

Feb. 26, 1974

C. HARMON
METHOD OF MAKING ISOTROPIC FIBROUS WEBS
CONTAINING TEXTILE LENGTH FIBERS
Filed March 26, 1969

3,794,557

Fig. 1.

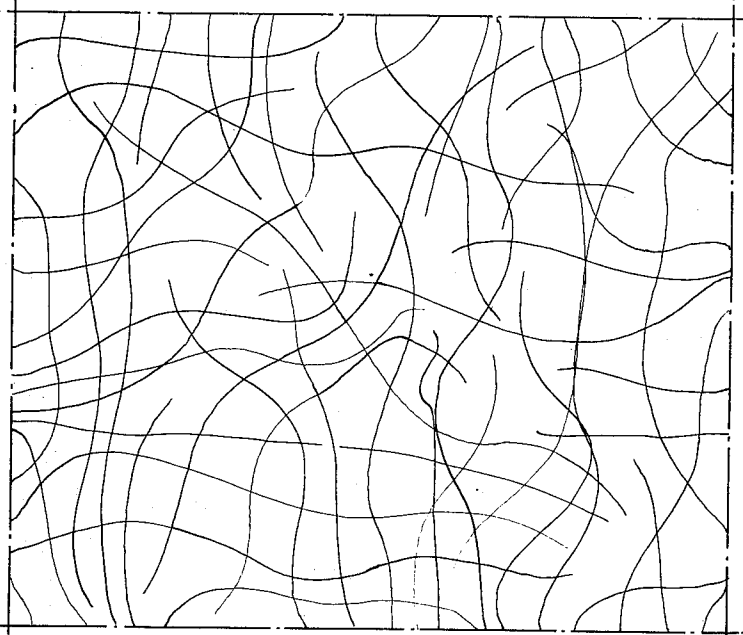
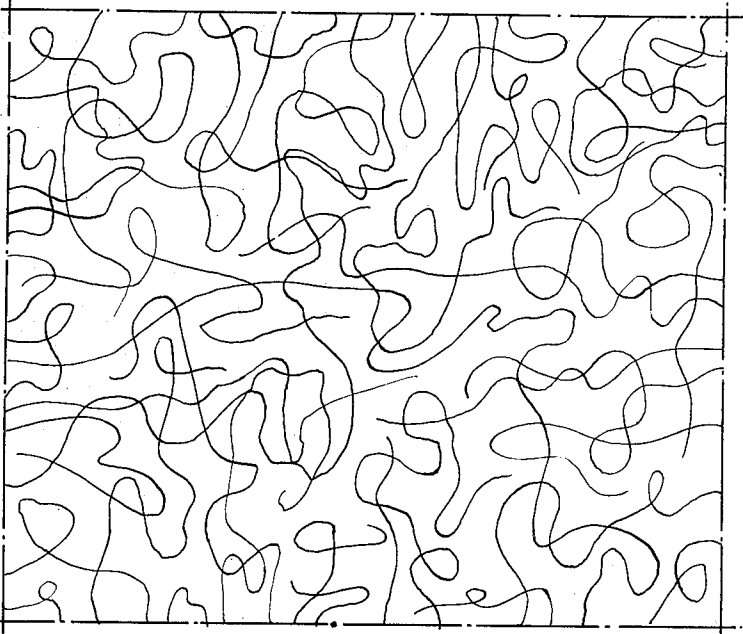


Fig. 2.



INVENTOR
CARLYLE HARMON
BY *Alexander T. Kardos*
ATTORNEY

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METHOD OF MAKING ISOTROPIC FIBROUS WEBS CONTAINING TEXTILE LENGTH FIBERS

Carlyle Harmon, Scotch Plains, N.J., assignor to

Johnson & Johnson

Filed Mar. 26, 1969, Ser. No. 810,573

Int. Cl. D21h 5/12

U.S. Cl. 162—157 C

1 Claim

ABSTRACT OF THE DISCLOSURE

Fibrous webs containing textile length rayon fibers which are substantially straight and unidirectional and have few, if any, portions which sharply reverse in direction, said fibers having a denier of less than about 3 and preferably about $1\frac{1}{2}$ or 1 and a length of at least about $\frac{1}{2}$ inch and preferably at least about $\frac{3}{4}$ inch or 1 inch, said fibrous webs being made by adding said textile length rayon fibers to aqueous media containing a synthetic, extremely high molecular weight, linear polymeric, water soluble, hydrophilic dispersing agent to form an aqueous fiber slurry, and forming a fibrous web from said aqueous fiber slurry on paper making equipment, said fibrous webs being isotropic and possessing excellent uniformity insofar as density and appearance are concerned, and well suited for further processing into nonwoven fabrics having excellent tear resistance and tensile strength.

The present invention relates to isotropic fibrous webs of excellent uniformity of density and appearance and comprising substantially straight, unidirectional, textile length rayon fibers having a denier of less than about 3 and preferably about $1\frac{1}{2}$ or 1, and an average length of at least about $\frac{1}{2}$ inch up to about 2 inches and preferably at least about $\frac{3}{4}$ inch or 1 inch; and to improved methods of making the same.

Many people have been engaged for many years in the manufacture of nonwoven textile fabrics which can be made without resorting to the spinning of fibers into yarns and strands, or the weaving, knitting or other fabrication of such yarns and strands into fabrics or cloth. The nonwoven fabrics have usually been manufactured by laying down one or more layers of textile length fibers, and then bonding or cementing the fibrous layers into a self-sustaining non-woven textile fabric.

The most common approach hitherto has been to lay down one or more layers of textile length fibers by textile carding techniques which generally align the majority of the fibers more or less lengthwise of the layer being laid down. This leaves a minority of the fibers generally crosswise of the layer being laid down, whereby the strength in the cross direction is considerably less than that in the long direction and which occasionally is inadequate for the purposes intended. Also, the tear resistance in the long direction has been on the low side, notably because of the fiber orientation in that direction. Additionally, the fibers of the layer laid down, and even those laid down in the long direction, are not straight or unidirectional, but often curve, twist, and meander, possess hook-shaped portions, as well as other portions which sharply reverse or frequently change directions by as much as 180° whereby their full fiber-length potential cannot be realized. A typical showing of such a plurality of fiber reversals and sharp changes in direction is noted in FIGS. 3 and 4 of U.S. Pat. 3,119,152 which issued Jan. 28, 1964, disclosing a prior art effort to straighten fibers in carded fibrous webs.

It has also been proposed to suspend textile length fibers which have been more or less individualized in a moving air stream, and then to filter the fibers out onto a screen to form an air-laid fibrous layer in which the fibers are ar-

ranged at random. This procedure will provide a fabric which is essentially isotropic, that is, it possesses the same properties in all directions in the plane of the fabric. Again, however, the individual fibers, unfortunately, are not straight or unidirectional, but curve, twist, and meander and very often sharply reverse or frequently change directions by as much as 180° whereby their full fiber-length potential is not realized.

Efforts have also been directed to the possibility of laying down a uniform, isotropic layer of textile-length fibers by fluid or paper making techniques but such efforts have been completely unsuccessful. The reason for the inability of such fluid or paper making techniques to lay down such textile length fibers in a uniform layer is pertinent to the present invention and will be discussed in greater detail hereinafter.

As used herein, "textile length" fibers are intended to include fibers having an average length of at least about one half inch and preferably greater, say, on the order of at least about $\frac{3}{4}$ inch or 1 inch and up to 2 inches. Such fibers are often referred to in the textile industry as "cardable" fibers, indicating that they have sufficient length as to be used in carding processes on conventional textile carding machines.

Such textile length fibers are to be distinguished from "papermaking" fibers which are extremely short and are usually in the range of from about $\frac{1}{50}$ inch (0.050") to about $\frac{1}{8}$ inch (0.167"). Wood pulp fibers are, of course, the best known example of paper making fibers. Such fibers are not cardable by conventional carding machines. Occasionally, fibers are used in the paper making industry which are referred to as "long fibers." Such fibers may range in average length up to about $\frac{1}{4}$ inch (0.250") or even $\frac{3}{8}$ inch (0.375") and the term "long fibers" may be loosely considered accurate, when the frame of reference, namely, the paper making industry, is considered. However, when the textile industry is the frame of reference, such fibers are not of textile length, are not cardable, and are not within the scope of the present invention.

Hitherto, in efforts to use "long fibers" in the manufacture of paper or fibrous webs by paper making techniques, it has been proposed that paper formation aids or dispersing agents be added to the slurry of fibers as early as the bleaching and beating steps, or at an intermediate stage, say to the furnish in the stuff box, or perhaps at the fan pump or head box, immediately prior to delivery of the fiber slurry to the paper making machine proper, whether it be a Fourdrinier or a cylinder machine.

Such efforts have been mildly successful and, as a result, "long" paper fibers having a length of about $\frac{1}{4}$ inch and occasionally even ranging up to about $\frac{3}{8}$ inch have been used and moderately well-formed paper has been obtained. However, efforts to use textile length fibers ranging from about $\frac{1}{2}$ " up to $\frac{3}{4}$ ", 1", and longer, say up to 2 inches have been completely unsuccessful. The resulting products containing such textile length fibers possessed clumps, tangles and bundles of fibers, were not uniform insofar as density or appearance were concerned, and were generally unacceptable to the industry for further processing into nonwoven fabrics.

It is therefore a principal purpose of the present invention to provide methods of making fibrous webs from textile length fibers ranging from about $\frac{1}{2}$ inch to 1 inch or longer, say, up to 2 inches, wherein the fibrous web does not contain any significant amount of clumps, tangles or bundles or fibers, is uniform insofar as density and appearance are concerned, is classified as isotropic, and is therefore acceptable to the industry for further processing into nonwoven fabrics having excellent tear resistance and tensile strength. Additionally, it is another

principal purpose of the present invention to form such fibrous webs basically from aqueous fiber suspensions by fluid or paper making techniques.

Rayon fibers having a denier of 3 or less and especially in the area of about $1\frac{1}{2}$ or 1 denier or less become very limp and flaccid when they are placed in water. They imbibe water freely and swell and lay in the water to be moved about and to be bent and twisted substantially unresistingly by any eddy current or other turbulence in the water. This, of course, is to be contrasted to the action of other synthetic fibers, such as, for example, nylon, polyesters, acrylics, polyolefins, and the like, which do not imbibe water freely, do not swell, and do not merely lay limply or flaccidly in the water to be moved about or bent and twisted substantially unresistingly by every eddy current or turbulence in the water.

These rayon fibers, because of their length and their small denier, and because of their limp, swollen and flaccid nature, are thus moved about in the water, contact and slide against each other, and gradually flocculate or conglomerate into clumps, tangles and bundles of fibers which resist subsequent deflocculation and dispersion.

I have found that long paper making fibers, having an average length ranging up to about $\frac{1}{4}$ inch or even occasionally up to $\frac{3}{8}$ inch, form such clumps, tangles and bundles of fibers in water and frequently do respond to treatment by means of the addition of deflocculating or dispersing agents whereby the clumps, tangles and bundles can be opened up and the fibers dispersed relatively uniformly in the water. However, textile length rayon fibers, having an average denier of from about 1 to about 3 and an average length of at least about $\frac{1}{2}$ inch, and usually in the range of about $\frac{3}{4}$ inch to 1 inch, and up to about 2 inches, do not respond to the addition of such deflocculating or dispersing agents and the clumps, tangles and bundles remain permanently as such, whereby inferior non-uniform products are ultimately produced.

I have now discovered that if, instead of having the textile length rayon fibers in the aqueous medium first, and then subsequently adding the dispersing agent to the resulting fiber slurry, the dispersing agent is added to the aqueous medium first and then the textile length rayon fibers are subsequently added thereto, followed by moderate stirring and mild agitation, the individual textile length rayon fibers can be dispersed in water uniformly with a minimum of fiber flocculation and clumping. Substantially no clumps or tangles of fibers are formed at any time if this procedure is followed.

It is believed that by so doing the fibers enter a favorable aqueous environment containing the dispersing agent which is immediately conducive to their maintaining their individuality with respect to each other whereby there is substantially no tendency to flocculate or form clumps, tangles or bundles. This, of course, is to be contrasted to the prior situation wherein fibers are initially placed in an unfavorable aqueous environment not containing any high molecular weight, linear polymeric, water soluble, hydrophilic dispersing agent, which environment is conducive to the loss of fiber individuality whereby the fibers flocculate and form clumps, tangles and bundles which are subsequently difficult or perhaps impossible to deflocculate or disperse.

It has also been discovered that a specific type of dispersing agent must be used in the dispersing of the textile length rayon fibers under these conditions.

The dispersing agents of this invention are synthetic, long chain, linear polymers having an extremely high molecular weight, say, on the order of at least about 1 million and up to about 15 million, or 20 million, or even higher. They are oxygen-containing and/or nitrogen-containing with the oxygen present, for example, as an ether linkage or in a carboxyl group, or with the nitrogen present, for example, as an amide or as an amine. As a result of the presence of the oxygen and/or nitrogen, the dispersing agents have excellent hydrogen bonding properties

in water. The dispersing agents are water soluble, very hydrophilic and associate with water to form viscous aqueous solutions. It is believed that they normally operate by hindering the onset of turbulence and eddy currents and by damping out turbulence and eddy currents when they do occur. Smoother and more laminar fluid flow is provided with a reduction of frictional drag between fibers and frictional losses through contact with surfaces or walls of the equipment.

It is also believed that these long chain, linear, extremely high molecular weight polymeric dispersing agents are deposited on and coat the surface to give it a slippery hand. This development of excellent slip characteristics also aids in deterring the formation of clumps, tangles and bundles. Further, it is believed that the rayon fibers are stiffened to some degree by the dispersing agent and lose some of their limpness and flaccidness whereby they resist to a greater degree the formation of clumps, tangles and bundles.

Examples of such dispersing agents are: polyethylene oxide which is a non-ionic, long straight chain homopolymer and has an average molecular weight of from about 1 million to about 7 million or higher; polyacrylamide which is a long straight chain non-ionic or slightly anionic homopolymer and has an average molecular weight of from about 1 million up to about 15 million, or higher; acrylamide-acrylic acid copolymers which are long, straight chain anionic polyelectrolytes in neutral and alkaline solutions but non-ionic under acid conditions, and possess an average molecular weight in the range of about 2-3 million, or higher; polyamines which are long straight chain cationic polyelectrolytes and have a high molecular weight of from about 1 million to about 5 million or higher; etc.

The concentration of the dispersing agents in the aqueous media may be varied within relatively wide limits and may be as low as about 1 part per million up to as high as about 200 parts per million. Higher concentrations up to about 600 parts per million may be used but tend to become uneconomical due to the cost of the dispersing agent. However, if recovery and recycling means is provided whereby the aqueous medium and the dispersing agent therein is recycled and re-used, then concentrations up to 1000 parts per million or even higher can be used.

In terms of the ratio of the amount of the dispersing agent used to the amount of the fibers being treated, such is in the ratio range of from 25 pounds of dispersing agent per ton of fibers treated to about 2500 pounds of dispersing agent per ton of fibers treated. Greater ratios of dispersing agent, say, up to 15,000 pounds or more per ton of fibers treated can be used where recovery and recycling techniques are employed.

The fiber concentration in the fiber slurry may also be varied within relatively wide limits. Concentrations as low as about 8 parts per million by weight to about 1000 parts per million by weight are suitable, with preferred ranges being from about 50 parts per million by weight to about 500 parts per million by weight. Lighter or heavier ranges may be employed for special products intended for special purposes.

The fibers are preferably added in a damp or wet condition to the aqueous medium in which they are to be dispersed prior to being formed into fibrous webs. Such has been found to offer the least interference to the desired random dispersion and separation of the fibers. The amount of moisture or water on the fibers is, of course, considerably above the maximum natural moisture regain of the fibers and is normally on the order of at least about 50% water based on the weight of the fibers and may range up to about 1000% water or even higher based on the weight of the fibers. Such fibers are, of course, moist or wet to the hand.

The fibers of the improved fibrous webs of the present invention are found to be relatively straight and sub-

stantially untangled. They do curve and they do meander to some degree but they almost invariably are unidirectional and infrequently reverse sharply or double back sharply on themselves to head in the opposite direction. The fibers are substantially completely randomly distributed whereby the resulting fibrous web is substantially isotropic and uniform, has substantially constant density throughout, and is generally acceptable to the nonwoven fabric industry.

The improvement in the fiber configuration is set forth graphically in the accompanying drawings wherein:

FIG. 1 is a simplified, fragmentary, schematic representation of the fibers of the present invention in a fibrous web, with a magnification of 5X; and

FIG. 2 is a simplified, fragmentary, schematic representation of the fibers of a typical prior art air-laid isotropic fibrous web, with a magnification of 5X.

One important characteristic of a fibrous web is the development of its fiber length potential, which is the ratio of (1) the actual length of a fiber (the maximum distance between two points thereon, usually but not necessarily the ends thereof) to (2) the maximum fully-extended length of a perfectly straight fiber measured from one end to the other end.

A typical analysis of these fibrous webs reveals that the development of the fiber length potential of the invention fibrous web of FIG. 1 is on the order of from about 50% to about 95%, with an average development of fiber length potential of at least about 70%. That is to say that the average maximum length of a 1 inch fiber processed according to the present invention is at least about 0.7 inch.

This is to be contrasted to the prior art air-laid fibrous web of FIG. 2 wherein the development of the fiber length potential is on the order of only about 20% to about 30%. The average maximum length of a 1 inch fiber in such a prior art air-laid fibrous web is usually less than about 30%.

It is not essential that the fibrous webs of the present invention contain only textile length rayon fibers having a denier of from about 1 to about 3. In fact, in many cases, it may be desired that blends of textile length rayon fibers and other natural or synthetic fibers of the same or different denier, or other fibrous materials be used. Such other natural and synthetic fibers include shorter length rayon fibers, heavier denier rayon fibers, wood pulp fibers, cotton fibers of various lengths, and the like. Such fibers are cellulosic absorbent fibers but it may be desired to add other fibers which may be less absorbent to obtain various properties, characteristics, or special effects. Such other less absorbent fibers include other cellulosic fibers such as cellulose acetate; polyamide fibers such as nylon 6 and nylon 6,6; polyester fibers such as "Dacron" and "Kodel;" acrylic fibers such as "Acrilan" and "Orlon;" modacrylic fibers such as "Dynel" and "Verel;" olefin fibers such as polyethylene and polypropylene; etc.

Such other fibers may be included in such blends in percentages as small as 5% or 10% by weight or may even be included in percentages as high as 90% or 95% by weight. Percentages of such other fibers may be as low as 1% by weight or as high as 99% by weight in particular circumstances where specific properties, characteristics or special effects are desired or required.

It is also to be noted that the denier of these other synthetic fibers may possess any desired value, as dictated by the needs and requirements for their use. Deniers in the range of from about 1 denier or even smaller, up to about 30 or 40 denier or even higher, are value depending upon the particular circumstances.

The invention will be described in greater detail in the following examples wherein there are disclosed preferred embodiments of the present invention for purposes of illustration but not for purposes of limitation of the broader aspects of the present inventive concept.

EXAMPLE I

To a sheet mold (24" x 24" x 21") containing 135 liters of water at room temperature is added 5650 milliliters of a 0.25% aqueous solution of "Polyox" coagulant (Union Carbide Corp.) as a dispersing agent.

"Polyox" coagulant is a polyethylene oxide polymer having an average molecular weight in excess of about 5 million. It is a long chain, linear polymeric, gel forming material which is water soluble and very hydrophilic and which rapidly associates with water to form viscous aqueous solutions. A 1% solution has a viscosity in excess of 5000 cps. at 25° C. (Brookfield RVF viscometer, 2 r.p.m.).

After thorough mixing of the water and polyethylene oxide, 30.0 grams of wet one-inch long, 1.5 denier, bright rayon fiber (consisting of 38% dry fiber and 62% water) is added to the mold. Based upon the water, the fiber concentration is 80 parts per million and the concentration of the polyethylene oxide is 100 parts per million. The contents of the sheet mold are moderately stirred with a paddle until a uniform suspension of fibers is attained. The water is then drained from the sheet mold, leaving a layer of evenly distributed rayon fibers on a 24" x 24" screen. The sheet (30.6 gram/meter² basis weight) is sprayed with a 0.5% aqueous solution of polyvinyl alcohol as a temporary holding binder and dried. Light transmission through this bonded sheet is quite uniform over the entire sheet surface.

The fibers of the sheet are viewed through a microscope and found to be relatively straight and substantially untangled. There are substantially no clumps, tangles or bundles of fibers. There is no hydration bonding between the individual fibers. The fibers curve and meander to some degree but are substantially unidirectional and infrequently sharply reverse direction or double back on themselves to head in the opposite direction. The fibers are substantially completely randomly distributed. The fibrous web is substantially isotropic and uniform, has substantially constant density throughout and is acceptable to the nonwoven fabric industry for further processing by conventional procedures into nonwoven fabrics having excellent tear resistance and tensile strength.

EXAMPLE II

The procedures of Example I are followed substantially as set forth therein with the exception that the polyethylene oxide is omitted from the water. The resulting fibrous web has an extremely mottled appearance and does not have a uniform density, due to the presence of numerous light and heavy concentrations of fibers throughout. Clumping, bundling and entangling of fibers is very noticeable. The products are inferior and are unacceptable to the nonwoven industry for processing into nonwoven fabrics.

EXAMPLE III

The procedures of Example I are followed substantially as set forth therein with the exception that the rayon fibers are added to the water in the sheet mold first, that is, before the polyethylene oxide dispersing agent is added. The fiber slurry is mixed thoroughly and then the polyethylene oxide is added, followed by stirring.

The resulting product is definitely non-uniform and inferior. It has a mottled appearance due to the presence of numerous light and heavy concentrations of fiber throughout the sheet. Clumping, bundling and entangling of the fibers in the sheet is very noticeable. The product is inferior and is unacceptable to the nonwoven industry for bonding or further processing into a nonwoven fabric.

EXAMPLE IV

The procedures of Example I are followed substantially as set forth therein with the exception that the polyethylene oxide dispersing agent is replaced by "Cyatame 5" (American Cyanamid) which is a synthetic, high molecu-

lar weight anionic polyacrylamide linear polymer. Its average molecular weight is about 15 million. The pH of a 0.1% solution of the polymer is 6. Its viscosity at 25° C. (0.1% solution) is 160 cps. at 12 r.p.m. (Brookfield Model LVF No. 1 spindle). It is water soluble and very hydrophilic and rapidly associates with water to form viscous aqueous solutions.

0.28 gram of the polymer in the form of a 0.1% solution is added to the water in the sheet mold. This represents a ratio of about 100 pounds of the polymer per ton of the fiber. This is equivalent to approximately 2 parts of polymer per million parts of water.

The fibers of the sheet are studied through a microscope and found to be relatively straight and substantially untangled.

There is no hydration bonding between the rayon fibers. The fibers curve and meander to some degree but are substantially unidirectional and infrequently sharply reverse direction or double back on themselves to head in the opposite direction. The fibers are substantially completely randomly distributed. The fibrous web is substantially isotropic and uniform, has substantially constant density throughout, and is acceptable to the nonwoven industry for further processing into a nonwoven fabric having excellent tear resistance and tensile strength.

EXAMPLE V

The procedures of Example IV are followed substantially as set forth therein with the exception that the concentration of the "Cytime 5" polymeric dispersing material is increased to a proportion of approximately 250 pounds per ton of fiber. This is equivalent to approximately 10 parts per million parts of water. The results are comparable; the fibers are similarly disposed, and somewhat improved over the preceding example, as viewed through a microscope, and the resulting fibrous web possesses similar properties and characteristics.

EXAMPLE VI

The procedures of Example I are followed substantially as set forth therein with the exception that the polyethylene oxide dispersing agent is replaced by "Poly Hall" 295 (Stein-Hall), a slightly anionic polyacrylamide having an average molecular weight of between 5 and 6 million. The pH of a 1% solution of such a polymer is 7.0 and its viscosity (20 r.p.m., 25° C. Brookfield) is 4500 cps.

5.65 grams of the polyacrylamide is added in the form of a 0.1% solution. This is equivalent to 40 parts per million on a water basis or a ratio of 1000 pounds of polymer per ton of fiber.

The fibers of the improved webs are found to be relatively straight and substantially untangled. There are no clumps, tangles or bundles of fibers. There is no hydration bonding. The fibers to curve and they do meander to some degree but they are substantially unidirectional and infrequently sharply reverse or double back on themselves to head in the opposite direction. The fibers are substantially completely randomly distributed whereby the resulting fibrous web is substantially isotropic and uniform, has substantially constant density through, and is generally acceptable to the nonwoven fabric industry.

EXAMPLE VII

The procedures of Example VI are followed substantially as set forth therein except that only 3 grams (0.1% solution) of the polyacrylamide is added to the water in the sheet mold. This is equivalent to 20 parts per million on water basis or a ratio of 500 pounds of polymer per ton of fiber.

The results are satisfactory and acceptable but are not quite as good as those obtained in Example VI.

EXAMPLE VIII

The procedures of Example VI are followed substantially as set forth therein except that the amount of polyacrylamide which is added to the water in the sheet mold

is reduced even further to only 1½ grams, still in the form of a 0.1% solution. This is equivalent to 10 parts per million on a water basis or a ratio of 250 pounds per ton of fiber.

The results are satisfactory and acceptable, although again not as good as those obtained in Examples VI and VII.

EXAMPLE IX

The procedures of Example I are followed substantially as set forth therein with the exception that the polyethylene oxide dispersing agent is replaced by "Separan NP 10" (Dow), a synthetic long chain linear polymer formed by the polymerization of acrylamide. The average molecular weight is approximately 1 million. It is essentially nonionic in solution although a small percentage of the amide groups are usually hydrolyzed to anionic carboxyl groups. The viscosity of a 1% solution of the polymer (pH 7) is 400 cps. at 35° F. and 6 r.p.m. (Brookfield viscometer, No. 4 spindle). It is a water soluble, hydrophilic polymer which is rapidly wetted by water and forms highly viscous solutions even at concentrations of 1% or 2%.

14 grams of the polyacrylamide is added to the water in the sheet mold in the form of a 0.1% solution. This is equivalent to 100 parts per million on a water basis or a ratio of 2,500 pounds of polymer per ton of fiber. The resulting fibrous web is improved over the fibrous webs obtained by a conventional paper making process not using any polyacrylamide or other dispersing agent.

EXAMPLE X

The procedures of Example IX are followed substantially as set forth therein, except that "Separan NP 20" (Dow), a synthetic, long chain, linear polymer formed by the polymerization of acrylamide, having an average molecular weight of about 2 million is used. 14 grams of the polyacrylamide is added in the form of a 0.1% solution. This is equivalent to 100 parts per million on a water basis or a ratio of 2,500 pounds of polymer per ton of fiber.

The fibers of the improved fibrous webs are found to be relatively straight and substantially untangled. There are substantially no clumps, tangles or bundles of fibers. There is no hydration bonding. The fibers do curve and they do meander to some degree but they are substantially unidirectional and infrequently sharply reverse or double back on themselves to head in the opposite direction. The fibers are substantially completely randomly distributed whereby the resulting fibrous web is substantially isotropic and uniform, has substantially constant density throughout, and is generally acceptable to the industry.

EXAMPLE XI

The procedures of Example I are followed substantially as set forth therein with the exception that the polyethylene oxide dispersing agent is replaced by "Separan AP 30" (Dow), a synthetic long chain linear polymer containing both amide and carboxylic groupings in the approximate ratio of 3:1. The molecular weight has an average between 2 and 3 million. In neutral and alkaline solutions, it is anionic; under acid conditions, ionization is repressed and the polymer is nonionic. The viscosity of a 1% solution of the polymer (pH 7) is 7000 cps. at 41° F. and 6 r.p.m. (Brookfield viscometer, No. 4 spindle). It is a water soluble hydrophilic polymer which is wetted by water and forms highly viscous solutions even at low concentrations of only 1% or 2%.

14 grams of the polymeric dispersing agent is added to the water in the sheet mold in the form of a 0.1% solution. This is equivalent to 100 parts per million on a water basis or a ratio of 2,500 pounds of polymer per ton of fiber.

The fibers of the improved fibrous webs are found to be relatively straight and substantially untangled. There are substantially no clumps, tangles or bundles of fibers.

There is no hydration bonding. The fibers do curve and they do meander to some degree but they are substantially unidirectional and infrequently sharply reverse or double back on themselves to head in the opposite direction. The fibers are substantially completely randomly distributed whereby the resulting fibrous web is substantially isotropic and uniform, has substantially constant density throughout, and is generally acceptable to the industry.

EXAMPLE XII

The procedures of Example I are followed substantially as set forth therein except that the polyethylene oxide dispersing agent is replaced by "Reten 210" (Hercules), a synthetic, strongly cationic polyamine, having a very high average molecular weight of at least about 1 million. 14 grams of this dispersing agent are added to the water in the sheet mold in the form of a 0.1 solution. This represents a ratio of about 2500 pounds of dispersing agent per ton of fibers or about 100 parts of polymer per million as based on the water in the sheet mold. The fibrous web is improved over the fibrous webs obtained by a conventional paper making process not using any dispersing agent.

EXAMPLE XIII

The procedures of Example XII are followed substantially as set forth therein except that the concentration of the dispersing agent is quadrupled to 56 grams in the water in the sheet mold.

The fibers of the sheet are viewed through a microscope and found to be relatively straight and substantially untangled. There is substantially no hydration bonding between the individual fibers. The fibers curve and meander to some degree but are substantially unidirectional and infrequently sharply reverse direction or double back on themselves to head in the opposite direction. The fibers are substantially completely randomly distributed with substantially no fiber clumps or bundles. The fibrous web is substantially isotropic and uniform, has substantially constant density throughout, and is acceptable to the nonwoven fabric industry for bonding into a nonwoven fabric.

EXAMPLES XIV AND XV

The procedures of Example I are followed substantially as set forth therein except that the rayon fibers are (1) $\frac{3}{4}$ inch, 3 denier and (2) $1\frac{1}{4}$ inch, 3 denier. The results

are comparable; the fibers are similarly disposed, as viewed through a microscope, and the resulting fibrous web possesses similar properties and characteristics.

The fibers of the improved fibrous webs are found to be relatively straight and substantially untangled. They do curve and they do meander to some degree but they are substantially unidirectional and infrequently sharply reverse or double back on themselves to head in the opposite direction. The fibers are substantially completely randomly distributed whereby the resulting fibrous web is substantially isotropic and uniform, has substantially constant density throughout, and is generally acceptable to the industry for bonding into a bonded nonwoven fabric.

What is claimed:

1. A method of making a uniform, isotropic fibrous web containing textile length rayon fibers wherein there is substantially no hydration bonding between the individual fibers which are well suited for further processing into a nonwoven fabric which comprises: adding polyethylene oxide, a synthetic, extremely high molecular weight, linear, polymeric, water soluble, hydrophilic dispersing agent to an aqueous medium, said dispersing agent having a molecular weight of at least about 1 million; then adding textile length rayon fibers to said aqueous medium and forming an aqueous fiber slurry by means of moderate stirring and mild agitation; and forming a uniform, isotropic fibrous web from said aqueous fiber slurry by papermaking techniques, said fibrous web being characterized in that there is substantially no hydration bonding between the individual fibers.

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F. FREI, Assistant Examiner

U.S. Cl. X.R.

162—169