United States Patent

Dorsey et al.

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[54] **WATER RESISTANT CORRUGATED ARTICLES HAVING IMPROVED FOLD FLEXIBILITY**

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Related U.S. Application Data

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[52] **U.S. Cl.** **229/3.1**, 117/92, 229/DIG. 4

[51] **Int. Cl.** **B65d 25/14**

[58] **Field of Search** ....229/3.1, 37, DIG. 4, 3.5; 117/45, 92, 158, 155; 93/49

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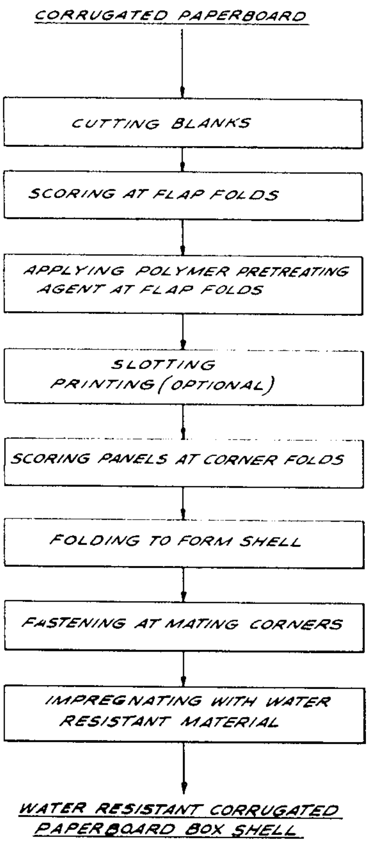
[57] **ABSTRACT**

A method for forming a flexible fold in corrugated paperboard rendered water resistant by impregnation with a solidifiable water proofing agent that imparts rigidity to the paperboard in which the fold is first treated with a non-rigid polymer pretreating agent prior to impregnation and a water resistant corrugated article having folds rendered flexible by this method. The method is particularly useful in manufacturing water resistant corrugated paperboard boxes having improved fold flexibility.

10 Claims, 6 Drawing Figures



Patented May 2, 1972

3,659,772

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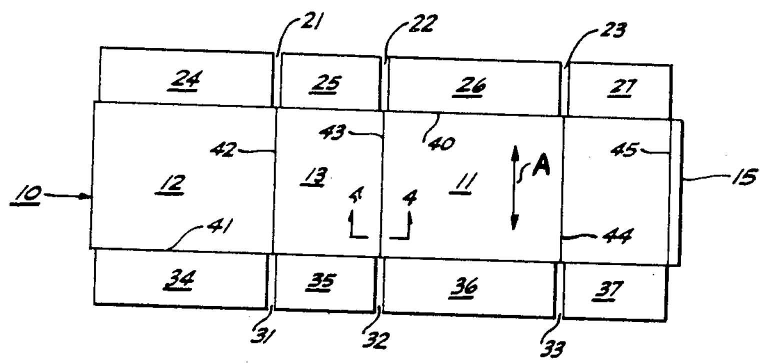

FIG-3

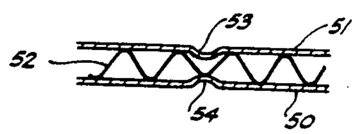

FIG-4

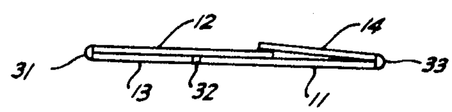

FIG-5

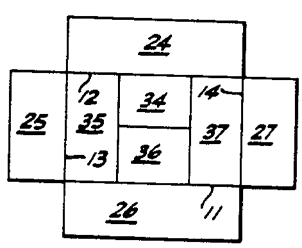

FIG-6

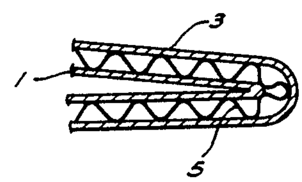

FIG-1

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3,659,772

2 Sheets-Sheet 2

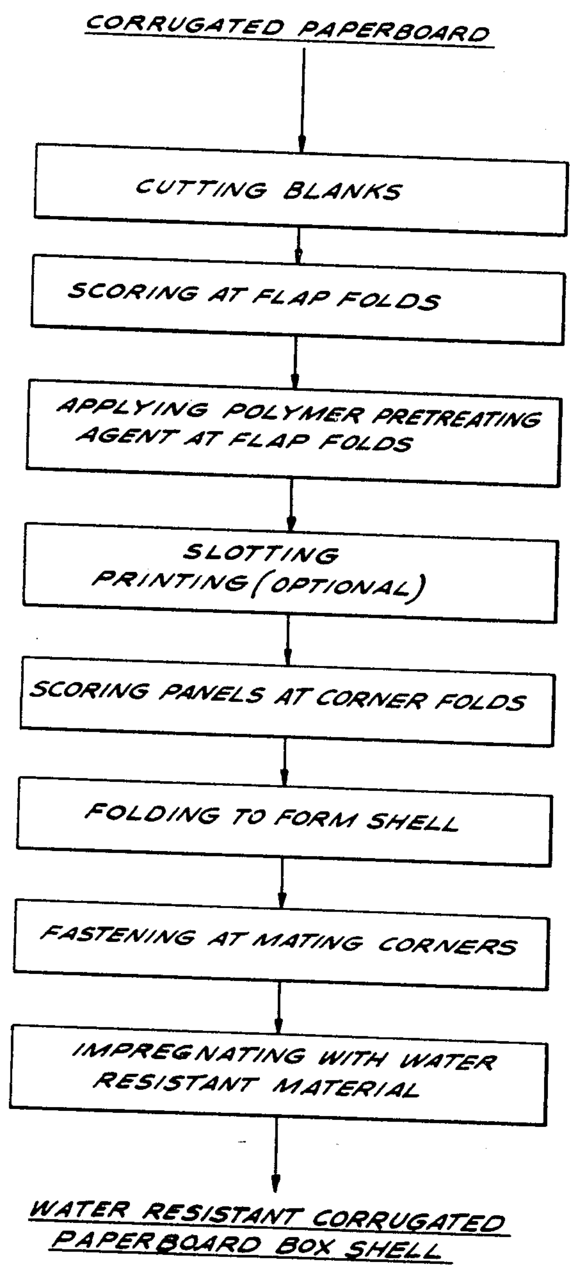

FIG-2

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WATER RESISTANT CORRUGATED ARTICLES HAVING IMPROVED FOLD FLEXIBILITY

This is a division of application Ser. No. 539,749 filed Apr. 4, 1966, now U.S. Pat. No. 3,529,516, patented 9-22-70.

This invention relates to corrugated paperboard articles rendered water resistant by impregnation with wax and wax-polymer compositions that impart rigidity to the paperboard, and more particularly to water-resistant corrugated paperboard boxes having improved fold flexibility.

Corrugated paperboard has found wide use in a variety of applications where a relatively inexpensive, intermediate strength structural material is required, the manufacture of inexpensive storage and shipping containers constituting one of the primary high volume uses of this material. However, a major deficiency of conventional corrugated paperboard is its poor durability and strength when wet, which limits the type of goods suitable for handling in these containers and necessitates special precautions to prevent exposure of the container to moisture during storage and shipment. To overcome this problem, a corrugated paperboard product which exhibits superior strength on exposure to moisture has been developed. Moisture resistance is achieved by impregnating corrugated paperboard with a waterproofing agent, such as wax or wax-polymer compositions. The impregnated product retains substantial wet strength, even when contacted with liquid water, thus permitting shipment of wet goods and eliminating the necessity of protecting the carton from external water.

Water resistant fiberboard boxes formed from this impregnated corrugated paperboard, sometimes called wet pack boxes, have been found particularly useful in the storage and shipment of certain produce and other perishable goods as the commodity can be iced without damage to the boxes. In one application, water resistant boxes containing the perishable goods are loaded into refrigerated railroad cars or trucks and the entire cargo packed in ice. In another application, crushed ice is placed directly into the boxes, either before or after packing the perishable commodity. In either case, boxes manufactured from this impregnated corrugated paperboard are substantially unaffected by water from the melting ice, thereby maintaining their body and shape during transit and affording convenient means of handling the perishable goods at the destination.

Water resistant fiberboard boxes are conventionally mass produced from flat paperboard roll stock by one or more automatic or semi-automatic machines performing a series of sequential steps which corrugates the raw paperboard and transforms it into finished boxes ready for assembly. Water resistant boxes, like most fiberboard boxes, are usually produced and distributed collapsed into flat shells ready for final assembly at the point of use.

Both water resistant and ordinary corrugated fiberboard boxes are conventionally manufactured by substantially similar methods. However, in an additional step, the water resistant boxes are impregnated with waterproofing agent, usually by dipping the collapsed shell into a bath of molten waterproofing agent and allowing excess material to drain therefrom. The waterproofing agent solidifies on cooling to form a water resistant solid. The saturation technique of waterproofing is superior to other techniques wherein only a coating of water resistant material is deposited on the surface of the paperboard. With the saturation application, the waterproofing agent penetrates into the paperboard in considerable quantity to form a cohesive structure of paperboard and solidified waterproofing agent. The waterproofing agent, particularly in the case of wax-polymer compositions, imparts increased strength and rigidity to the paperboard in addition to rendering it water resistant. The degree of saturation of the paperboard with the waterproofing agent depends on the absorptivity of the paperboard, the soaking and draining times, the properties of the waterproofing agent, and the dip and drain temperatures. These variables are normally controlled so that the paperboard is partially saturated with waterproofing agent, the degree of saturation depending on an economic

balance between the improvement desired and the cost of the waterproofing agent.

As in the case of conventional boxes, the collapsed water resistant fiberboard shells are prepared for use by opening the collapsed shell into a rectangular box shape, and closing and sealing the bottom flaps. The box is then filled and subsequently closed by folding and sealing the top flaps. The assembly, filling and closing steps are frequently performed by machine operation, although these operations can also be accomplished wholly or in part by hand.

While conventional boxes in most cases have been satisfactorily assembled, filled and closed in the aforedescribed manner, a serious problem has resulted in the assembly and closure of water resistant fiberboard boxes. It has been found that the impregnated corrugated fiberboard used in the manufacture of water resistant boxes often will not withstand the bending necessary to assemble, fill and close the box without rupture or tearing of the paperboard. While some failure of the panel and bottom flap folds has been experienced, the most acute problem is failure of the top flap folds since, in most cases, these flaps suffer more severe flexing. In a typical operation the top flaps are folded outward either 90° or 180° to afford easier access into the top of the box during the filling operation, and then are closed by a reverse fold of either 180° or 270°, depending on the magnitude of the initial fold. The bottom flap and panel folds are normally flexed to a lesser degree, although even so, bottom flap and panel score cracking is not uncommon.

In practice, the impregnated paperboard facings have been found to rupture and tear along the fold lines during the assembly and filling operation to the extent that the box must be discarded, often requiring the additional costly step of manually transferring the goods to a new container. It is not unusual that a flap will be completely torn from the box on bending. More seriously, a fold will be sufficiently weakened that the box will structurally fail during transit, causing loss or damage to the contained goods. Thus, not only does fold failure cause poor appearance, but these failures also have increased the cost of using water resistant fiberboard boxes and curtailed a wider acceptance of these containers. The foregoing problem is not limited to a single box manufacturer, but has been more or less universally encountered by all manufacturers of water resistant corrugated fiberboard boxes, despite the fact that a variety of corrugated fiberboards and waterproofing materials have been employed.

Accordingly, it is an object of the present invention to provide an article constructed of water resistant corrugated paperboard that has improved fold flexibility. Another object of the invention is to provide a water resistant corrugated paperboard box having improved fold flexibility. Another object of the invention is to provide a corrugated paperboard box impregnated with a solidifiable waterproofing agent which imparts increased rigidity to the corrugated structure, the box having the fold lines treated to retain flexibility, especially where the fold is transverse to the flutes of the corrugated paperboard. A still further object of the invention is to provide an improved water resistant corrugated fiberboard box. An even further object of the invention is to provide an improved water resistant corrugated fiberboard box. A yet further object of the invention is to provide a wax or wax-polymer impregnated corrugated fiberboard box shell having flexible folds that can be readily assembled into a box form.

These and other objects of the invention will be apparent to those skilled in the art from the following description and from the appended drawings in which the same numerals refer to corresponding parts throughout and wherein:

FIG. 1 is a schematic illustration of the structural deformation caused by bending the corrugated paperboard;

FIG. 2 is a schematic diagram illustrating the steps of manufacturing water-resistant corrugated paperboard boxes in accordance with the method of this invention;

FIG. 3 is a plan view of a box blank;

FIG. 4 is a cross-sectional view of a scoreline taken along line 4—4 of FIG. 3;

FIG. 5 is a side elevation view showing the edge of the collapsed box shell obtained by folding the box blank; and

FIG. 6 is a top view of an assembled water-resistant corrugated box.

Briefly, in accordance with the present invention, the bending quality of a corrugated paperboard impregnated with a solidifiable material which imparts increased rigidity to the paperboard can be improved in designated areas by treating the paperboard within these areas prior to impregnation with various polymer materials, and subsequently exposing the paperboard to the impregnant for a controlled short time period. The pretreated areas of the paperboard exhibit greater flexibility after solidification of the impregnant than do the untreated areas, thus forming areas of greater flexibility in an othersive substantially more rigid paperboard structure. Flexible folds can be formed in a sheet of substantially rigid impregnated paperboard by treating the paperboard at the desired fold line with a selected polymer material prior to impregnation. A fold formed by this method can withstand many flexures at the fold line without tearing of the paperboard or rupture of the solidified impregnant. This technique is particularly adapted to the manufacture of corrugated fiberboard boxes rendered water resistant by impregnation with wax and wax-polymer compositions which impart increased rigidity to the paperboard, as both the top and bottom flap folds and the panel folds can be readily treated prior to impregnation. Consequently, subsequent impregnation of the paperboard with the waterproofing material yields a corrugated fiberboard box having both a high degree of water resistance and flexible folds.

A substantially rigid corrugated paperboard structure can be folded along crease or score lines either parallel with or transverse to the flutes of the corrugating medium. The line along which the fold is made is a substantially straight line extending completely across the material being folded. The term "bending quality" as used herein is intended to mean the ability of a substantially rigid corrugated paperboard to bend or fold along these lines so that adjacent sections of a unitary piece of corrugated paperboard situated on opposite sides of a fold line are movable with respect to each other. A corrugated paperboard having good bending quality is capable of being repeatedly flexed or folded without tearing or damage of the structure to the point that the paperboard is seriously weakened.

The method of this invention is generally useful in forming flexible folds in any corrugated paperboard subsequently impregnated with a material which renders the paperboard more rigid and brittle than the untreated board. Corrugated paperboards susceptible to impregnation generally include those having one or more layers of corrugating medium adherently attached to flat facings. Commercial corrugated fiberboard structures suitable for impregnation include single face construction wherein a single corrugating medium is adherently attached to a single flat facing, single wall (double faced) construction wherein a single medium is interposed between two exterior facings, double wall construction formed by three flat facings having a medium disposed between each of the facings, and triple wall construction formed by four flat facings and three intermediate corrugating mediums alternately disposed therebetween. The adherent layers are usually glued together with water soluble starch, although a less soluble modified starch is preferred in the case of corrugated fiberboard produced for water resistant box construction.

A corrugated paperboard useful in the manufacture of water resistant boxes comprises a light weight corrugated paper adherently interposed between two relatively light weight flat sheets of paperboard. It is to be understood that the thickness of the various individual members can be selected to impart the necessary strength to the corrugated paperboard product, the term "relatively light weight" being employed to indicate that the thickness or gage of the component materials is relatively small as compared to the thickness of the ultimate structure. The faces of a single wall (double faced) corrugated paperboard are often of different weights, with the heavier material usually being placed on the interior of the box. In general, the minimum paper weight employed in corrugated paperboard for water resistant box construction is 26 pounds per thousand square feet. The combined weight of facings usually ranges between 52 and 264 pounds per thousand square feet of corrugated paperboard, and between 52 and 180 pounds per thousand feet for single wall (double faced) paperboard.

The thickness of a corrugated paperboard is dependent upon the thickness of the facings and the flute construction. Flutes have been commercially standardized by prescribing the flute height and the number of flutes per foot. Type A-flutes are three-sixteenths inch in height with approximately 36 flutes per lineal foot, type B-flutes are three thirty-seconds inch in height with approximately 51 flutes per lineal foot, and type C-flutes are nine sixty-fourths inch in height with approximately 42 flutes per lineal foot. Other types of flute construction are also employed in special applications. The total thickness of the corrugated structure can vary from approximately three thirty-seconds inch to about nine-sixteenths inch for heavy triple wall construction.

When a corrugated paperboard is folded, the inside face (relative to the fold) is sharply flexed on a radius of the magnitude of the thickness of the face material. Although there is a sharp bend or flexure of the face material, the fibers of the paper are not greatly stretched. The corrugating medium is subjected to a very complicated series of distortions, depending in part on whether the fold is parallel or transverse to the direction of the flutes. The outer face of the corrugated paperboard (again relative to the fold) is flexed over a larger radius than the inside face, the radius of flexure being up to 30 times the thickness of the face material depending upon the construction of the particular fiberboard. However, although the bending radius is less severe, the outside face must stretch a substantial distance. The length of the semicircle over which the outside face must stretch for a 180° bend is indicated as follows for various thicknesses of corrugated paperboard:

Thickness, Inches	Approximate Length of semicircle, Inches
3/32	0.29
1/8	0.39
5/32	0.49
3/16	0.59

It is apparent that the stretch required increases markedly with the thickness of the paperboard.

The structural effects encountered when corrugated paperboard is folded parallel to the direction of the flutes, is illustrated in FIG. 1 wherein there is shown a typical single wall corrugate comprised of interior facing 1, exterior facing 3, and corrugated member 5 folded through an angle of approximately 180°. Interior facing 1 is flexed sharply at the fold, outer facing 3 is flexed over a much larger arc, and corrugated number 5 is at least partially collapsed. Similar structural effects are encountered when the corrugate is folded normal to the direction of the flutes.

In a desirable product the paper in the outside face and absorbed waterproofing material, either within the paper or on its exterior surface, must stretch without tearing. The exact amount of paper which participates in this stretching is not known, but observations suggest that only fibers quite close to a line directly opposed to the inside bend line participate in the stretching phenomena. When a very hard and brittle board is folded, there is very little stretch before rupture. A relatively sharp and straight break is created extending the full width of the piece subject to bending. In commercially desirable water resistant corrugated paperboards, stretching occurs for the full width of the piece with no tearing of the paper or rupture of the waterproofing material. In intermediate cases, small tears of various lengths appear in the section subjected to stretching. It is apparent that when a corrugated paperboard is subjected to reverse bending, the opposite result is effected with the unstretched face formerly on the inner side of the fold then subjected to stretching.

The ability of the paper fibers to stretch on bending of the paperboard is decreased as the degree of saturation of the paperboard with solidifiable impregnant is increased. While the degree of saturation can be controlled by varying the impregnating conditions, a product having satisfactory rigidity and wet strength usually cannot be obtained by decreasing the saturation of the entire board sufficiently to achieve the flexibility required at the folds. It is therefore advantageous to saturate corrugated paperboard with solidifiable impregnant sufficiently to obtain an impregnated board having the requisite properties, while providing supplemental treatment only in those areas where substantial flexibility is desired. The pretreatment technique of this invention is therefore desirably employed only in those areas in which the improved bending quality is required, such as along fold lines and the like.

Although the exact mechanism by which the pretreatment method of this invention functions to increase the flexibility of a corrugated paperboard impregnated with a solidifiable material which imparts rigidity to the paperboard is not completely understood, it is believed that the various polymer materials useful in the practice of this invention reduce the rate of absorption of impregnant in the treated area by forming a film or coating of adherent barrier material upon at least a portion of the paper fibers in the treated area. On the subsequent exposure of both the treated and untreated areas of the paperboard to impregnant for a limited short time period, the treated areas of the paperboard having the reduced absorption rate will absorb less impregnant than the adjacent untreated areas. Thus, the net result of the pretreatment and the subsequent impregnation is to produce a corrugated paperboard having selected areas impregnated to a lesser degree than the bulk of the paperboard. However, despite any uncertainty as to the theoretical aspects of this method, it has nevertheless been demonstrated that treatment of a corrugated paperboard with a suitable agent prior to impregnation effects sufficient flexibility retention that the paperboard exhibits good bending quality after impregnation.

Materials found useful in the practice of this invention are polymers capable of application in a liquid form so as to penetrate into the paper and form a viscous liquid or elastic, non-rigid solid or semi-solid adherent film or coating of material on at least a portion of the paper fibers in the treated area. Particularly useful materials are those which form adherent coatings which are substantially immiscible with the impregnant. By substantially immiscible it is meant that the coating is not readily miscible with the impregnant to the extent the coating is substantially or completely dissolved by the impregnant during the period of impregnation. Thus, coating materials can be employed which are soluble in the impregnant, providing that the solubility rate is limited.

Polymers suitable for the pretreatment of impregnated corrugated paperboard are preferably nontoxic, odor-free and translucent when applied to the paperboard. A material which is capable of materially reducing the absorption rate of the impregnant, but which itself imparts substantial rigidity to the paperboard is generally unsatisfactory. Thus, an important characteristic of the pretreating material is that it not impart substantial rigidity to the paperboard. Another characteristic of practical consideration is that the material itself possess low volatility, and that it be capable of application without the use of highly volatile solvents, thereby eliminating a potential fire hazard from the treating operation.

A number of hydrocarbon polymers exhibit the foregoing properties and are generally useful in imparting flexibility to an impregnated corrugated paperboard. Among the useful hydrocarbon polymers are various relatively low molecular weight polyolefins, such as for example polyethylene, polypropylene, polybutylene, and the like, varying in consistency from viscous liquids to non-rigid or elastic semi-solids. A particularly preferred class of polyolefin are those having a substantial proportion of isoalkene monomer units, such as isobutylene. Preferred polyisobutylenes are highly paraffinic hydrocarbon polymers composed of long straight-chain molecules having terminal unsaturation only. Polyisobutylene polymers vary in consistency from highly viscous liquids to rubbery solids depending on the molecular weight, which can vary from about 10,000 to about 135,000. One particularly preferred polyisobutylene is a viscous liquid having a molecular weight within the range of from about 10,000 to about 11,700.

Another preferred hydrocarbon polymer useful in imparting flexibility to an impregnated corrugated paperboard is polyterpene, and particularly a polyterpene melting within the range of about 15° C. to about 35° C. and exhibiting a melt viscosity of 1 centipoise at a temperature within the range of from about 115° C. to about 130° C.

Still another hydrocarbon polymer material exhibiting the foregoing properties and which is useful in the practice of this invention is a polystyrene melting within the range of between about 15° C. and about 35° C. and exhibiting a melt viscosity of 1 centipoise at a temperature of between about 75° C. and about 100° C.

The pre-impregnation treating materials of this invention can be successfully applied by any one of a number of convenient techniques. It is within the scope of this invention to apply the polymer in liquid form, molten if necessary, directly onto the areas to be treated. Another method useful for the application of solid polymer is to apply the polymer as a powder directly onto the outer surface of the corrugated paperboard, and then to subject this material to sufficient heat to melt or fuse the polymer causing it to penetrate into the paperboard and to form an adherent coating on the paper structure which solidifies on cooling. Melting can be accomplished by applying the polymer powder onto a hot board maintained at a temperature sufficient to melt the polymer, or the board having applied polymer powder can be passed through a heated zone to melt the polymer. In another embodiment, solid polymer can be applied as a strip, e.g., as a continuous tape applied in selected locations on the surface of the paperboard. The solid polymer is then heated to fuse the material and cause it to penetrate into the paperboard and to form an adherent coating in the area selected for treatment.

In a preferred method of application, the pretreating agent is dissolved in a suitable low volatility solvent and applied to the paperboard in liquid form. The solvent is absorbed by the paper, leaving a residue or deposit of pretreating agent. Although the treating material need be diluted with only sufficient solvent to obtain a material of suitable consistency for application and which is capable of readily penetrating into the paperboard, superior results can be obtained in most applications with a solution containing not more than about 50 weight percent of polymer material. Preferred solvents for the aforementioned polymer materials are mineral oil and molten wax, or mixtures of the two. In a preferred application, between about 5 and about 50 weight percent of polymer can be dissolved in mineral oil and/or molten wax and applied to the paperboard in the areas selected for treatment. An even more preferred range of polymer treating agent concentration is between about 10 and about 30 weight percent.

The foregoing liquid polymers and polymer solutions are applied to a corrugated paperboard by heating the mixture above their melting points to obtain a homogeneous liquid mixture of reduced viscosity, and applying this liquid to the area to be treated. Application temperatures are typically within the range of about 50° F. to about 400° F. While many solutions can be satisfactorily applied at room temperature, superior results can usually be attained, particularly with more viscous solutions, by heating the material prior to application to a temperature within the range of about 150° F. to about 400° F. Application can be made by brush, roller, wick, or the solution can be sprayed onto the paperboard. In a preferred embodiment, the solution is applied to either side of a sheet of corrugated paperboard in an area to be accorded reduced rigidity. The quantity of treating material applied is controlled to attain the desired reduction in absorptivity. The exact application rate can best be determined by several test runs performed on samples of the paperboard treated and impregnated under conditions simulating the commercial operation. A corrugated paperboard treated in the foregoing manner and subsequently impregnated with a solidifiable impregnant can be folded in the treated area without tearing or rupture of the paper or impregnant, yet the paperboard, as a whole, is afforded increased rigidity and water resistance.

Accordingly, compositions for application to selected areas of a corrugated paperboard prior to impregnation to impart flexibility to the impregnated board consist of viscous liquid or elastic solid hydrocarbon polymers dissolved in mineral oil and/or molten wax. A preferred composition contains between about 5 and about 50 weight percent of the above-described polyolefin, polyterpene, or polystyrene polymers. An even more preferred composition contains between about 10 and about 30 weight percent polymer.

In a further preferred mode of practicing the method of this invention, the corrugated paperboard is scored along the desired fold line to facilitate bending. Scoring is accomplished by compressing the corrugated paperboard along a desired fold line sufficiently to stress the material at the fold beyond its yield point so that permanent deformation occurs which weakens the structure sufficiently to facilitate folding of the material along the desired line without unnecessary loss of strength. The scoring operation should not be sufficiently extreme as to produce a cut or tear in the facing material, yet must be sufficient to cause the necessary deformation of the paperboard. Scoring can be accomplished by any one of a number of commercially practiced methods whereby the paperboard is deformed in various configurations, the depth and width of the score line being controlled to produce desired results. A score line regarded as commercially satisfactory to impart increased flexibility to a corrugated paperboard used for conventional box construction, can usually be combined with the treatment of this invention to impart flexibility to impregnated corrugated paperboard. Scoring can be readily accomplished, in most cases, either prior to or after application of the pretreating composition.

The method of this invention is useful in improving the bending quality of a corrugated paperboard impregnated with any solidifiable material which imparts increased rigidity to the corrugate structure. Solidifiable materials found useful in increasing the water resistance of corrugated paperboard include various waxes, such as paraffin waxes derived from petroleum, and mixtures of these waxes with minor proportions of a polymer capable of improving various properties of the wax. Preferred compositions found useful in impregnating corrugated paperboard to improve its water resistance generally include a major proportion of a refined paraffin wax; a minor proportion of a polymer such as polyethylene, or the like; and a small amount of various additives imparting improved properties to the solidified composition. The polymer content of the mixture is typically between about 2 and about 20 weight percent, and the additive content less than 1 weight percent.

As previously disclosed, the method of this invention has particular application in the manufacture of water resistant corrugated fiberboard boxes. Corrugated fiberboard boxes are conventionally manufactured on a commercial scale by an integral process in which flat paperboard roll stock is corrugated and formed into box shells. Although a wide variety of corrugated paperboards and box designs can be employed in the construction of commercial water resistant corrugated fiberboard boxes, the bulk of these boxes are of the self-enclosing RSC (Regular Slotted Container) design constructed from a single piece of single wall (double faced) corrugated consisting of two outer facings and an intermediate fluted member. Three paperboard roll stocks are formed into an integral structure by a continuous corrugating machine which forms the corrugating medium into a series of arched trusses and attaches the flat paperboard facings to the medium with adhesive applied at the tips of the flutes. Conventional corrugators used to manufacture corrugated fiberboard for box construction are frequently equipped to score the material in a direction normal to the flutes of the medium and to cut the fiberboard into blanks of appropriate size, thus performing the first steps of the actual box-making operation. The transverse score lines produced on the corrugator extend the length of the blank and define two spaced flap sections on either side of an intermediate panel section.

The scored box blank is subsequently passed to machines which slot the blank normal to the flap score with slots extending from the outer edge of the blank to the score line so as to subdivide each flap section into four flaps. The slots in each of these flap sections are situated opposed to a corresponding slot in the other flap section. The slotted blank is scored parallel with the flutes to form score lines extending across the panel section between opposed slots. If desired, breathing vents, drain holes, hand grips, and the like can be cut into the blank. Also various advertising or identification can be printed onto the blank, the printing being oriented so that it will be properly displayed on assembly of the box.

At this stage of manufacture, the box comprises a flat sheet of paperboard having four opposed flaps on either side of an intermediate panel section subdivided by parallel score lines into side and end panel sections. The flaps are defined by the slots and transverse score lines extending the length of the panel section. The score lines facilitate bending of the paperboard on assembly of the box.

The box shells are formed by folding the blank along the panel score line situated at approximately its midpoint so that the blank is essentially folded double, or alternatively, by folding two end sections toward the middle so that the mating end sections are at an intermediate point of the flat shell. The overlapping mating ends of the panel section, having a lip cut for this purpose, are joined by gluing, stapling, or the like, to form the manufacturer's joint which is located adjacent one corner of the box. At this point the shell is conventionally dipped into a liquid reservoir of the molten waterproofing agent for a controlled length of time, and then removed therefrom and allowed to drain for a specified period at a controlled temperature.

The foregoing method of manufacturing water-resistant corrugated paperboard boxes is more fully illustrated in FIG. 2 wherein there is shown the sequence of steps of (1) cutting a corrugated paperboard to obtain a substantially rectangular box blank; (2) scoring at the flap folds normal to the direction of the flutes; (3) applying polymer pretreating agent at the flap folds; (4) slotting the blank to form the flaps; (5) optionally scoring at the corner folds parallel to the flutes; (6) folding the blank; (7) fastening the mating corner section to form a collapsed shell; and (8) impregnating the collapsed shell with molten waterproofing agent. Where printing is desired it is preferably performed simultaneously with the slotting step.

One embodiment of box blank formed in accordance with the method of this invention is illustrated in FIG. 3 wherein there is shown a generally rectangular blank **10** of corrugated paperboard from which a folding box or carton can be assembled. The blank is usually cut so that the flutes are in a vertical direction when the box is assembled, which direction is indicated in FIG. 3 by arrow A. The blank includes an integral front panel **11**, back panel **12**, right hand (relative to the front of the box) end panel **13**, and left hand end panel **14**. Lip **15** is adjacent to and integral with end panel **14**. Slots **21, 22** and **23** are provided to define top flaps **24, 25, 26** and **27**. Opposed slots **31, 32** and **33** define bottom flaps **34, 35, 36** and **37**. The blank is scored at **40** and **41** normal to the direction of the flutes to facilitate folding of the flaps. Also, the blank can be optionally scored along the lines **42, 43, 44** and **45** in a direction parallel to the flutes to facilitate folding at the corners. A suitable score is illustrated in FIG. 4 wherein there is shown a section of single well corrugated paperboard comprised of interior face 50, exterior face 51 and corrugated member 52 deformed at 53 and 54 to facilitate folding. It is to be understood that in accordance with the method of this invention, the aforementioned scores can be treated with polymer pretreating agent at any point of the manufacturing step prior to impregnation of the corrugated paperboard with the waterproofing agent. As illustrated in FIG. 5 the blank is formed into a collapsed box shell by folding along the score lines 42 and 44 and fastening the abutting ends at lip 15. FIG. 6 illustrates one mode of assembling the impregnated collapsed shell into a water-resistant box, shown here with the top flaps opened.

The corrugated paperboard can be treated by the method of this invention along score lines at any stage of the box manufactured prior to the impregnation step. Either selected folds can be pretreated, or all of the folds can be so treated. As a practical matter, it is often convenient in many operations to pretreat the flap folds immediately upon scoring, and to subsequently pretreat the panel folds in a separate operation prior to folding the blank to form the shell. Further, the pretreatment can be accomplished with equal facility prior to the scoring operation. The particular choice of sequence largely depends upon the equipment available and the preference of the operator.

While the resulting product of the foregoing process is a self-enclosing water resistant corrugated box, it is apparent that by only slight manipulation of the process techniques within the skill of the art, various water resistant corrugated fiberboard containers and products can be produced.

In another aspect, this invention pertains to water resistant corrugated fiberboard boxes impregnated with solidifiable waterproofing materials, which boxes have folds rendered flexible by limiting the absorption of waterproofing material in the fold areas according to the method of this invention.

The invention is further described by the following examples which are illustrative of various embodiments thereof, but which are not intended as limiting the scope of the invention.

EXAMPLE 1

A flat piece of commercial single wall corrugated fiberboard 12 inches by 12 inches in size having 42 pound faces and a 33 pound medium corrugated in type A-flutes is commercially scored with a wide score normal to the flutes and tested for flexibility. The flexibility test consists of folding the fiberboard along the score line so that it is flexed through an angle of 180°, reversing the fold so that the fiberboard is flexed 360° in the opposite direction, and then repeating with successive 360° folds in alternating directions until the test sample has been flexed a total of twenty times. The appearance of the material at the score is then observed and found to be in good condition with no visible tears.

A duplicate piece of corrugated fiberboard is impregnated with a waterproofing agent comprising a mixture of 94.7 weight percent paraffin wax melting between about 130° F. and about 134° F., 5.0 weight percent of polyethylene polymer, and 0.3 weight percent of a flexibility improving additive. Impregnation is accomplished by submerging the board in a body of molten water-proofing agent maintained at 250° F. for 60 seconds, and then draining for 3 minutes at a temperature of 230° F. After cooling to solidify the impregnant, the impregnated board is subjected to the above flexibility test with the result that it tears along the fold prior to completion of the test.

Another duplicate piece of the corrugated fiberboard is impregnated by the above method; however, prior to impregnation the board is treated by painting the score on both faces with a viscous liquid polybutene polymer. Both the treating agent and the board are at room temperature at the time of application. The polybutene polymer employed in this test is manufactured by the American Oil Company and marketed under the trade name Amoco L–100. Approximately one-half hour is required for the cold polymer material to penetrate into the paperboard, after which time the board is impregnated. The impregnated board is subjected to twenty flexures without tearing of the paper or rupture of the waterproofing agent.

EXAMPLE 2

A flat piece of commercial single wall corrugated fiberboard 12 inches by 12 inches in size having 42 pound faces and 33 pound medium corrugated in type A-flutes is commercially scored with a narrow score normal to the flutes and impregnated by the method described in Example 1. This board is tested for flexibility by bending at the score line with the result that it tears along the fold prior to completion of the test.

A duplicate piece of corrugated fiberboard is impregnated by the above method; however, prior to impregnation the board is treated by painting both faces along the score with a polymer treating solution. This solution is applied at a temperature of approximately 300° F. The polymer solution is a mixture of 25 weight percent polystyrene polymer marketed by the Pennsylvania Industrial Chemical Company under the trade name Piccolastic A–25 in approximately 75 weight percent of light mineral oil. The hot liquid readily penetrates into the paperboard. The impregnated board is subjected to twenty flexures without tearing of the paper or rupture of the waterproofing agent.

EXAMPLE 3

The test of Example 2 is repeated on a commercial corrugated fiberboard 12 inches by 12 inches in size having 69 pound faces and 33 pound medium corrugated in type–A flutes. The board is commercially scored normal to the flutes with a wide score. A sample of the board impregnated without score treatment is tested for flexibility by bending at the score line with the result that the board tears along the fold prior to completion of the twenty flexure test.

A duplicate sample of the corrugated fiberboard is treated prior to impregnation by painting both faces of the board along the score line with a polymer treating solution applied at a temperature of 300° F. The polymer solution of this example is a mixture of 25 weight percent polyisobutylene marketed by the Enjay Chemical Company under the trade name Vistanex LM-MH and about 75 weight percent of light mineral oil. The treating solution readily penetrated into the paperboard. The impregnated board is subjected to twenty flexures without tearing of the paper or rupture of the waterproofing agent.

EXAMPLE 4

Another duplicate piece of the corrugated paperboard described in Example 3 is treated prior to impregnation by painting both faces of the board along the score line with a polymer treating solution applied at a temperature of 300° F. The polymer solution of this Example is approximately 12.5 weight percent polyisobutylene marketed by the Enjay Chemical Company under the trade name Polyisobutylene B–60, 37.5 weight percent paraffin wax, and 50.0 weight percent light mineral oil. This composition is conveniently prepared by dissolving Tervan 2800, also a product of the Enjay Chemical Company, in mineral oil. Tervan 2800 is a mixture of approximately 25 weight percent Polyisobutylene B–60 and wax. On application, the hot treating solution readily penetrates into the paperboard. The impregnated board is subjected to twenty flexures without tearing of the paper or ruptures of the waterproofing agent.

EXAMPLE 5

Still another duplicate piece of corrugated paperboard described in Example 4 is treated prior to impregnation by painting both faces of the board along the score line with a polymer treating solution applied at a temperature of 300° F. The polymer solution of this example is a mixture of approximately 25 weight percent polyterpene and 75 weight percent light mineral oil. The polyterpene is marketed by the Pennsylvania Industrial Chemical Company under the trade name Piccolyte S–25. Following this pretreatment, the board is impregnated and subjected to twenty flexures without tearing of the paper or rupture of the waterproofing agent.

Having fully described our invention, we claim:

1. In a corrugated paperboard article rendered water resistant by impregnation with a water proofing agent that imparts increased rigidity to the paperboard, the improvement which comprises flexible folds in said corrugated paperboard formed by treating the paperboard in a confined area along the folds prior to impregnation with said water proofing agent with a polymer pretreating agent that penetrates into the paperboard.

2. The article defined in claim 1 wherein said water proofing agent is wax and/or a wax-polymer composition.

3. The article defined in claim 1 wherein score lines are formed on said corrugated paperboard at said folds.

4. The article defined in claim 1 wherein said polymer pretreating agent is polyolefin, polyterpene or polystyrene.

5. The article defined in claim 1 wherein said polymer pretreating agent is polyisobutylene.

6. The article defined in claim 1 wherein said polymer pretreating agent is polybutylene.

7. In a corrugated paperboard box rendered water resistant by impregnation with wax and wax-polymer compositions that impart increased rigidity to the paperboard, the improvement which comprises flexible folds in said paperboard along which said paperboard is folded during the assembly and use of the box, said folds being rendered flexible by scoring the paperboard along a desired fold line and treating the paperboard in a confined area along the fold prior to impregnation with said wax and wax-polymer compositions with a polymer pretreating agent that penetrates into the paperboard selected from the group consisting of polyolefins, polyterpenes and polystyrenes.

8. In a water resistant corrugated paperboard box of the type comprising a single sheet of corrugated paperboard cut to obtain a unitary member consisting of side and end panel sections having integrally formed top and bottom enclosing flaps and impregnated with a solidifiable waterproofing material selected from the group consisting of wax and wax-polymer compositions, the improvement which comprises top flap folds treated in a confined area along the folds prior to impregnation with said wax and wax-polymer compositions with a polymer pretreating agent that penetrates into said paperboard, said pretreating agent being selected from the group consisting of polyolefin, polyterpene and polystyrene.

9. The article defined in claim 8 including bottom flap folds treated in a confined area along the folds with said pretreating agent prior to impregnation.

10. The article defined in claim 8 including panel folds between said side and end panels treated in a confined area along the folds with said pretreating agent prior to impregnation.

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