METHODS FOR PRODUCING RECYCLED PULP FROM WASTE PAPER

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ABSTRACT
The invention provides methods and apparatus for using waste paper to produce recycled pulp that can be used by the paper industry. The recycled pulp produced by the methods and apparatus of the invention can optionally be mixed with virgin pulp to produce paper or paper-products. The waste paper can be any grade, including low quality waste paper, such as mixed waste paper or old newsprint.
FIG. 1

RAGGER 16

FIBER SEPARATOR 12

JUNK TRAP 15

WASTE WATER TREATER 42

WASTE MATERIAL → FIBER SEPARATOR 12 → RECYCLED PULP

FIG. 2

WASTE MATERIAL → FIBER SEPARATOR 12 → DE-LIQUEIFIER 14 → RECYCLED PULP

WASTEWATER TREATER 42
METHODS FOR PRODUCING RECYCLED PULP FROM WASTE PAPER

RELATED APPLICATIONS

[0001] This application claims priority under § 119 to U.S. Application No. 60/524,620 filed Nov. 25, 2003, the disclosure of which is incorporated by reference.

FIELD OF THE INVENTION

[0002] The invention provides methods and apparatus for using waste paper to produce recycled pulp that can be used by the paper industry. The recycled pulp produced by the methods and apparatus of the invention can optionally be mixed with virgin pulp to produce paper or paper-products.

BACKGROUND OF THE INVENTION

[0003] Various processes for recovering fibers from waste paper, such as paperboard food cartons and packages, office waste paper, magazines and newspapers, have been proposed. Typically, these recycling processes involve treating the waste paper in a hydrapulping machine where the fibers are separated by the agitation of the water, and caustic soda or similar reagents are used to break down the integrity of the waste paper. These processes produce a stream of separated fibers which may be passed through various screening devices to remove prohibitives, and the resulting slurry containing the fibers may pass through a de-inking process. After appropriate treatment, the slurry of fibers passes through a de-watering stage, so that the recovered fibers are collected in an essentially dry state and packed in bales for subsequent use in making paper. There remains a need in the art for new and improved methods and apparatus for recycling waste paper to produce fibers that can be used in the paper industry. The invention is directed to this, as well as other, important ends.

SUMMARY OF THE INVENTION

[0004] The invention provides methods and apparatus to produce recycled pulp that can be sold or traded to paper mills. The recycled pulp of the invention can be stored and/or transported in containers and can be delivered to paper mills by any conventional method, e.g., truck, train, ship, and the like. Unlike methods whereby dry bales of recycled fibers are sold or traded to paper mills which then re-pulp the dry bales of recycled fibers, the invention provides recycled pulp (i.e., fibers in liquid) which is in a form that can be easily and readily used by paper mills. The methods and apparatus of the invention eliminate the steps of (i) producing a dry bale of recycled fibers, and (ii) re-pulping the dry bale of recycled fibers. The invention produces recycled pulp that can be immediately used by the paper industry, either alone or in combination with virgin pulp, to produce paper and/or paper products. These and other aspects of the invention are described in more detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 is a block diagram of a system or apparatus according to the invention.

[0006] FIG. 2 is a block diagram of a system or apparatus according to the invention.

[0007] FIG. 3 is a detail of a fiber separator of the systems or apparatuses of FIGS. 1 and 2.

[0008] FIG. 4 is a detail of a de-liquefier of the systems or apparatuses of FIGS. 1 and 2.

[0009] FIG. 5 is a detail of a fiber cleaning system that may be added to the systems or apparatuses of FIGS. 1 and 2.

[0010] FIG. 6 is a detail of, among other things, a fiber separator, and a de-liquefier of a system or apparatus according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The invention provides methods and apparatus for using waste paper to produce recycled pulp that can be used by the paper industry. The recycled pulp produced by the methods and apparatus of the invention can optionally be mixed with virgin pulp to produce paper and/or paper products.

[0012] “Pulp” refers to fibers in liquid (e.g., water). The fibers can be in a liquid slurry, liquid suspension, or the like.

[0013] “Fibers” includes wood-based cellulosic fibers, non-wood-based cellulosic fibers, natural textile fibers, man-made fibers, or a mixture of two or more thereof. The term “fibers” includes natural and man-made fibers that are capable of entrapping or entraining air within their structure, such as rockwool, cellulosic fibers, glass fibers and the like.

[0014] “Cellulosic pulp” refers to wood-based cellulosic fibers and/or non-wood-based cellulosic fibers.

[0015] “Virgin pulp” refers to pulp obtained directly from trees.

[0016] “Recycled pulp” refers to pulp produced from waste paper. “Relatively pure recycled pulp” refers to pulp that contains cellulosic pulp in an amount of about 50% or more; 60% or more; 70% or more; or 80% or more. In another embodiment, “relatively pure recycled pulp” refers to pulp that contains cellulosic pulp in an amount of about 50% to about 99%; about 60% to about 99%; about 70% to about 99%; about 80% to about 99%; or an amount of about 90% to about 99%.

[0017] The recycled pulp produced by the methods, systems and apparatus of the invention is in a form that can be directly used for further processing by a paper mill without having to be re-pulped. In one embodiment, the recycled pulp has a solids content, for example, between about 1 wt % and about 85 wt %. In the embodiment of the invention that does not use a de-liquefier (as described herein), the recycled pulp can have a solids content between about 1 wt % and about 25 wt %; between about 1 wt % and about 20 wt %; or between about 5 wt % and about 15 wt %. In the embodiment of the invention that uses a de-liquefier (as described herein), the recycled pulp can have a solids content between about 30 wt % and about 85 wt %; between about 30 wt % and about 75 wt %; or between about 45 wt % and about 70 wt %. Because the recycled pulp of the invention is not dried, it can be immediately used by the paper mills without having to be re-pulped. Alternatively, it can be stored and used at a later date by the paper mills without having to be re-pulped.
[0018] “Prohibitives” include any material which, in excess of the amount allowed, would make the waste paper unusable as the grade specified or any materials that may be damaging to the equipment that processes the waste paper. Scrap Specifications Circular 2003, page 22, Institute of Scrap Recycling Industries, Inc. (2003).

[0019] “Outthrow” is all papers that are manufactured or treated or are in such a form as to be unsuitable for consumption as the grade specified. Scrap Specifications Circular 2003, page 22, Institute of Scrap Recycling Industries, Inc. (2003).

[0020] “Waste paper” refers to and includes any grade of waste paper known in the art. Any grade of waste paper known in the art, including those described herein, can be used in the methods, systems and apparatus of the invention to produce recycled pulp. An unexpected advantage of the invention is that any grade, including low quality grades, of waste paper can be used as a starting material. The four broad classes of waste paper are (1) pulp substitutes, (2) de-inking grades, (3) brown kraft grades and (4) mixed waste paper.

[0021] Pulp substitutes are generally substitutes for chemical pulps. Chemical pulps are pulp produced by chemical treatments. The quality of pulp substitutes is most similar to that of virgin fiber, so their price is also related to virgin fiber (e.g., converting and printing trimmings; guillotine shavings (mechanical and wood free separately); tinted (suitable for bleaching); and lightly printed waste paper (e.g.: ledger, ruled book trimmings). Polycrystalline coated (e.g.: plastic coated liquid packaging board cartons, footboard, paper plate and cup board) also produces a good quality pulp, but requires separate initial repulp treatment.

[0022] Brown kraft grades include, for example, corrugated plant waste; old corrugated containers; KLS (kraft lined strawboard is waste-based old corrugated container having more than 33 wt % kraft linerboard); used kraft sacks; and converting waste. This waste paper is used mainly for test linerboard and fluting. Old corrugated container bleaching is used for fine papers.

[0023] Mixed waste paper is the cheapest and lowest quality waste paper. Traditionally, this has been the balance, after taking out household waste paper and other grades that are easy to sort. Mixed waste paper has been used for chipboard and gray back folding boxboard.

[0024] There has been a continuing degradation in the quality of old newsprint marketed in the United States. Old newsprint is usually graded as #6 or #8. The methods and apparatus of the invention are able to process mixed waste paper, including old newsprint.

[0025] Household waste is commanding attention as the last major vein of waste paper to be mined. Called residential mixed paper, the U.S. recovery rate of the approximately 9 million tons per year is only about 20%. The collection system used determines the quality of the resulting waste paper. When old newsprint is collected separately in the United States, the resulting waste paper composition is approximately 30% carton board/SBS packaging; 30% white grades and mail; 25% mechanical fiber (news/magazine/coated and uncoated); and 15% brown kraft (bag and old corrugated containers). This waste paper may be a substitute for medium quality OCC, with the lower price offsetting the lower yield.

[0026] Specific grades of waste paper, as defined by Scrap Specifications Circular 2003, pages 22-25, Institute of Scrap Recycling Industries, Inc., that can be used as the starting material to produce the recycled pulp of the invention include: (1) soft mixed paper; (2) mixed paper; (4) boxboard cuttings; (5) mill wrappers; (6) news; (7) news, de-inking quality; (8) specialty news de-inking quality; (9) over-issue news; (10) magazines; (11) corrugated containers; (12) double sorted corrugated; (13) new double-line kraft corrugated cuttings; (15) used brown kraft; (16) mixed kraft cuttings; (17) carrier stock; (18) new colored kraft; (19) grocery bag scrap; (20) kraft multi-wall bag scrap; (21) new brown kraft envelope cuttings; (22) mixed groundwood shavings; (23) telephone directories; (24) white blank news; (25) groundwood computer printout; (26) publication blanks; (27) flyleaf shavings; (28) coated soft white shavings; (30) hard white shavings; (31) hard white envelope cuttings; (33) new colored envelope cuttings; (35) semi-bleached cuttings; (37) sorted office paper; (39) manifold colored ledger; (40) sorted white ledger; (41) manifold white ledger; (42) computer printout; (43) coated book stock; (44) coated groundwood sections; (45) printed bleached board cuttings; (46) misprinted bleached board; (47) unprinted bleached board; (48) #1 bleached cup stock; (49) #2 printed bleached cup stock; (50) unprinted bleached plate stock; and (51) bleached plate stock. Each grade has specifications on prohibitives and outthrow.

[0027] Bagasse is an alternative or additional starting material that can be used in the methods, systems and apparatus of the invention to make recycled pulp. Bagasse is the cellulose fiber separated from the non-fibrous component of plants, such as sugar from sugar beets or sugar cane and natural rubber from rubber plants. In the case of sugar cane, bagasse is available in a bagasse belt around the world parallel to the equator, which extends from Spain in the North to South Africa and Australia in the South. Usually, the sugar cane harvesting campaign lasts 4-9 months, which means most pulp mills must carry large stocks of bagasse. Normally, the bagasse is burned in the sugar mill’s boilers to provide its steam and power requirements. Substitution of an alternative fuel frees up the bagasse for a pulp mill, but prices the bagasse at the fuel-equivalent price. Before pulping, the earth and dirt are washed off, and any magnetic materials removed. Bagasse can be used in a wide range of paper grades, including coated papers. The following table shows some typical levels, which would also apply approximately to other non-wood pulps, with similar properties (e.g.: fiber length).

<table>
<thead>
<tr>
<th>Bagasse Pulp Grade</th>
<th>Paper Grade</th>
<th>% Bagasse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleached mechanical,</td>
<td>Newsprint</td>
<td>75-80</td>
</tr>
<tr>
<td>chemomechanical, or</td>
<td>Mechanical printing papers</td>
<td>50</td>
</tr>
<tr>
<td>thermomechanical pulp:</td>
<td>Tissue</td>
<td>50</td>
</tr>
<tr>
<td>High yield unbleached</td>
<td>Corrugating medium</td>
<td>75-100</td>
</tr>
<tr>
<td>semichemical pulp:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unbleached chemical pulp:</td>
<td>Multiwall sack, extensible</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Kraft linerboard</td>
<td>40-60</td>
</tr>
<tr>
<td></td>
<td>Wrapping paper (B grade)</td>
<td>50-75</td>
</tr>
<tr>
<td></td>
<td>Fruit wrap and tissue</td>
<td>60-90</td>
</tr>
<tr>
<td></td>
<td>Glassline and greaseproof</td>
<td>50-90</td>
</tr>
</tbody>
</table>
It has been unexpectedly discovered that the methods and apparatus of the invention can be used to process any grade of waste paper, including low quality grades of waste paper, such as old newsprint and mixed waste paper. The waste paper used in the methods and apparatus of the invention can be a single grade or can be a combination/mixture of two, three, four, five, six, seven or more different grades of waste paper.

In FIG. 1, an apparatus 10 for converting waste material into recycled pulp is shown. The apparatus 10 comprises at least one fiber separator 12 and, optionally, at least one waste liquid treater 42 in communication with the fiber separator 12. The fiber separator 12 is preferably a liquid-based fiber separator, such as an aqueous based fiber separator. The apparatus 10 can optionally comprise at least one junk trap 15 and/or at least one ragger 16 for removing prohibitives.

In FIG. 2, the apparatus 10 comprises at least one fiber separator 12, at least one de-liquefier 14, and, optionally, at least one waste liquid treater 42 in communication with the fiber separator 12 and/or the de-liquefier 14. The de-liquefier 14 is located downstream from the fiber separator 12 and the de-liquefier 14 is for removing liquid from the recycled pulp. The fiber separator 12 may be a liquid-based fiber separator, such as an aqueous based fiber separator. The apparatus 10 can optionally comprise at least one junk trap (not shown) and/or at least one ragger (not shown) for removing prohibitives.

The fiber separator 12 can comprise one or more batch pulpers and/or continuous pulpers, which are known in the paper making art. Exemplary conventional fiber pulpers include TA series pulpers (available from Allmand); Aquabrusher (available from APMEW or Bellmer); Grubbens pulper (available from Cellwood or Corner); Barracuda pulper (available from GL&V); Shark pulper (available from GL&V); HDK Channel pulper (available from Metso Paper/Fiber); HD Vertical pulper (available from Metso Paper/Fiber); Preflo pulper (available from Metso Paper/Fiber); Delta pulper (available from Thermo Black Clawson, Lamont, Aikawa); Hydra pulper (available from Thermo Black Clawson, Lamont, Aikawa); St series pulpers (available from Voith Paper); and Uni-pulpers (available from Voith Paper).

While it is preferable to remove the more fragile prohibitives intact, batch pulping may be used together with a helical low attrition rotor (resembling an inflated cork screw) to minimize prohibitive breakdown. Examples of such equipment include Bi Pulp (available from A Celli and Corner); Tri Dyne (available from GL&V); CHD (Continuous High Density pulper system with screen for accepts); SMG Pulper (available from Metso Paper/Fiber); and Helico pulper and Hi Con pulper (available from Thermo Black Clawson, Lamont). U.S. Pat. No. 4,129,259, the disclosure of which is incorporated by reference herein in its entirety, is related to a Hi-Con pulper, available from Thermo Black Clawson.

The removal of large prohibitives from waste paper may be achieved by subsystems around the fiber separator 12, such as a junk trap 15. The junk trap can be used to remove prohibitives (e.g., stones, metal, and other heavy materials) that can sink into this dead area of the pulper, between two valves, and is automatically purged at desired time intervals. A Privet Double Dumper™ is an example of such a junk trap.

A ragger 16 is also useful for removing prohibitives (e.g., baling wire, rags, plastic strips, string, and the like). The prohibitives entangle each other and may be withdrawn from the fiber separator 12 as an endless ragger rope by the capstan-like ragger 16. An example of such equipment includes the Valmet ragger (available from Metso Paper/Fiber). The rope may be periodically cut by the ragger rope cutter to facilitate its disposal. An example of such equipment includes the Valmet tail cutter (available from Metso Paper/Fiber), Broken ragger tails, weighing up to 3 tons, can be retrieved from the fiber separator 12 without emptying it. An example of equipment useful for such operations includes the Ragger tail grabber (available from Neilsen & Hiebert Systems).

Drum pulpers provide an alternative approach to the conventional pulper. Characteristics of drum pulpers include continuous operation, minimum degradation of fibers and prohibitives, and low power consumption (e.g., energy conservation). Examples of equipment useful for such an operation include the Fibreflow Drum pulper (available from Andritz-Ahlstrom) and the Horizontal Drum-Soaking-Mixing-Screening System (available from Finckh).

In other embodiments of the invention, the fiber separator 12 can include a secondary pulper downstream from the primary pulper. The secondary pulper will complement the primary pulper’s ability to take out large prohibitives by removing high and low density prohibitives, while also deflaking undisintegrated flakes of paper. The secondary pulper may be either batch or continuous, and models are available for both batch and continuous primary pulpers. Examples of secondary pulpers include Selector and Selump pulpers (available from A Celli); Epurex (available from Corner), ESC series (available from Corner), Turboremover pulpers (available from Corner); RejectsMaster pulper (available from Finckh); BCPurge pulper (available from GL&V); Tamtrap TTP pulper (available from Metso Paper/Fiber); Dumping Poire (batch); Helico pulper+Helipoire System, Poire Pulper (continuous), Hydra Impactor, Hydrapurge (available from Thermo Black Clawson, Larmont); and Contaminex, Fiberizer, and Turboseparator (available from Voith Paper).
Metso Paper/Fiber); Frotapulper (available from MoDoMe kan); Triturator/Kneading Disperser (available from Thenno Black Clawson, Lamort); Disperser (available from Voith Paper). Examples of kneading systems include MDR Kneader (available from Andritz-Ahlstrom), Ultra Twin Flyte (available from Thermo Black Clawson), Kneading Disperser (available from Voith Paper).

[0038] As shown in FIG. 4, the de-liquifier 14 may include any of the many types of equipment used for thickening, washing, and/or separation. For example, the de-liquifier 14 may include a thickener 25 for increasing the solids content of the recycled pulp that comes out of the liquid-based fiber separator 1.

[0039] The liquid removed by the de-liquifier 14 may be called filtrate or pressate (e.g., when from a press). The solid material from a filter may be called filter cake. A belt filter press can perform this function. Exemplary belt filter presses include Double Wire Press (available from Andritz-Ahlstrom); BDP (available from Buderus Process); TurboDrain (1 wire); Winkelpress (2 wires); and Cascade S (both types in series) (available from Bellmer and Corner); HC Press, Gap Washer, and TwinWire (with Paraformer headbox) (available from Metso Paper/Fiber and Phoenix Process Equipment); Saltel Belt Press (available from Saltel); DNT Washer (available from Thermo Black Clawson); Variop Split (available from Voith Paper); and Osprey (available from William Jones, London).

[0040] The de-liquifier 14 may include a screw press 40 that may have either a single screw (e.g., Brown Stock Washing) or double screw (e.g., two counter rotating intermeshed screws). Examples of screw presses include: Andritz/Dupps Screw Press (available from Andritz-Ahlstrom); Belpress BP (available from Beltce); Krima Screw Press (available from Cellwood); FKC (available from FKC-Fukoku Kogyo); CHS (available from GL&V/Celbec); and Fibroplex (available from Thermo Black Clawson, Lamort).

[0041] Other types of equipment that may be included with the de-liquifier 14 include the curated screen for example, Hydra Screen, Hydrasieve, and Micra Screen (available from Andritz-Ahlstrom); Bow Screen and DSM (available from Dutch State Mines and GL&V/Celbec); and Hydrosol (Sprac) and Vertiscreen (available from Thermo Black Clawson); the Deckcr; Dewatering drum screen [e.g., (available from Corner); AKTRON (available from Kufferath); RE (available from Saltex and Sinclair); Free Drainage Thicken (available from Thermo Black Clawson, Lamort); Screen Drum F type and ZTR B (available from Voith Paper and Warburton Holder); the Disc save all filter [e.g., Discfilter (available from Hydrotech); the Disc thickener [e.g., AKSE (available from Kufferath)]; the Gravity decker [e.g., Hooper (available from Andritz-Ahlstrom and Finckh); Drainpac (available from GL&V/Celbec); Tandec (available from Metso Paper/Fiber); the Gravity screen [e.g., (available from Nash), Sweco (available from Sweco); and the Gravity Strainer (available from Thermo Fibertek)]; the lamella plate clarifier (inclined plate clarifier, slant plate clarifier) [e.g., Settle Plate Clarifier available from Heuser Apparatbau]; the Plate and frame press [e.g., filomat MCCM (available from Filtration Ltd) and Ommifilter (available from Voith Paper)]; the Rotary pressure drum filter/washer; the Rotary vacuum drum filter/washer; the Screw thickener [e.g., KW Washing Screen (available from Andritz-Ahlstrom); Krima Screw De waterer (available from Cellwood and Corner); Akusand, Akuscreen (available from Kufferath); Sandsep, Spiropress (available from Spi- rac); Hydrascreen (there is also a vertical version), and Lamort Baker Water Extractor (available from Thermo Black Clawson, Lamort)); the Sidehill screen [e.g., Kenfil (available from Kent Filtration); the Spraying filter [e.g., Spradisc (available from GL&V/Celbe) and White Water Filter (Swecon]); the Tubular filter; the Twin roll press; the PreRoll Press; WiRoll Press (available from Metso Paper/Fiber); and the Vibrating screen.

[0042] The waste liquid treator 42 included in the system is an optional aspect of the invention and may be beneficial in allowing the reuse of the liquid in the processing of the waste paper and waste materials of the invention.

[0043] In another embodiment shown in FIG. 3, the liquid-based fiber separator 12 may include a conveyer 44 for providing the waste paper to the pulper 22. Also shown in FIG. 3 is that the fiber separator 12 may include a surge tank 34 for accumulating sufficient quantities of pulp and liquid to support pseudo continuous processes downstream. One skilled in the art will recognize that these types of conveyors 44 are commonly used to feed waste paper to the pulper 22. To that end, the fiber separator 12 of the invention may include one or more conveyors 44. The conveyer includes a steel slat type conveyor (or apron conveyor) for baled and loose waste paper, a chain belt type conveyor for loose waste paper, where the rubber belt is driven by a chain; and a sliding belt type conveyor for dried bales and loose waste paper, where the belt (with a low friction underside) may be supported by a steel trough. Although not shown, bale wire may be removed automatically (dewing) and compacted using equipment such as: Wire Wizard (available from Advanced Dynamics, B&G Fordtech, and FMW); Wire-Write (available from Lamb and Metrans); and Wire- master (available from Neilsen & Hiedtke Systems and Suthib).

[0044] In another embodiment, further aspects of the invention relating to a fiber cleaning system 30 are represented in FIG. 5. The fiber cleaning system 30 may include, for example, a screen 32, conical cleaners 36, a washer or washers 37, and a surge tank 34.

[0045] A screen 32 may be used in the cleaning system 30 to remove prohibitives. Common principles apply to the variety of useable screens. In each case, the actual equipment used is that appropriate for the fiber material and prohibitives present. A pressure screen is one type of screen 32. Examples of such a screen include: pressure screens (available from A. Celli, Fiedler, Finckh; BelWave (available from GL&V); Nimega (available from Metso Paper/Fiber); Coba, Lehman, and ThermoTek (available from Thermo Black Clawson, Lamort); and C Bar (Voith paper).

[0046] Screening is commonly divided into coarse, intermediate and fine. Coarse screening may use screen hole diameters usually ranging between about 0.5-2.5 mm (between about 20-100 thousands), but going up to about 10 mm at a “high consistency” feed of between about 2 wt. % and 5 wt. %. If following a pulper extraction plate orifice diameter of between about 3 or 6 mm, hole size may be reduced to about 1 mm. Intermediate screening uses screen slot widths usually ranging between about 0.25-0.65 mm.
(between about 10-26 thousands) at a “high consistency” feed of between about 2.5 wt. % and 5 wt. %. Fine screening uses screen slot widths usually ranging between about 0.08-0.25 mm (between about 3.2-10 thousands) at a “low consistency” feed of between about 1 wt. % and 3 wt. %. One, two or three separate screenings may be used, depending on the application. The above distinction becomes blurred when considering the pulper extraction plate (sometimes with a screen following it) as coarse screening and placing coarse and fine screen stages in one pressure screen body. Examples of other usable screens include: Airsorter, Hooper, MODUScreen C, H, and F (available from Andritz-Allstrom); Cyberscreen, PV Screen, Selectifier and Ultra Screen (available from Corner); C.H. Horizontal Screen, Diabolo, and Hico Screen N (available from Finch); Alfascreeen, CellectoScreen (both horizontal), Hi-Q, S Screen (Gl&V), Key Screen (Maule), DeltaScreen, MiniDelta Screen, TAP Screen, TAS Screen, and TL series (available from Metso Paper/Fiber); SP Screen series and Ultra-V (available from Thermo Black Clawson, Lamort); and Centriscreen, EcoScreen, Minisorter, MultiSorter, Omniscreen, Omnisorter and Spectro Screen (available from Voith Paper).

Partial cascade is similar to forward flow, except that accepts from the 3rd (tertiary) stage screen are screened again in the 2nd (secondary) stage screen instead of joining the main stock flow.

In A-B configuration, two similar screens are employed in series for mechanical pulp screening and sometimes fine screening. The additional unit may give greater cleanliness relative to forward flow.

The conical cleaners 36 may include one or more hydrocyclones. One skilled in the art will recognize that hydrocyclone (hydroclone) is the generic name for equipment that uses centrifugal force, and other hydrodynamic forces, produced by pumping into a cyclone for insoluble solids separation. The cyclone geometry provides decreasing (cross-sectional) diameter. For the solids, this means increasing acceleration, due to the increasing G force, i.e., acceleration measured relative to the acceleration of free fall due to gravity, 9.81 m/s², and increasing Prohibitive/fiber separation efficiency. Banks (e.g., rows) of the numerous individual cleaners may be combined in a variety of orientations (a circle, rows, etc.) so as to share common feed and discharge chambers. Examples of such a variety of orientations include: Spirelpak (available from Thermo Black Clawson, Lamort) and Tripac 90 (available from Gl&V/Cellico).

The conical cleaners 36 may include one or more of a forward flow (conventional) cleaner; a high density cleaner, a reverse cleaner, a through flow cleaner, core bleed cleaner, an asymmetrical cleaner and a rotating body cleaner. A conventional centrifugal cleaner (CC, centricleaner, forward flow cleaner, free vortex cleaner) is approximately the shape of a narrow cyclone (i.e., an inverted cone), with the stock entering at a tangent in the top. A whirlpool like vortex is formed, so that high density prohibitives move to the bottom of the cone from where they are rejected. The accepted stock goes to the top of the cone from where it passes upstream. Examples of forward flow (conventional) cleaners include: Ahlcleaner RB series, CentriCleaner, and TC series (available from Andritz-Allstrom, Corner and Fiedler); Albia I, Cleanacap 270 to 1500 series, Elast 0 Cone, Posiflow and TWF series (available from Gl&V); CT series, Hydraulon, ELP series and Ultra Cyclone (available from Thermo Black Clawson, Lamort); and Cycleclean, and KS series (available from Voith Paper and Wilbanks). Up to about 5 stages of cleaners may be used, depending on the cleanliness required.

A high density cleaner (HD cleaner) is a huge diameter forward flow cleaner operating between the ranges of about 2% and 6% consistency. It is located close to the pulper when using lower grade waste paper furnish and removes high density prohibitives. An attrition section helps to separate fiber from rejects. The latter are removed from the rejects chamber either manually (via the door) or automatically (by 2 timed valves). Examples of high density cleaner (HD cleaner) include: (that available from A. Celli); Ahlcleaner RB 300HD (available from Andritz-Allstrom); Cleantrap, Grubbens High Density Cleaner (available from Cellwood), (Corner); Albia TFRB, Combipal (available from Gl&V); HC Cleaner (available from Metso Paper/Fiber); HD Cyclone, Liquid Cyclone, Low Profile Cyclone and Ruffclone (available from Thermo Black Clawson, Lamort, Aikawa); DIC, D2C, and High-Consistency Purifier S series and T series (available from Voith Paper).
In a reverse cleaner, the normal accepts and rejects exit points are reversed. Good low-density prohibitive removal may be achieved. About 50% of the flow (and proportionally more of the fiber) may be rejected. The accepts flow may be thickened by a factor of up to about 2.5. Examples of reverse cleaners include: Cleanpac 2708, Cleanpac RT (reverse, thickening), Tripac 90 Reverse (available from GL&V/Cellico), Contra-Clone, CT series, and Xtreme, (available from Thermo Black Clawson, Lamort); and KS series (available from Voith Paper).

In a through flow cleaner (flow through, parallel flow), both the rejects and accepts come out at the same end. It removes low density prohibitive together with air. Rejects are about 10% of the feed flow. Examples of through flow cleaners (flow through, parallel flow) include: Cleanpac 250 EWR and UniFlow (available from GL&V); XX-Clone (available from Thermo Black Clawson); and Coreclean (available from Voith Paper).

The core bleed cleaner has the configuration of a forward flow cleaner, but with the addition of a central bleed for low density prohibitive (plus deaccretion) from the accept stream. Each rejects stream equals about 10% of the feed flow. Examples of core bleed cleaners include: Abl cleaner SC 133 (available from Andritz-Ahlstrom); Albina TDLR, Cleanpac 350 Combi, and Cleanpac 700 LD (available from GL&V); and KS/E series (available from Voith Paper).

The asymmetrical cleaner is essentially a forward flow cleaner, but with one straight side and, the other side converging on it. This departure from symmetry about a central axis provides, among its benefits, the ability to manipulate (and remove) particles according to their position within the cleaner strata (e.g., levels). The asymmetrical cleaner takes two different forms: those resembling the Cleanpac 270 SR (Step Release having steps in the converging side plus a constricted cone end removed available from GL&V/Cellico) and those resembling the Cleanpac 270 Hys (having increases in the feed and accepts pressure available from GL&V/Cellico).

The rotating body cleaner differs from the others in that a horizontal cylinder (e.g., 500 mm diameter) rotates at 1,300-1,500 rev/min, thus exerting a greater centrifugal force of about 700 G over a longer retention time, to give good low-density prohibitive removal efficiency. An example of a rotating body cleaner includes the Gyroclean (available from Thermo Black Clawson, Lamort). Gyrocleans may be efficient stickies separators.

An elutriation section may be added to the last stage of a conical cleaner to reduce the rejects' fiber content and liquid consumption. This may be achieved by injecting liquid, which pushes good fiber back into the system for subsequent separation. The elutriation section may include valves to periodically discharge the rejects. Examples of elutriation sections include: Albina WFR (wet fiber recovery control), FRB, RCC, and Fiberizer FMR (available from GL&V) and Rejcomat (available from Voith Paper).

Another embodiment of the invention is represented by reference to FIG. 6 which shows the fiber separator, fiber cleaning system, and de-liquifier combined in a manner that is beneficial for production of recycled pulp according to the invention.
recycled pulp. The MRF provides an excellent source of waste material/waste paper for the apparatus, systems and methods of the invention.

[0065] Various modifications of the invention, in addition to those described herein, will be apparent to one skilled in the art from the foregoing description. Such modifications are intended to fall within the scope of the appended claims.

What is claimed is:
1. A method for making recycled pulp comprising:
   (a) providing waste material that comprises waste paper and, optionally, prohibitives;
   (b) adding the waste material to a liquid-based fiber separator apparatus; and
   (c) producing recycled pulp having a solids content from about 1 wt% to about 85 wt%.
2. The method of claim 1, wherein the recycled pulp has a solids content from about 1 wt% to about 25 wt%.
3. The method of claim 1, wherein the waste paper comprises a pulp substitute, a de-inking grade, a brown kraft grade, mixed waste paper, or a mixture of two or more thereof.
4. The method of claim 1, wherein the waste paper comprises one or more grades selected from (1); (2); (4); (5); (6); (7); (8); (9); (10); (11); (12); (13); (15); (16); (17); (18); (19); (20); (21); (22); (23); (24); (25); (26); (27); (28); (30); (31); (33); (35); (37); (39); (40); (41); (42); (43); (44); (45); (46); (47); (48); (49); (50); (51); or a mixture of two or more thereof, wherein the grade is based on the classification described by Scrap Specifications Circular 2003, pages 22-25, Institute of Scrap Recycling Industries, Inc.
5. The method of claim 1, wherein the recycled pulp is relatively pure recycled pulp.
6. A method for making recycled pulp comprising:
   (a) providing waste material that comprises waste paper and, optionally, prohibitives;
   (b) adding the waste material to a liquid-based fiber separator apparatus to produce the recycled pulp;
   (c) removing liquid from the recycled pulp to produce recycled pulp that has a solids content from about 30 wt% to about 85 wt%.
7. The method of claim 6, wherein the recycled pulp has a solids content from about 45 wt% to about 70 wt%.
8. The method of claim 6, wherein the waste paper comprises a pulp substitute, a de-inking grade, a brown kraft grade, mixed waste paper, or a mixture of two or more thereof.
9. The method of claim 6, wherein the waste paper comprises one or more grades selected from (1); (2); (4); (5); (6); (7); (8); (9); (10); (11); (12); (13); (15); (16); (17); (18); (19); (20); (21); (22); (23); (24); (25); (26); (27); (28); (30); (31); (33); (35); (37); (39); (40); (41); (42); (43); (44); (45); (46); (47); (48); (49); (50); (51); or a mixture of two or more thereof, wherein the grade is based on the classification described by Scrap Specifications Circular 2003, pages 22-25, Institute of Scrap Recycling Industries, Inc.
10. A method for providing recycled pulp to a paper mill comprising:
   (a) providing waste material that comprises waste paper and, optionally, prohibitives;
   (b) adding the waste material to a liquid-based fiber separator apparatus to produce the recycled pulp, wherein the recycled pulp is in a form that does not need to be re-pulped for further processing into paper or a paper product; and
   (c) transporting the recycled pulp to a paper mill.
11. The method of claim 10, further comprising removing liquid from the recycled pulp, wherein the recycled pulp is in a form that does not need to be re-pulped for further processing into paper or a paper product.
12. The method of claim 10, further comprising storing the recycled pulp in a container prior to transporting the recycled pulp to a paper mill.
13. The method of claim 10, wherein the waste paper comprises a pulp substitute, a de-inking grade, a brown kraft grade, mixed waste paper, or a mixture of two or more thereof.
14. The method of claim 10, wherein the waste paper comprises one or more grades selected from (1); (2); (4); (5); (6); (7); (8); (9); (10); (11); (12); (13); (15); (16); (17); (18); (19); (20); (21); (22); (23); (24); (25); (26); (27); (28); (30); (31); (33); (35); (37); (39); (40); (41); (42); (43); (44); (45); (46); (47); (48); (49); (50); (51); or a mixture of two or more thereof, wherein the grade is based on the classification described by Scrap Specifications Circular 2003, pages 22-25, Institute of Scrap Recycling Industries, Inc.
15. A method for producing a recycled paper product comprising:
   (a) providing waste material that comprises waste paper and, optionally, prohibitives;
   (b) adding the waste material to a liquid-based fiber separator apparatus to produce the recycled pulp, wherein the recycled pulp is in a form that does not need to be re-pulped for further processing into paper or a paper product;
   (c) transporting the recycled pulp to a paper mill; and
   (d) mixing the recycled pulp with virgin pulp to produce the recycled paper product.
16. The method of claim 15, wherein the recycled pulp that is in a form that does not need to be re-pulped for further processing is recycled pulp having a solids content of at least about 30 wt%.
17. The method of claim 16, wherein the recycled pulp has a solids content from about 30 wt% to about 85 wt%.
18. The method of claim 15, wherein the recycled pulp is relatively pure recycled pulp.
19. The method of claim 15, wherein the waste paper comprises a pulp substitute, a de-inking grade, a brown kraft grade, mixed waste paper, or a mixture of two or more thereof.
20. The method of claim 15, wherein the waste paper comprises one or more grades selected from (1); (2); (4); (5); (6); (7); (8); (9); (10); (11); (12); (13); (15); (16); (17); (18); (19); (20); (21); (22); (23); (24); (25); (26); (27); (28); (30); (31); (33); (35); (37); (39); (40); (41); (42); (43); (44); (45); (46); (47); (48); (49); (50); (51); or a mixture of two or more thereof, wherein the grade is based on the classification described by Scrap Specifications Circular 2003, pages 22-25, Institute of Scrap Recycling Industries, Inc.

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