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[54] **DRY METHOD FOR SEPARATING PAPER CONSTITUTENTS FOR RECOVERY AND RECYCLING**

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[57] **ABSTRACT**

A method for separating mixtures of waste paper into two components using the differences in strength and/or water-receptivity characteristics of the two components which are typically the liner board and corrugated medium of corrugated paper or a mixture of magazines and newsprint. In separation, the material of the paper mixture is cut into pieces ranging in size from about one to six inches in either dimension, treated with a debonding agent and then subjected to differential size reduction wherein one of the mixture components is reduced to small pieces, e.g., one-quarter inch in either dimension, while the other remains in pieces of essentially the same size. Separation of the two distinctly different sized components is then effected.

16 Claims, No Drawings

DRY METHOD FOR SEPARATING PAPER CONSTITUTENTS FOR RECOVERY AND RECYCLING

This invention relates to an essentially dry method for separating two paper constituents and more particularly for separating an essentially unsized, highly water-receptive paper constituent from a sized, less water-receptive paper constituent. The method may also be used to separate and remove fibrous or film contaminants such as asphalt-impregnated tape, plastic films and the like. In the following description and claims the term "essentially dry" is used to designate paper stock having up to 35 to 40 % moisture by weight.

In the recovery of paper for recyling from a composite paper product such as corrugated board or from a physical mixture such as a combination of newspapers and magazines, there arises the problem of separating two kinds of paper having different properties and physical characteristics. At least a partial separation is essential to allow each type of paper to be reused in the most efficient and economical manner.

Although, as will be evident, the method of this invention is not limited to the processing of corrugated board, the problems which are faced in the industry may be illustrated with reference to the handling of this well-known paper composite product. Corrugated board is formed as a corrugated medium between and adhered to two outside layers of linerboard. The corrugated medium and linerboard serve two distinct and different roles and are therefore formed of two distinct and different types of paper. The corrugated medium must be highly crush-resistant and have a high degree of stiffness. It is formed of so-called "semichemical" hardwood fibers which generally make up at least 80 to 85 percent of the corrugated medium. The corrugated medium paper is as a result of its composition and purpose an unsized, highly water-receptive material. In addition, this material has comparatively low-strength characteristics when compared with linerboard.

In contrast to the corrugated medium, the linerboard is formed of unbleached, softwood kraft pulp. The fibers are relatively long, the linerboard is sized, exhibits a relatively low degree of water receptivity and high puncture resistance. It will be seen that if these paper constituents of corrugated board are recovered as a single, mixed material, the recovered fibers are not ideally suitable for serving as either corrugated medium or as linerboard since each must possess distinct and different characteristics. Typically, a corrugated board will comprise some 84 pounds of linerboard per one thousand square feet, 36 to 38 pounds of corrugated medium and some 6 pounds of starch used primarily as an adhesive.

At present there is no known commercially available, practical process for separating the liner from the medium component in the recycle of old corrugated contains. An experimental method now under evaluation for separating these two paper constituents in corrugated board involves a wet process in which some 5 % by weight of hammermilled corrugated board is thoroughly mixed into about 95 % by weight of water and beaten under high energy conditions to form an all-fiber slurry. Subsequent to this, the two types of fibers are separated by centrifuging the fiber slurry. It will be apparent that this requires in addition to handling a large quantity of water (which may be recycled) the processing of wet fibers to separate the two different fiber types.

As another example for the need for an efficient and economical method for separating paper constituents, the recovery of newsprint may be cited. Newsprint itself is generally free from any sizing and is highly water receptive. However, in the collection of old newspaper, a number of magazines get mixed in and these are generally formed of papers which are highly sized and coated, and which have relatively low water receptivity. In order to reuse the newsprint in the usual well-known manner to make recycled newsprint and the like it is necessary to remove a substantial portion of the paper which is not newsprint. Hand sorting of the material prior to the newsprint recovery process is not economical and a wet process of separation is not currently available.

It will be seen from these two illustrative situations that it would be desirable to have a method for separating two different paper constituents which are to be reused, each for a different purpose.

It is therefore a primary object of this invention to provide an improved method for separating and recovering two different paper constituents so that each constituent may best be used for the purpose for which it is recovered. It is another object to provide a method of the character described which is an essentially dry process and which does not require the separation of two types of fibers from large masses of wet fibers. It is yet another object of this invention to provide a method for the recovery of the two types of paper making up corrugated board in forms such that each type may be reprocessed and used in the same role in reconstituted corrugated board formation as originally used. This invention has as an additional object the providing of chemical additives that will facilitate the differential size reduction of the component parts by weakening one component and/or strengthening the other component. Still an additional object is to provide a method of the character described which enables magazine paper to be effectively separated from newsprint in the recycling of papers. Other objects of the invention will in part be obvious and will in part be apparent hereinafter.

By the method of this invention the corrugated board or mixture of newspapers and magazines is first reduced to small pieces, i.e., one to several square inches in area, and then chemical additives including a debonding liquid which may contain urea, ethylene carbonate, wetting agents, etc., uniformly distributed over the paper pieces. The quantity of debonding liquid is maintained at a level which is no greater than 50 % by weight of the paper treated. Immediately or shortly after the application of debonding agent the paper is subjected to a differential size reduction treatment so that a substantial proportion of the unsized, water-receptive constituent is reduced to fine pieces of the order of 1/4 inch on a side while the paper constituent which is sized and which is not readily receptive to water remains essentially in its original size, e.g., one to several square inches in area. The fractions are then separated out, preferably in a suitable air separator, in an essentially dry condition. In the case of corrugated board, partial delamination to break a portion of the adhesive bond between the linerboard and the corrugated medium is desirable, and some physical treat-

ment such as dry heating may be used to enhance the debonding process.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the composition possessing the features, properties and relation of constituents, which are exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

The method of this invention may now be described in further detail. The paper feed, e.g., corrugated board is first reduced to small pieces several inches (i.e., 1 to 6 inches) in either dimension. This may conveniently be done in a shredder or in a hammermill or by a rotary cutter. If the paper is corrugated board it may in some instances be desirable to subject these pieces to some physical treatment, such as dry heat, which will help to break the adhesive bonds between the linerboard and the corrugated medium. such heating should, of course, not be performed at a temperature or for a time which would cause any appreciable thermal degradation of any of the fibers making up the paper feed. This step of physical treatment is an optional one.

Where the paper feed is corrugated board, the next step is the partial delamination of the pieces to expose at least a portion of the corrugated medium (unsized, highly water receptive component). It is not necessary to remove all of the linerboard from the corrugated medium and normally about 70 % delamination is sufficient. Since the linerboard is normally adhered to the corrugated medium by means of some suitable adhesive, e.g., starch, some physical treatment, such as the optional dry heating step mentioned, may be used to break the adhesive bonds before delamination. If the paper feed being processed is a mixture of newspaper and magazines, then the delamination step, along with the optional step of physical treatment, is eliminated.

The purpose of the debonding liquid is to act on the unsized, water-receptive constituent, e.g., the corrugated medium of corrugated board or the newsprint in a mixture with magazine paper. The debonding liquid is applied as a solution in which the concentration of the active debonding agent ranges between about 2 and about 10 % by weight. Normally the solvent will be water; but such nonpolar water-miscible liquids as alcohols and the like may also be used. Since the debonding agent is to act selectively on the unsized, water-receptive paper constituent and since the resulting separated materials are to be discharged in an essentially dry state it is necessary that the amount of debonding agent which is uniformly distributed over the milled or shredded material be controlled. Therefore, the amount of debonding liquid applied to the paper feed should range between about 20 and about 50 % by weight of the paper feed. Moreover, the quantity of debonding liquid used and the concentration of the debonding agent in the debonding liquid should be adjusted so that from about 1 to about 3 % by weight of debonding agent based on paper feed weight is applied.

The liquid component of the debonding liquid serves as a lubricant as well as a deterent to the build-up of static electricity in the subsequent step of fiberizing in which at least a major portion, i.e., more than 60 percent of the unsized, waterreceptive constituent is reduced to fibers. The debonding agent comprises one or more components which are capable of destroying or materially reducing the hydrogen bonds in the paper constituent to be reduced to fibers. Exemplary of suitable debonding agents are urea, ethylene carbonates and surfactants (anionic or nonionic) or mixtures of these materials. In a typical mixture the ratio of urea to ethylene carbonate may range from about 1 to 3 to about 3 to 1, and the surfactant may be present in an amount ranging from about 0.1 to 1 % by total weight of the urea and ethylene carbonate. This debonding agent is conveniently dissolved in water to form the debonding liquid.

The debonding liquid may be applied to the paper feed in any manner suitable for attaining substantially uniform distribution of the liquid over the surfaces of the paper pieces. The spraying of the debonding liquid in the form of a fine mist into a stream of the milled paper pieces as they are discharged from the hammermill or shredder into the differential size reduction equipment is exemplary of one way in which such uniform application may be achieved.

Once the debonding liquid is applied to the milled paper pieces, the next step of differential size reduction follows within a short time, and preferably it follows immediately. Thus the selective size reduction should be begun not later than about 10 minutes after application of the debonding liquid.

In another embodiment of the method of this invention, an additional chemical agent may be added to the paper pieces which will preferentially strengthen the less water-receptive constituent of the mixture. As an example, a 2 % boric acid solution may be sprayed onto the paper pieces to gelantize the starch coating which is present on the magazine component pieces of No. 1 waste news. The application of an effective amount of this additive serves to increase the strength of the starch coated paper thereby making it less susceptible to the subsequent differential sizing treatment.

The controlled and selective mechanical size reduction of a waste paper mixture or composite material is preferably carried out in a low-energy input mill apparatus such as a Micro Bud (Trademark) mill or apparatus similar in construction and operation to a Waring blender. The purpose of this step of differential size reduction is to reduce a large portion of the unsized, more water-receptive constituent into small pieces (e.g., 1/4 inch or less) while retaining the sized, less water-receptive constituent in essentially its originally cut size. Thus in the case of the recovery of corrugated board, the corrugated medium being unsized and having readily absorbed the debonding liquid is reduced to small pieces while the linerboard remains substantially intact. In simiar fashion, the difference in water receptivity and size content between newsprint and magazines is taken advantage of to reduce a substantial portion of the newsprint to very small pieces. A minor portion of the linerboard fraction, say between about 10 and 30 % of its original weight, may be reduced to small pieces and may be removed with the corrugated medium fraction. However, this quantity of soft wood kraft material may be mixed with the semi-chemical hardwood of the corrugated medium for reprocessing to form so-called "bogus medium" or it may be added to virgin semichemical pulp to make corrugated medium.

In applying the method of this invention to separating newsprint and magazines up to about 20 % of the news-

print may be removed with the magazine fraction and still provide an economical recovery system. It is, of course, preferable in all cases to carry out as complete a separation of the constituents as is possible.

Subsequent to the step of differential size reduction, which may be a continuous or a batch operation, the resulting mixture of small pieces of paper and those pieces which have not been appreciably reduced in size is subjected to particle classification and separation. This is conveniently done by passing the mixture through an air separator such as a so-called Segradyne separator wherein the small lighter peices are borne out on an air stream as one fraction and the remaining larger pieces are removed as a second fraction. Both fractions after separation are essentially dry because of the relatively small quantity of debonding liquid used. the ability to achieve effective separation with a limited amount of debonding liquid is, in turn, attributable to the combination of steps used which take advantage of the difference in the physical and chemical characteristics of the paper constituents being separated and recovered.

In a similar manner, paper components containing fibrous or plastic film contaminants such as asphalt-laminated gummed tape and polyethylene film can be removed from the recycled product by the method of this invention. The stronger asphalt tape and plastic film containing pieces will remain essentially the same size as the magazine component of a magazine-newsprint mixture feed when subjected to the differential size reduction step. Therefore, it is possible to separate papers containing such contaminants along with the magazine fraction.

The method of this invention may be further described with reference to the following example which is meant to be illustrative and not limiting.

Samples of old corrugated boxes were cut into 1 1 inch × 1 inch squares with a paper cutter. The squares of corrugated board were placed in a Waring blender (dry) to delaminate the linerboard and medium fractions. A 10 % by weight solution of urea in water containing 0.2 % by water weight of a nonionic surfactant was made up as a debonding liquid. An amount equivalent to 40 % by paper stock weight of this debonding liquid was applied to the delaminated pieces of corrugated board. This quantity of debonding liquid provided a urea pick-up of about 2½%.

The pieces of board moistened with the debonding liquid were then subjected to the action of the Waring blender for about 5–10 seconds. As a result of this mechanical differential size reduction the corrugated medium was reduced to small (1/4 inch or smaller) pieces while the linerboard fraction remained essentially intact.

This differentially sized material was then placed in an air separator to segregate the pieces of linerboard from the smaller pieces of corrugated medium. In the air separator, the corrugated medium fraction was collected as the "accepts," i.e., the lighter fraction, and the linerboard fraction was collected as the "rejects," i.e., the heavier fraction.

Physical strength measurements were made on handsheets of paper formed from these two fractions. In forming these hand sheets the two recovered fractions were disintegrated and dispersed in accordance with TAPPI standard procedure No. 410 for forming papermaking furnishes. The hand sheets were made on a Noble-Wood laboratory apparatus from these furnishes and the physical data, given in Table 1, were obtained by standard procedures.

Table 1

Physical Properties of Hand Sheets

Sample Identification	Basis Wt. gm/m²	Freeness Canadian Std-ml	Burst psi	Tensile Kg/15mm	Tear gm
Control—Aggregate Material	2.76	670	10.0	1.27	69.7
Linerboard Fraction	2.71	655	10.0	1.53	71.2
Corrugated Medium Fraction	2.71	690	6.2	1.03	45.2

From the data given in Table 1, which also includes the physical data on a handsheet formed of a fiber mixture recovered from corrugated board, it will be seen that an effective separation was made between the two kinds of fibers used in forming the corrugated board. This is particularly evident from the tensile and tear strength data.

In a similar manner, magazine cover stock was mixed with newsprint and torn into 1 inch × 1 inch pieces. The previously described solution of debonding agent was sprayed onto the pieces to produce about a 40 % moisture pick-up (2.5 % urea pick-up by weight of paper). The treated pieces were then subjected to the shearing action of the Waring Blender for about 5 seconds. As in the case of the corrugated board, the difference in the physical characteristics of the two constituents made it possible to retain most of the stronger, more water-resistant component (magazine fraction) essentially intact while reducing the size of the more water-receptive and weaker component (newsprint fraction) to form small pieces. The two fractions were separated one from the other by the air separation technique previously described.

The method of this invention provides an essentially dry process for separating paper constituents which is based upon differences in water receptivity and physical strength. The elimination of the need to form a paper slurry elimates the need to handle wet pulp and to recycle large quantities of water.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description are efficiently attained and, since certain changes may be made in carrying out the above method without departing from the scope of the invention, it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

We claim:

1. An essentially dry method of separating for recovering and recycling two paper constituents which differ in water receptivity, comprising the steps of

a. reducing the paper material to be separated to pieces having maximum dimensions no greater than six inches;

b. uniformly distributing an effective amount of a debonding liquid over the pieces formed to selectively debond the fibers in the more water receptive component, said amount being no greater than about 50 % by paper weight;

c. subjecting the pieces from step (b) without any additional liquid to differential size reduction whereby the pieces of the more water-receptive constituent are reduced to fibers and small pieces no greater than about 1/4 inch in dimension while the major portion of the less water-receptive constituent remains essentially intact; and

d. separating out said fibers and small pieces as essentially dry material from said less water-receptive constituent which is also in an essentially dry condition.

2. A method in accordance with claim **1** wherein the amount of debonding liquid is equivalent to between about 20 and 50 % by weight of said paper material.

3. A method in accordance with claim **1** wherein said debonding liquid is water.

4. A method in accordance with claiam **1** wherein said debonding agent comprises an aqueous solution of an active debonding material which is urea, ethylene carbonate, or mixtures thereof, the concentration of said active debonding material ranging between about 2 and 10 % by weight of the water used in forming said aqueous solution.

5. A method in accordance with claim **4** wherein said active debonding material is a mixture of urea and ethylene carbonate in a weight ratio ranging from about 1 to 3 to about 3 to 1 and said debonding liquid contains a surfactant in an amount equivalent to form about 0.1 to 1 % by total weight of said urea and ethylene carbonate.

6. A method in accordance with claim **1** wherein said two paper constituents are the linerboard and the corrugated medium of corrugated board.

7. A method in accordance with claim **6** wherein said differential size reduction is carried out until at least from about 70 to about 90 weight percent of said corrugated medium is reduced to said small pieces.

8. A method in accordance with claim **6** including the step of partially delaminating the corrugated board subsequent to step (a) thereby to expose said corrugated medium.

9. A method in accordance with claim **8** wherein said corrugated board is subject to physical treatment prior to said step of partially delaminating thereby to enhance the action of said debonding agent.

10. A method in accordance with claim **9** wherein said physical treatment comprises dry heating.

11. A method in accordance with claim **1** wherein said two paper constituents are newspapers and sized magazine paper.

12. A method in accordance with claim **11** including the step of adding to pieces formed in step (a) an agent capable of gelatinizing the sizing on said magazine paper thereby to render it even less water receptive.

13. A method in accordance with claim **1** wherein at least a portion of said less water-receptive constituent comprises contaminants such as asphalt-gummed tape, plastic films and the like.

14. A method in accordance with claim **1** wherein no longer than **10** minutes elapses between the performance of step (b) and step (c).

15. A method in accordance with claim **1** wherein said step of subjecting said pieces to differential size reduction is carried out in a low-energy level input mill.

16. A method in accordance with claim **1** wherein said step of separating out said fibers and said small peices comprises carrying off said fibers and small pieces in a dry air stream.

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