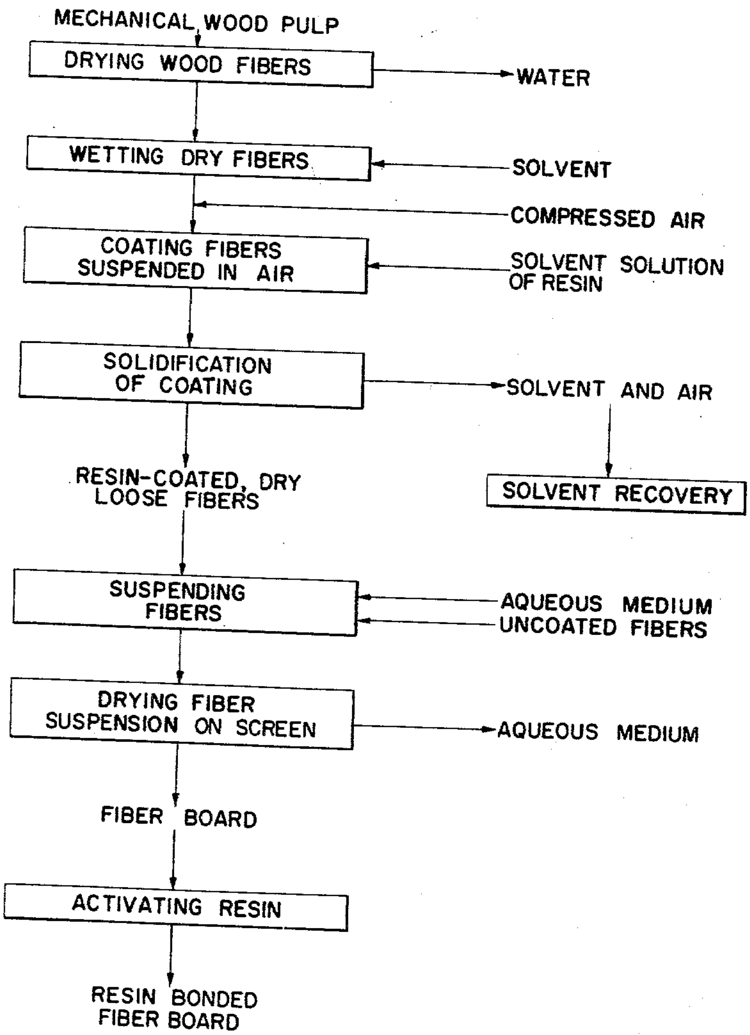
COATING FIBERS DISPERSED IN GASEOUS CARRIER WITH A BONDING AGENT AND PAPER MADE THEREFROM

Filed Oct. 17, 1960



INVENTORS
RICHARD THIER
THEODOR PLOETZ
BY Kelman and Berman
AGENTS

United States Patent Office 3,173,829 Patented Mar. 16, 1965

3,173,829

COATING FIBERS DISPERSED IN A GASEOUS CARRIER WITH A BONDING AGENT AND PAPER MADE THEREFROM

Richard Thier, Buderich, near Dusseldorf, and Theodor Ploetz, Hosel, Kreis Mettmann, Germany, assignors to Feldmuhle Aktiengesellschaft, Dusseldorf-Oberkassel, Germany, a corporation of Germany

Filed Oct. 17, 1960, Ser. No. 62,879
Claims priority, application Germany, Oct. 21, 1959, F 29,665
11 Claims. (Cl. 162—141)

This invention relates to the manufacture of paper and paper-like products from fibrous raw materials, and more particularly to a process for manufacturing such products from precoated fibers.

Paper is largely made from cellulosic material, and this term will be understood to include not only relatively pure cellulose as represented, for example, by cotton linters, but materials which contain an appreciable percentage of impurities, such as mechanical or chemical wood pulp, and other raw materials of vegetabilic origin which largely consists of hemicellulose. Paper produced entirely from mechanical pulp lacks mechanical strength and is practically without utility. Even inexpensive grades of paper, such as newsprint, are therefore produced from a fibrous raw material in which approxmiately 10 to 20 percent of a relatively pure cellulose are admixed to the wood pulp. Without such an admixture the strength of the paper would frequently not be adequate for permitting the sheet formed to be conveyed through the papermaking apparatus. The fibrils of the relatively pure cellulose interlock with other fibers to form a felt-like structure.

It is a primary object of the invention to provide a paper-making process which does not, or not necessarily rely on the felting action of the raw material itself, and thus permits paper and paper-like materials to be made from a wide range of raw materials having desirable properties but not in themselves capable of being consolidated into sheets by usual paper making procedure.

Another object of this invention is to provide a method of bonding fibers of a raw material into a continuous sheet wherein the fibers are individually coated with a substantially continuous coating of bonding agent.

A further object is the provision of a process which concentrates the bonding agent on the fiber surface and thus achieves maximum bonding effect with a minimum amount of bonding agent.

With these and other objects in view, the process of the invention mainly consists in dispersing the fibers of the raw material in a gaseous carrier, forming a liquid coating of bonding agent on the dispersed fibers from a dispersion of a homogeneous liquid phase containing the agent which is water insoluble; solidifying the bonding agent on the fibers while the latter are still dispersed in the carrier; and then making paper from the suspended fibers in any known manner, for example, by suspending the coated fibers in an aqueous medium from which the water is removed on a Fourdrinier screen or otherwise. The sheet obtained is then bonded on the dry end of the paper machine itself or in a separate operation where the bonding agent is activated by heat or pressure, or both.

According to a known method, sizing is added to cellulose fibers from which paper or paper-like products are to be manufactured before the fibers are suspended in an aqueous medium during a conventional paper-making process. It has been proposed to add water-insoluble waxy materials, such as paraffine, to the pulp after digestion, and preferably during dehydration by impregnation of the sheets of pulp. When the pulp is comminuted in the paper factory, the sizing remains in the fibers. It

is also known to impregnate the dry chips from which wood cellulose is made with water-insoluble substances so that the fibrous material produced by mechanical comminution of the chips will be pre-charged with a sizing agent. Both known processes aim at avoiding the precipitation of sizing from a mixture of the pulp dispersion with a sizing dispersion by acidification. This conventional process is undesirable because of the required operation in an acid medium.

The afore-mentioned known processes are intended to improve the ink resistance of the paper, that is, to reduce the absorptive properties of the paper to such an extent that it may be used for writing with ink. The known methods fully succeed in this respect since the impregnant is made to penetrate the interior of the individual fibers so that mechanical comminution after impregnation does not destroy the effectiveness of the wax-like material although large new surface areas of relatively low impregnant concentration are formed.

The present invention also contemplates making paper and paper-like materials on substantially conventional paper making machinery from fibers which were previously loaded with addition agents. A basic feature of this invention resides in the novel method of combining an addition agent which serves as a binder with the fibers in such a manner that the binder is concentrated on the surface of the fiber and covers the latter substantially completely. The binder deposited in such a manner provides a firm bond between the individual fibers with a minimum quantity of addition agent.

In its more specific aspects the invention charges the fibrous raw material for paper manufacture while suspended in a gaseous medium with a binder which is insoluble in water, and which has been transformed into a liquid either by heating beyond its melting point or by dissolution in a suitable solvent. The binder is transformed on the still suspended fibers by cooling or by evaporation of the solvent, or by both, into a state in which it has no adhesive properties and is not tacky whereupon the fibers are suspended in water in the usual manner prior to paper making. When the fibrous web formed passes through the dry end of the paper making machine, the binder is temporarily plastified by heat, pressure, or both, and the fibers of the web are bonded to each other.

It is essential for the economy of the briefly described process of the invention that the binder adhere to the surface of the fibers and cover that surface over the largest possible area. It is preferred for this reason to employ fibers which are readily wetted by the liquid or liquefied binder. In the case of wood or cellulose fibers wettability is enhanced by predrying the fibers or by impregnating them so that the binder will form a thin coating over the greatest possible portion of the fiber surface.

In the conventional sizing process in which the sizing is precipitated from a joint suspension with pulp by means of acid the sizing also is deposited on the fiber surface. The precipitated particles, however, retain their approximately spherical shape and make contact with the fiber surface in areas so small as to provide practically point contact between the fiber and the sizing particles which are held to the fiber surface by electrostatic attraction. The coating produced is far from being continuous, and a substantially complete envelope cannot be achieved even with very large amounts of sizing deposited by precipitation.

The method of the invention is also basically different from a known felting process in which fibers coated with a liquid binder are collected on a support and bonded by the liquid and adhesive material into a felted body. It is essential for the process of the invention that the fibers loaded with a binder are made to loose their adhesiveness before they are collected so that they are obtained in a loose condition so that they may be readily dispersed in an aqueous medium without disturbing their surfaces and the film of binder deposited thereon. The binder particles remain firmly adhered to the fiber surface and cannot be removed with the excess water on the screen of the paper making machine.

The process of the invention has particular utility for the bonding of fibers which do not tend to interlock to form a felt-like structure, or which interlock very weakly. Products made from such fibers by the method of the invention owe their cohesive strength exclusively or predominantly to the binder. The process of the invention thus permits making a paper the fibrous ingredients of which are essentially pure mechanical pulp without the usual addition of 10% to 20% of pure cellulose. Such paper has adequate mechanical strength for newsprint. The cost of the very small amount of binder sufficient for this purpose is only a fraction of the otherwise necessary expense for pure cellulose. It will be appreciated that fibers coated with a binder by the process of the invention may be jointly dispersed in an aqueous medium with uncoated fibers, and that paper or paper-like products of good strength may be made from the mixture.

The process of the invention is illustrated on the attached flow diagram in one of its more specific aspects, and will be further described by reference to specific examples of procedures which may be performed on conventional paper-making apparatus.

Example I

As indicated in the flow diagram, mechanical wood pulp is pre-dried in a continuous oven and discharged into a bin where it is sprayed with a solvent mixture of equal volumes of benzene and ethyl acetate so as completely to wet the surfaces of the fibers. Wetting is facilitated by the immediately preceding drying operation.

The wetted fibers are blown from above into a closed coating chamber and a solution containing 50% butyl polyacrylate resin in a mixture of equal volumes of benzene and ethyl acetate is sprayed onto them at such a rate that equal weights of pulp and polyacrylate on a dry basis are fed during the same time to the chamber. The polymer solution impinges on the fiber surfaces and spreads uniformly over them substantially without penetrating into the interior of the fibers.

The temperature of the polyacrylate solution is 50° C. when it leaves the spray nozzle. Because of the friction encountered by the suspension of fibers in compressed air, the temperature of the air stream is also somewhat above ambient temperature, approximately 35° C. During the downward movement of the fibers through the chamber, the solvent mixture evaporates substantially completely, and the coating solidifies while the fibers are still separated from each other by air, and the fiber surfaces are no longer tacky when the fibers eventually collect in a heap on the chamber bottom.

The dry resin coated fibers are withdrawn from the chamber in loose form and are transferred to a vat for suspension in an aqueous medium in a conventional paper-making process. The solvent bearing air discharged from the chamber is stripped of its solvent content in a condenser and a major portion of the solvent is reclaimed.

The coated particles are mixed in the vat with an equal weight of uncoated wood pulp and the slurry obtained is dried on a screen and finally between heated rollers at such a rate as to produce a thin cardboard weighing 120 grams per square meter. The temperature of the heated rollers is higher than the softening temperature of the butyl polyacrylate binder so that the coating on the fibers is activated by the heat and pressure to bond the coated fibers to each other and to the uncoated fibers admixed prior to paper-making proper. In order to avoid adhesion of the board to the heated rollers, the latter are preferably coated with polytetrafluoroethylene.

The mechanical properties of the cardboard produced

are at least equal to those of a board obtained from the same mechanical pulp by conventional paper making methods with the addition of 20% of pure cellulose derived from wood. While the manufacture of cellulose from wood yields only 40 to 50% of the original weight of the wood as cellulose, the method of the invention makes use of the full weight of the wood from which the raw material is derived, and thus saves a natural resource the depletion of which has already become a matter of concern to economists.

The paper board produced can readily be formed into permanent shapes by the application of heat and pressure which restore the fluidity of the binder. The flat product of the paper making machine may thus be transformed into seamless containers by hot drawing or pressing. The material is also amenable to forming by processes more commonly associated with plastic sheet forming, such as vacuum molding. Upon cooling, the original rigidity of the board is restored.

The main field of application for the board produced by the process of this example is in packaging. The flat board may be surfaced with a layer of paper or otherwise coated as in chrome imitation board. The flat board or the three-dimensional products shaped from it may be lacquered or otherwise coated to give them desired resistance properties for holding goods which attack card board.

Substantially the same results are obtained by replacing the butyl polyacrylate in the process described by an equal weight of a commercial mixture of polyacrylic acid esters. Most other synthetic thermoplastic materials may be employed as binders, and polyethylene has been found to be particularly suitable when used in benzene as a solvent in which the resin is adequately soluble at 90° C.

Thermoplastic materials for the purpose of this process also include the A-stages of many thermosetting resins such as phenol-formaldehyde resins or urea-formaldehyde resins which are still soluble or fusible. When thermosetting resins are employed in the early stages of their condensation reaction, it is possible to harden the flat sheets obtained from the paper making machine, or the containers formed from the sheets by subsequent application of heat or of hardening agents. The shaped product will then be relatively immune to heat distortion.

While batch withdrawal of coated fibers from the coating chamber bottom has been mentioned in this illustrative example of the invention, it will be understood that the coated fibers may be continuously withdrawn from the bottom of the coating chamber, and equipment for such continuous operation will readily suggest itself. The fibers may be dropped on a bucket conveyor in the chamber which passes through the wall of the chamber in sealing engagement therewith, or they may be dropped into water forming a liquid seal at the chamber bottom, and be removed together with a portion of the water. If loss of solvent with the gaseous carrier is not an important consideration, special precautions against escape of air from the coating chamber are not necessary.

The amount of resin to be mixed with the fibers in the coating chamber and the amount of untreated fibers to be mixed with the coated fibers in the vat may be varied at will to achieve the desired mechanical properties. A reduction of the ratio of resin to fiber in the final product will in all events reduce mechanical strength.

Example II

Cellulose fibers are predried as described in Example I, and are then introduced into the coating chamber without preliminary wetting. A concentrated solution of acetylcellulose in acetone is injected into the chamber at a temperature of 50° C. to coat the cellulose fibers in the same manner as described above. The solvent evaporates completely in the chamber and is reclaimed from the exhaust gases. The rate of bonding agent injected is such that the fibers collected at the bottom of the chamber consist to one half of cellulose and to one half of acetylcellulose.

The coated fibers are mixed with fine rayon fibers of 6 to 10 mm. length in equal amounts, and an aqueous suspension of the mixed fibers is fed to the paper making machine. The bonding coating of acetylcellulose is softened or partially fused at the dry end of the paper machine and the fibers are bonded to each other.

The paper board produced is well suited for packaging purposes, and particularly for the packaging of food because of its chemical intertness. The bonding agent content of 25% is amply adequate to provide the required mechanical strength.

The board produced may be postformed in the manner described in Example I when the bonding agent is softened by soaking in a volatile plasticizer such as acetone which is again removed in its entirety by the application of heat after forming.

Example III

Mechanical wood pulp is coated by a thermoplastic bonding agent substantially in the manner described in Example I. The coating treatment differs only in the use of a high electrical voltage for promoting deposition. An electrostatic field of approximately 2,000 v./cm. is applied between the fibers and the particles of the dispersed bonding agent. The charge of equal sign on the fibers keeps the fibers apart and makes them more readily accessible to the droplets of bonding agent. The electrostatic charge also causes more uniform deposition of the bonding agent solution than could otherwise be obtained by the movement of the fibers and liquid droplets under their kinetic energy only. The electrostatic field is not strong enough to interfere with movement of the fibers through the coating chamber.

The fibers coated with the aid of an electrostatic field are then processed in the manner described in Example I.

Example IV

Fibers of mechanical pulp are thoroughly dried and are then blown into the coating chamber by a stream of air the temperature of which is adjusted to keep the chamber temperature near 75° C. Fused low pressure ethylene is simultaneously dispersed in the chamber from a nozzle located near the top of the chamber at one half of the rate of pulp supply.

The polyethylene is deposited on the fibers at a temperature sufficiently high to permit the individual particles to spread over the fiber surface, yet low enough to cause the coating to congeal and to loose its tackiness completely as the fibers collect at the bottom of the chamber from where they are removed in loose condition.

The coated fibers may then be directly made into a fiber-board, or they may be mixed with uncoated pulp in the manner described in the preceding examples.

The fibers coated by the process of the invention differ in their structure from coated fibers prepared by immersion in solutions of bonding agents or by treatments of any kind with suspensions of insoluble bonding agents in aqueous media. It is virtually impossible to control the distribution in depth of a bonding agent which is applied to loose fibers by immersion. The solution rapidly penetrates to a depth greater than is necessary for optimum bonding. In a bulk treatment of fibers, penetration cannot be readily controlled by shortening the time of immersion without risking incomplete coverage of a portion of the charge and grossly uneven coatings. Immersion methods thus are inherently wasteful of bonding agent.

Aqueous dispersions deposit the bonding agent in the form of small, substantially spherical particles which retain their discrete shapes even after they attach themselves to a fiber. The bond produced by such particles is limited to small areas, almost to points. The mechanical strength resulting is inferior to that produced by

equal amounts of the same bonding agent applied by the method of this invention.

Collision of a liquid droplet with a substantially dry fiber in the absence of a second liquid phase causes absorption of the droplet in a surface element which is substantially a hemisphere about the point of first contact. A multitude of droplets colliding with the fiber surface in the process of the invention thus produces a thin surface layer impregnated with bonding agent. A relatively small amount of bonding agent covers a large surface area. Virtually no bonding agent is lost, particularly when an electrostatic field is applied during deposition. Contamination of the water drained from the wire screen of the paper making machine with the bonding agent is entirely avoided.

Predrying of the fibers, impregnation of the fiber surface, or both improve the wetting and lateral spreading of the bonding agent on the fibers. When the bonding agent is applied in solution, the solvent employed or another solvent miscible therewith is preferred as the impregnant.

While the making of a paper product from cellulosic materials has been described for the purpose of illustration, it will be understood that the process of the invention is not limited to any specific fibrous material nor to any specific bonding agents. Many materials which may be employed to advantage in performing the process of the invention will readily suggest themselves to those skilled in the art.

The method of the invention is capable of modification in any manner known to the art of paper making and to related fields such as the manufacture of felt and non-woven fabrics, and the substitution of other known devices for the conventional paper making apparatus mentioned for the purposes of illustration is fully contemplated, and may obviously be resorted to by those skilled in the art without departing from the spirit and scope of the invention as hereinafter defined by the appended claims.

What we claim is:

1. A process for the manufacture of paper and paper-like products from a fibrous raw material, comprising the steps of dispersing solid fibers of a raw material in a gaseous carrier; feeding the dispersion formed to a treating zone; dispersing homogeneous liquid droplets of a bonding agent insoluble in water in said treating zone; depositing said droplets of bonding agent on said fibers in said treating zone to form a liquid coating of said agent on said fibers; solidifying said coating on the fibers while the same are dispersed in said carrier until said bonding agent is substantially deactivated; precipitating the coated fibers carrying the solidified agent from the carrier; suspending the precipitated fibers in an aqueous medium; spreading the resulting suspension on a support; substantially removing the aqueous medium from the spread suspension to form a fiber sheet; and activating said bonding agent to bond the fibers of said sheet to each other.

2. A process as set forth in claim 1, wherein said bonding agent is dispersed while fused to form said homogeneous droplets, and is solidified by cooling.

3. A process as set forth in claim 1, wherein said bonding agent is dispersed while dissolved in a volatile solvent, and is solidified by volatilization of said solvent.

4. A process as set forth in claim 3, further comprising the step of wetting said fibers with a second volatile solvent miscible with said first-mentioned volatile solvent prior to dispersing of said bonding agent for improved wetting of said fibers by said agent.

5. A process as set forth in claim 1, wherein said bonding agent is thermoplastic and activated by heat.

6. A process as set forth in claim 1, wherein said bonding agent is pressure sensitive and activated by pressure exerted on said sheet.

7. A process as set forth in claim 1, further comprising the step of drying said fibers prior to the dispersing

of said bonding agent for improved wetting of said fibers by said agent.

8. A process as set forth in claim 1, further comprising the step of charging the dispersed fibers and the dispersed bonding agent in said treating zone with electric charges of opposite polarity whereby said agent is electrically attracted to said fibers.

9. In a process for the manufacture of paper and paper-like products from a fibrous raw material, dispersing solid fibers of a raw material in a gaseous carrier; feeding the dispersion formed to a treating zone; dispersing homogeneous tacky liquid droplets of a bonding agent insoluble in water in said treating zone; depositing said droplets of bonding agent on said fibers in said treating zone to form a liquid coating of said agent on said fibers; detackifying said coating on the fibers while the same are dispersed in said carrier; suspending the coated fibers in an aqueous medium; substantially removing the aqueous medium from the resulting suspension in such a manner as to form a sheet of coated fibers; and activating said bonding agent to bond the fibers of said sheet to each other.

10. In a process as set forth in claim 9, admixing suspended fibers free of said bonding agent to said coated fibers suspended in said aqueous medium whereby said sheet of coated fibers contains said uncoated fibers mixed with said coated fibers; and said uncoated fibers are bonded to said coated fibers and to each other when said bonding agent is activated.

11. In a process as set forth in claim 10, at least a portion of said fibers being cellulosic.

References Cited by the Examiner

UNITED STATES PATENTS

1,326,287	12/19	Raymond	162—183
1,889,642	11/32	Davis	162—183
1,970,426	8/34	Levin	162—168
1,996,082	4/35	Powell	162—152
2,077,720	4/37	Seigle et al.	161—122
2,686,141	8/54	Sawyer	264—24
2,737,179	3/56	Dahle	162—182
2,772,157	11/56	Cilley et al.	162—164
3,013,525	12/61	Fuller et al.	117—100
3,035,525	5/62	Mathews	162—145

DONALL H. SYLVESTER, *Primary Examiner.*

RICHARD D. NEVIUS, MORRIS O. WOLK, *Examiners.*