method such as other hydrolases and other enzyme varieties can be added in similar points of the process, individually or in any combination with esterases such as lipases. Enzyme application on virgin stock to control natural stickies can be made in one of several storage tanks in which the pulped stock is held or prior to the paper machine.

[0030] B. Adsorbents and Absorbents

[0031] A variety of different adsorbents and absorbents can be used. The difference between adsorbents and absorbents can be determined when a material extracts one or more substances from a fluid (gas or liquid) medium on contact. If the material undergoes any physically and/or chemical changes or both, it is an absorbent; otherwise it is an adsorbent. Both absorbent and adsorbent are usually

porous solids, which take another material into its interior resulting from contact. The mechanism of an absorbent is to encapsulate the stickies particles within crevices of the absorbent for the purpose of covering the sticky surface or binding the stickies particles with a material that is hydrophobic or hydrophilic and would enhance the removal of the stickies contaminant. Adsorbents are used to attach to the stickies particles for similar purposes of covering part of the sticky surface or making a stickies/adsorbent complex that is more hydrophobic or hydrophilic or otherwise easier to handle with mill equipment. Preferred materials have a high surface area. These may be in the form of powders, particles, gels, beads or microparticles, and added in dry form or as a liquid slurry.

[0032] The most preferred materials are clay, bentonite, silica gel or colloidal silica, and talc. Acid or alkaline activated bentonite having a high surface area of 400-1000 m²/gram or more is most preferred. Modified silica beads are also preferred. In both cases the adhesives enter and bind into the crevasses and are encapsulated within the materials. Materials such as talc tend to bind the adhesives on their surfaces.

[0033] These materials are usually added as a water slurry, typically of 0.05% to 10.0% consistency in water and more typically between 1.0% and 5% consistency in water. Dosing of the absorbent or adsorbent is expressed in weight of absorbent or adsorbent to air dried stock and is in the range of 0.005% to 5.0%, more preferably 0.05% to 3.0%, and most preferably 0.10% to 1.5%.

[0034] C. Other Additives

[0035] Water soluble polymers such as a cationic water soluble polymer can be used to attach the stickies to a substrate for removal. Examples of such polymers include epichlorohydrin/dimethylamine polymers (EPI-DMA) and cross-linked solutions thereof, polydiallyl dimethyl ammonium chloride (DADMAC), DADMAC/acrylamide copolymers, and ionene polymers. Examples of ionene polymers include those set forth in U.S. Pat. Nos. 5,681,862, 5,575,993, and 5,256,252. The polymer can be used in any amount and preferably in dosage ranges of from about water soluble polymer added in a dosage range of from about 0.1 to 1000 ppm, more preferably 1.0 to 100 ppm, and most preferably 2.5 to 10 ppm.

[0036] Other materials include dispersants such as surfactants which could include, but are not limited to, soaps, fatty acid alkoxylates, fatty alcohol alkoxylates, and EO/PO polymeric surfactants. Other conventional paper treatment chemicals or ingredients such as solvents, suspension aids, fillers, chelants, preservatives, buffers, water, and stabilizers can also be added during processing.

II. Methods of Treatment

[0037] Each mill may utilize a different process, depending on the material to be recycled, nature of the problem, water loops, age of plant, end use, and goals from the treatment. Individual enzymes or a blend of any combinations of enzymes may be applied with or without the absorbents or adsorbents. A typical mill scheme is shown in FIG. 1. As shown in FIG. 1, pulp is created in a pulper 10, passed through screens 12, optionally through a primary flotation 14 and cleaners 16, then washers 18, thickeners 20, then disperger 22, then bleaching 24, optionally a secondary

flotation 26, thickener 28, then a wet lap machine 30 or in the case of integrated use, through a storage chest 32 and then on to the paper machine. Water from the dewatering stages may pass through water clarification such as a dissolved air flotation unit 19 and 29.

[0038] Enzymes are typically added into the pulper 10, which is used to mix the enzymes thoroughly through the pulp and utilize the time in the pulper and the time in the dump chest for the reaction of the enzymes. Typical pulping cycles may take up to 60 minutes and mixing time in the subsequent dump chest may be up to 240 minutes. Enzymes typically include hydrolases, lyases, and oxidoreductases. Individual enzyme or any combinations of them may be applied together with absorbents or adsorbents. Hydrolases include cellulases, β -glucosidases, hemicellulases, pectinases, amylases, proteases, and esterases and other lipases, which may break down poly (vinyl acetate) types of stickies materials. Lyases include pectate lyases, which may break down the pectin types of materials holding the stickies particles together, or break the stickies particles free from fines. Oxidoreductases include laccases, peroxidases, which may modify other impurities attached to stickies particles and make the stickies particles more hydrophobic or hydrophilic or free from fibers and/or fines in order to enhance either the stickies removal or make them less troublesome to paper recycling or papermaking processes. These enzymes may be applied individually or in any combinations and the treatment time be from 1 minute to 16 hours, preferably 10 minutes to 4 hours and most preferably 30 minutes to 60 minutes. The enzymatic treatment pH may be in a range of between 3.5 to 12.0, and preferably between 4.5 and 9.5. The temperature of enzymatic treatment may be in a range of between 35° C. and 90° C., and preferably between 40 to 75° C. The dosage of enzymes may be from 0.0005% to 0.50% based on air dried fibers, more preferably from 0.0025% to 0.25%, and most preferably from 0.05% to 0.15% based on air dried fibers.

[0039] Enzymes can also be introduced prior to the pulping stage, typically by spraying or other means, onto the paper containing product which is going to be introduced into the pulper. Also, or alternatively, the enzymes can be present or introduced into the pulper during the pulping stage which can be by any conventional pulping technique such as mechanical pulping or chemical pulping for virgin fibers and batch, semi-batch or continuous pulpers for recycled fiber treatments, or combinations thereof. The enzymes can be introduced or brought into contact at any stock storage chest, other holding tank, or prior to the flotation deinking stage. In one embodiment, the enzymes are introduced after the flotation stage and prior to a washing stage. In another embodiment enzymes are applied prior to fine screens, and in another embodiment enzymes are applied before the paper machine. The composition can also be administered into the paper machine white water or in the makeup water in the deinking plant. Alternatively, the enzymes can be applied in the water treatment loops of virgin or recycling mills to treat stickies in the water filtrates.

[0040] Absorbent and/or adsorbent is added to the pulper, dump chest—flotation cells or mixing cells, washer, bleaching storage chest disperger, in the water treatment process, and in tanks holding the final product or prior to the paper machine. Material is mixed such that the absorbent/adsorbent achieves a suitable coverage of the stock and stickies

particles. Longer residence time after the materials are mixed with the stock can be helpful, but is not necessary. The absorbents and/or adsorbents may be applied before, after and/or together with enzymatic treatment. The dosage of the adsorbents and/or absorbents is between 0.005% and 5.0%, more preferably between 0.05% and 3.0%, and most preferably between 0.10% and 1.5% based on air dried fibers. The stock pH may be between 3.5 to 12.0, and preferably between 4.5 and 9.5. There is no limit on the application temperature of absorbents and/or adsorbents into the recycling process.

[0041] The introduction of these materials can be immediate, slow release, timed release, intermittent, and/or continuous. Adsorbents/Absorbents can remain with the material as it is processed, since the stickies are trapped and no longer freely distributed within the fiber slurry to be processed.

[0042] Typically, the remaining aspects of the papermaking operation as is known to those skilled in the art can be used in order to produce paper products. Thus, the conventional additive materials used with paper making pulps during stock preparation and papermaking can be used as well as the combination of enzymes and absorbents/adsorbents for stickies reduction. Continuous or non-continuous paper making machines can then convert aqueous suspensions of fibers and other ingredients into dry sheets of paper using such conventionally known operations which involve Fourdrinier machines or cylinder machines or other papermaking devices. Subsequent treatments of the sheets of paper to achieve the desired characteristics such as machine calendaring and/or coating of the paper sheets can be used following treatment.

[0043] The present invention will be further understood by reference to the following non-limiting examples.

Example 1

Comparison of Treatment with Enzyme Alone, Absorbent Alone, and Enzyme in Combination with Absorbent Under Controlled Conditions

[0044] A comparative study was conducted to look at stickies removal using enzymes (Enzynk® E4946, a mixture of acid and neutral cellulases, amylases, and lipases obtained from Enzymatic Deinking Technologies, LLC, Norcross, Ga. USA) treatment alone, activated bentonite treatment alone, and the combination of enzymes and activated bentonite treatment, in the laboratory in a Kitchen Aid mixer under highly controlled conditions of temperature, time (one hour), dosage, mixing conditions, and stickies.

[0045] The furnish treated was a 60/40 blend of US mixed office white ledger waste and office pack. A 1.5 kg quantity of the furnish was pulped in a high consistency pulper. Stickies were contributed from the waste paper plus an additional amount was added to ensure the batch contained a high quantity of stickies. Stickies added were 1 page of Avery Labels (#5160), 5 pieces of C-Line Products Border Badges, 10 pieces of 3M Post-It Notes, and 5 pieces of 3M Post-It Fax Pads. Both the enzymes and the bentonite were added with the wastepaper at the beginning of the pulping process.

[0046] The results are shown in **FIG. 2**. Using the amount of stickies remaining without additional treatment as 100%,

a reduction of 30% was obtained using enzyme treatment only and a reduction of 45% was obtained using bentonite treatment only. The combination removed 75% of the stickies, a result not predictable based on the use of either treatment alone.

Example 2

Large Scale Study Comparing Enzyme Treatment Alone, Absorbent Alone, and the Combination of Enzyme and Absorbent

[0047] This study was conducted at a waste paper processing mill under normal processing conditions. Materials were added at the pulper. 1.5 kg Enzynk® E2028 was added per ton wastepaper and 4.0 kg EnzAid® A3300 (activated bentonite) was added per ton mixed office wastepaper. The Enzynk® E2028 is a mixture of acid and neutral cellulases, amylases, and lipases and the EnzAid® A3300 is an activated bentonite treatment. Enzymes and bentonite were added at the pulper. Analyses consisted of light microscope examination of filtrate of machine chest stock after having been passed through a machine fabric.

[0048] As shown in **FIG. 3**, the stickies count (area, ppm) is significantly reduced by enzyme treatment alone and by bentonite treatment alone, from 3.50 to 2.62 and 2.52, respectively. However, treatment with the combination of enzyme and adsorbent provides an even more striking reduction as measured in the machine chest, from 3.50 with no treatment to 1.22 with the combination treatment. This degree of reduction could not have been predicted based on the results obtained with the individual treatments.

[0049] Modifications and variations of the present invention will be obvious to those skilled in the art from the foregoing detailed description and are intended to come within the scope of the following claims. All references cited herein are specifically incorporated by reference.

We claim:

1. A method for enhancing removal of or controlling adhesives and sticky contaminants in paper processing comprising

providing or contacting with waste paper or mill process water, in combination,

(a) an effective amount of one or more enzymes to modify or degrade the stickies particles, coatings, fibers or inks and

(b) one or more absorbents or adsorbents to absorb or adsorb to the stickies particles for improved removal or control of sticky contaminants in the paper making process.

2. The method of claim 1 wherein the enzymes and absorbents or adsorbents also improve dirt count or brightness.

3. The method of claim 1 wherein the enzymes are selected from the group consisting of hydrolases, lyases and oxidoreductases.

4. The method of claim 3 wherein the enzymes are selected from the group consisting of cellulases, hemicellulases, amylases, proteases, β -glucosidases, lipases, esterases, pectinases, pectate lyases, laccases, glucose oxidases, and peroxidases.

5. The method of claim 1 wherein the individual enzymes or any blends of these enzymes are applied in an amount of between 0.0005% and 0.50% based on air dried fibers, preferably between 0.0025% and 0.25%, and most preferably between 0.05% to 0.15% based on air dried fibers to react with the targeted substrate.

6. The method of claim 1 wherein the adsorbents and absorbents are selected from the group consisting of inorganic and organic particles, natural or synthetic.

7. The method of claim 1 wherein the adsorbents and absorbents are selected from the group consisting of talc, bentonite, silica, and clay.

8. The method of claim 7 wherein the adsorbents or absorbents are activated bentonite having a surface area of greater than 400 m²/gram.

9. The method of claim 1 wherein the absorbents or adsorbents are in the form of microparticles having particle sizes from 100 nm to 40 microns or specific surface areas from 1 m²/g to 2,000 m²/g.

10. The method of claim 6 wherein the inorganic substances are selected from the group consisting of silicate-linked minerals, carbonate-based minerals, and combinations thereof.

11. The method of claim 6 wherein the organic microparticles are selected from the group consisting of cross-linked polymers of cationic, anionic or nonionic nature, having molecular weight from 5,000 to 2,000,000 daltons.

12. The method of claim 10 wherein silicate-based minerals are selected from the group consisting of bentonite, montmorillonite, talc, and clay.

13. The method of claim 10 wherein carbonate-based minerals are selected from the group consisting of calcium carbonate, magnesium carbonate, and dolomite, natural or synthetically precipitated.

14. The method of claim 1 wherein the enzymes are added to the pulper, dump chest, flotation, washer, water treatment, storage chest, machine chest, or other parts of the stock preparation process.

15. The method of claim 1 wherein the absorbent or adsorbent are added as a dry powder or as a slurry.

16. The method of claim 1 wherein adsorbent or adsorbent is added at a dosage of between 0.005% and 5.0% based on air dried fiber, more preferably between 0.05% and 3.0%, and most preferably between 0.10% and 1.5% based on air dried fiber.

17. The method of claim 1 wherein adsorbent or adsorbent is bentonite and is added as a slurry in a concentration of between 0.05% and 10.0%, preferably between 1.0% and 5.0%.

18. The method of claim 1 further comprising one or more materials selected from the group consisting of water soluble polymers, dispersants, solvents, suspension aids, fillers, chelants, preservatives, buffers, water, and stabilizers.

19. The method of claim 18 wherein the water soluble polymer is a cationic water soluble polymer selected from the group consisting of epichlorohydrin/dimethylamine polymers (EPI-DMA) and cross-linked solutions thereof, polydiallyl dimethyl ammonium chloride (DADMAC), DADMAC/acrylamide copolymers, and ionene polymers.

20. The method of claim 18 wherein the material is a water soluble polymer added in a dosage range of from about 0.1 to 1000 ppm, more preferably 1.0 to 100 ppm, and most preferably 2.5 to 10 ppm.

21. The method of claim 18 wherein the material is a surfactant selected from the group consisting of soaps, fatty acid alkoxylates, fatty alcohol akloxyates, and EO/PO polymeric surfactants.

22. A system for enhancing removal of or controlling adhesives and sticky contaminants in paper processing comprising a kit containing an effective amount of a combination of enzymes and absorbent or adsorbents to modify or degrade the stickies particles, coatings, fibers or inks.

23. The system of claim 22 further comprising instructions on how to treat paper with both enzymes and adsorbents or absorbents.

24. The system of claim 22 wherein the enzymes are selected from the group consisting of hydrolases, lyases and oxidoreductases in an amount of between 0.0005% and 0.50% based on air dried fibers, preferably between 0.0025% and 0.25%, and most preferably between 0.05% to 0.15% based on air dried fibers to react with the targeted substrate.

25. The system of claim 24 wherein the enzymes are selected from the group consisting of cellulases, hemicellulases, amylases, proteases, β -glucosidases, lipases, esterases, pectinases, pectate lyases, laccases, glucose oxidases, and peroxidases.

26. The system of claim 22 wherein the adsorbents and absorbents are selected from the group consisting of inorganic and organic particles, natural or synthetic wherein the absorbents or adsorbents are in the form of microparticles having particle sizes from 100 nm to 40 microns or specific surface areas from 1 m²/g to 2,000 m²/g.

27. The system of claim 26 wherein the adsorbents and absorbents are selected from the group consisting of talc, bentonite, silica, and clay.

28. The system of claim 27 wherein the adsorbents or absorbents are activated bentonite having a surface area of greater than 400 m²/gram.

29. The system of claim 22 wherein the absorbents or adsorbents are selected from the group consisting of silicate-linked minerals, carbonate-based minerals, cross-linked polymers of cationic, anionic or nonionic nature, having molecular weight from 5,000 to 2,000,000 daltons, and combinations thereof.

30. The system of claim 29 wherein silicate-based minerals are selected from the group consisting of bentonite, montmorillonite, talc, and clay.

31. The system of claim 29 wherein carbonate-based minerals are selected from the group consisting of calcium carbonate, magnesium carbonate, and dolomite, natural or synthetically precipitated.

32. The system of claim 22 wherein adsorbent or adsorbent is bentonite and is in a form suitable to add as a slurry in a concentration of between 0.05% and 10.0%, preferably between 1.0% and 5.0%.

33. The system of claim 22 further comprising one or more materials selected from the group consisting of water soluble polymers, dispersants, solvents, suspension aids, fillers, chelants, preservatives, buffers, water, and stabilizers.

34. The system of claim 33 wherein the water soluble polymer is a cationic water soluble polymer selected from the group consisting of epichlorohydrin/dimethylamine polymers (EPI-DMA) and cross-linked solutions thereof, polydiallyl dimethyl ammonium chloride (DADMAC), DADMAC/acrylamide copolymers, and ionene polymers.

35. The system of claim 33 wherein the material is a water soluble polymer added in a dosage range of from about 0.1

to 1000 ppm, more preferably 1.0 to 100 ppm, and most preferably 2.5 to 10 ppm.

36. The system of claim 33 wherein the material is a surfactant selected from the group consisting of soaps, fatty acid alkoxyates, fatty alcohol alkoxyates, and EO/PO polymeric surfactants.

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