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WET WEB BINDING PROCESS AND PRODUCT

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This invention relates to a non-woven fabric product and to a method for wet binding man-made fibers into a non-woven sheet material. In one aspect it relates to a process for producing a fibrous web comprising man-made fibers of sufficient strength to enable production therefrom of a non-woven fabric web on conventional papermaking equipment.

Various methods for producing non-woven fabrics are of course well known. In the manufacture of paper, a non-woven material, the fibers hydrate during beating and fibrillate, i.e., the surface and ends of the fibers fray, thus producing minute fibrils which serve to felt or lock the fibers together during the papermaking process. Furthermore, conventional paper refining releases a glue-like substance from the pulp which greatly improves mutual fiber bonding. Thus in papermaking the use of a binding agent is generally not necessary, and the incorporation of a small amount of papermaking fibers with non-fibrillating synthetic fibers results in acceptable fiber to fiber bonding of the synthetic fibers. However, where the non-woven material to be produced consists entirely of man-made fibers or where natural cellulosic materials are not to be incorporated, a binding agent is required in the conventional papermaking process.

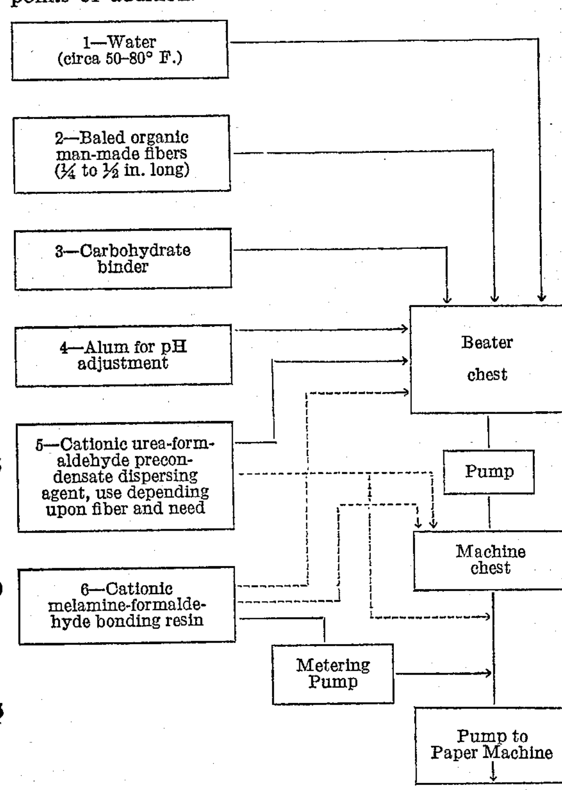
Heretofore in the production of a non-woven fabric of man-made fibers, a carded sheet of the fibers is first formed or a mat of the same is made by depositing the fibers from a liquid medium onto a screen. A binder material is then applied to the carded sheet or dried mat of unspun fibers which bonds the fibers together producing a strong material. Prior to binding, the unspun sheets are fleece-like and inherently weak due to the fact that the fibers are incapable of fibrillation and do not bond to one another as do natural cellulosic fibers, for example. Generally, in order to handle the very fragile sheets thus produced, a small amount of glue or starch is applied to the sheet after it has been formed to impart sufficient strength thereto to enable efficient application of the binding agent. Obviously, these operations effected upon the inherently weak non-woven fiber sheet are time-consuming and delicate and the rate of production is well below that possible in the commercial production of paper. Thus, while mats of man-made fibers may be produced on a screen, such as that employed on the conventional continuous papermaking machine, such a mat composed of fibers one-half inch in length or less does not possess sufficient strength to be adapted to conventional papermaking processes.

Accordingly, it is an object of the present invention to provide a wet binding process as distinguished from the common practice of applying a binder to an already formed sheet or mat, which will enable more rapid and efficient production of a novel non-woven fabric product. It is a further object of the present invention to produce a wet web of sufficient strength to enable production of the non-woven fabric on a conventional Fourdrinier machine at rates equivalent to the production of paper on such a machine.

The term "man-made fibers" is employed herein to designate fibers other than natural fibers such as wood, rag, asbestos, or grass. The man-made fibers are of organic origin and include the true synthetic fibers such as nylon, Orlon, Dacron; modified and regenerated cellulose fibers such as viscose, acetate rayon, Fortisan; regenerated protein fiber such as Vicara.

In accordance with the present invention, non-porous, non-hydratable, naked fibers are slurried in water to a consistency of about 1 to 6% by weight. The pH of the slurry is then adjusted to between about 4 and 6, as for example by the addition of the requisite quantity of paper makers' alum. A proteinous or carbohydrate binding agent is then added in amounts between about 8 and 25% by weight of the dry fibers and thoroughly dispersed throughout the slurry with mild mixing. Following the addition of the binding agent the slurry is dropped to the chest, and a cationic bonding agent, preferably a resin precondensate, added thereto. This resin is such as will react to some extent with the binding agent and promotes natural sorption of the binder onto the fibers. Reaction between the binder and the bonding agent precipitates a portion of the binder which, it is believed, is also sorbed onto the fibers and serves as a bond between the fibers. The resulting precipitate contributes in large part to the strength of the non-woven web to be produced. Following addition of the bonding agent, the resulting aqueous mixture is allowed to remain in the chest for a short period of time, usually about 10 minutes or more, and then continuously fed to the head box and moving screen of a conventional papermaking machine. The resulting wet web is of sufficient strength to permit continuous removal from the screen and to withstand the subsequent pressing and drying operations of the Fourdrinier without undue linting or picking of the fibers.

There follows a simplified flow diagram of the process wherein the numerals indicate the sequence of addition, although materials 5 and 6 may be introduced simultaneously to the fiber slurry, the solid lines indicate the preferred points of addition and the broken lines optional points of addition.



The present process is applicable to rayons, and particularly viscose rayon, the polyester fibers, the acrylic polymers, as well as the polyamides. However, efficiency of the binding agent will depend upon the particular fiber material and accordingly proteinous or carbohydrate binders are chosen which produce acceptable bonds between the particular fibers. For purposes of simplicity, the process of the present invention will be further described as it relates to the production of non-woven viscose fabrics. In any case, the length of the fibers has a direct bearing upon the strength of the resulting web and the quantity of binder and bonding agent necessary. Thus in practice of the present invention the fibers will generally be longer than papermaking grades, preferably between about ¼ and about ½ inch in length.

The diameter as usually reflected by the denier of the fibers constitutes an important variable in the final properties of the non-woven fabric. Successful trial runs using 1.5 denier and 2.25 denier indicate that from a paper-making standpoint the 1.5 denier was preferable to the heavier material. However, a mixture of 1.5 denier or less with coarser deniers may have some special applications.

As the binding agent I prefer one of the starches, not only because of their favorable economic position, but also because they effect the requisite bond between most of the fibers of the types indicated, and particularly the viscose fibers. Of the starches, cooked pearl corn starch is preferred, and while oxidized and modified starches also perform satisfactorily, they are considerably more expensive. Other binding agents include the mannolgalactams, locus bean gum, alginated starches, etc. Animal glue may be employed as may casein and soy protein.

The cationic bonding agent which reacts with and promotes sorption of the binder is added preferably in the chest in amounts equal to about 1 to about 6% of the weight of the dry fiber. It is as indicated preferably a resinous material, which itself has the ability of improving the wet strength of the fabric web to be produced. It may consist of a plurality of resins of differing chemical composition, or a single resin. I have found that a bonding agent which comprises melamine-formaldehyde resin precondensate, for example, American Cyanamid's "Parez 607" is eminently satisfactory, particularly with viscose fibers and a pearl corn starch binder, permitting retention of a major portion of the normally water soluble binder in the finished fabric.

With certain fibers it has been found that the melamine resin, or the complex which it forms with the starch binder as the case may be, tends to flocculate the fibers and this is particularly true with certain types of viscose fibers. While the precise reason for this agglomeration is not at present completely understood, it is reasonable to assume that since both the starch and the viscose are anionic and the melamine resin rather strongly cationic, there is a strong attraction between the resin and the fibers. In order to overcome flocculation, which results in a nonuniform finished sheet in which the fibers are disposed in a plurality of rather dense groups, I have discovered that it is necessary to incorporate a dispersing agent wth the slurry before the flocculating effect of the melamine is evidenced. The dispersing agent is also desirably a cationic resin precondensate soluble in water which is less cationic than the bonding resin. As a dispersant I prefer a urea-formaldehyde precondensate, and a solution of this material is added to the chest in amounts sufficient to provide about 3 to 10% of dry dispersant based on the dry weight of the fiber. Addition of the dispersant always precedes addition of the bonding resin, or the dispersant is added simultaneously therewith. When so added, the dispersant completely nullifies the flocculating effect of the bonding resing. Rohm and Haas' "Uformite 700" produces excellent results. It has been found that when melamine-formaldehyde is employed and added prior to the addition of the urea-formaldehyde dispersant, the fiber agglomerates cannot be easily redispersed. Urea-formaldehyde precondensate is a well known wet strength agent, but I have found that

while sorption of starch onto the fibers is increased with the use of urea-formaldehyde alone, the resulting web is not of sufficient strength to permit processing on the Fourdrinier machine, nor is it believed that urea-formaldehyde reacts to any extent with the starch to precipitate the same, and accordingly the bonding resin is always employed.

With some fibers, the cationic dispersing agent is entirely unnecessary, for example, with du Pont's polyacrylic fiber "Orlon."

Referring again to the initial slurrying of the fibers with water, very little if any refining is required and then only sufficient to break up any tight bundles produced by the fiber tow cutting operation. If the refining is carried to an extent greater than that necessary merely to adequately disperse the individual fibers, many of the fibers are themselves broken and due to their shorter average length the final strength of the non-woven fabric will be reduced. Furthermore, refining after the starch-resin complex has been sorbed onto the man-made fibers is detrimental to the binding strength of the starch-resin system, presumably because the starch-resin complex is abraded from the fibers. Thus additional binding agent, dispersant and bonding agent are required for the production of a non-woven web of sufficient wet strength for post bonding.

Although not necessary to the process of the present invention, it has been found that incorporation of a small quantity of a wetting agent with the slurry, preferably added with the alum prior to the final addition of "Parez 607" improves the saturating characteristics of the dry web which is to be produced without affecting its wet strength, thereby facilitating the post binding operation. In this connection, Rohm and Haas' "Triton CF-10" has proved acceptable, although other wetting agents will produce the desired result.

As already noted, the pH of the fiber slurry is adjusted to between about 4 and 6 and preferably between 4.5 and 5.5 prior to the addition of the bonding agent, since the dispersant and bonding agent develop maximum wet strength in the aforesaid pH range.

The binding agent has been noted as present in amounts between about 8 and 25% based on the dry weight of the fibers. In the case of starch and viscose rayon fibers, the amount of starch employed is preferably between about 15 and 25% by weight of the fibers.

In order to observe the effect of the individual additives in the production of a non-woven viscose rayon fabric made up of ¼ inch, 1.5 denier fibers, a number of sheets were prepared on a sheet mold screen, removed from the screen and dried. It was found that without the binding agent, starch; the dispersant, urea-formaldehyde precondensate; and the bonding agent, melamine-formaldehyde precondensate; added in the specified amounts, either the web did not have sufficient wet strength to support its own weight in a post-saturation bath, or the fibers were not sufficiently uniformly distributed to produce an acceptable sheet.

For example, with starch alone in amounts up to 25% by weight based on the weight of the dry fibers, the material had virtually no wet strength, although the fibers were uniformly distributed throughout the sheet. With the requisite amount of starch and melamine-formaldehyde resin, acceptable wet strength was attained, but the individual fibers were agglomerated and the sheet did not have uniform density. With the required amount of urea-formaldehyde and without starch or melamine the resulting web was exceedingly fragile and exhibited virtually no wet strength although fiber distribution was excellent. The addition of urea-formaldehyde and starch in the above specified amounts produced a fabric with excellent fiber distribution of wet strength just slightly better than with starch alone, but which deteriorated on the post binding operation. With melamine-formaldehyde alone, some agglomeration of the fibers was noted although not to the degree apparent with melamine-formaldehyde and starch. Wet strength, however, was not sufficient to permit processing on a Fourdrinier machine and post binding. With starch, urea-formaldehyde and melamine-formaldehyde added in the amounts above set forth, fiber distribution was excellent, and there was no picking or deterioration during passage through the wringer and on the dryer. The sheet had sufficient body to permit processing on a Fourdrinier machine without web deterioration. In each of the aforementioned tests, the pH of the water was adjusted to between about 4 and 6 prior to addition of the additives.

While the present invention is directed primarily to the production of a non-woven fabric web of sufficient strength to pass through the papermaking machine, the web issuing from the machine is not strong enough per se to have much usefulness. Thus, the greige goods will be further treated as by application of a post binder in order to obtain the ultimate in dry strength. A wide variety of such binders is available and the techniques of application are common knowledge in the trade. The reader's attention is directed to Proceedings of the American Association of Textile Chemists and Calorists at page 437–442 of "American Dyestuff Reporter" for June 17, 1957.

Application of a polyacrylic binder material, e.g., Rohm and Haas' P 1509 in amounts between about 10 and 30% based on the weight of the dry non-woven sheet, has resulted in dry strengths greater than four to five layers of kraft paper bag material, and it is contemplated that a single thickness of the present non-woven fabric will ultimately replace kraft in multiwall bags.

Having established the requisite concentrations of the additives necessary to produce a web of sufficient strength, several extended runs were made on a pilot Fourdrinier machine with precision cut ¼ inch 1.5 and 2.25 denier wet viscose manufactured by the American Viscose Company, starch, urea-formaldehyde precondensate and melamine-formaldehyde precondensate. The beater was charged with 500 pounds of city water and approximately 15 pounds (dry weight) of wet viscose. The charge was then dropped to the machine chest with additional dilution. After 40 to 60 pounds of viscose had been thus slurried and dropped to the chest, "Uformite 700" urea-formaldehyde resin precondensate was added in amounts ranging from 5 to 10% of the viscose on a dry solids basis, in the several runs. Pearl corn starch which had been cooked to 175° F. was then added to the chest in amounts between 15 and 25% of the viscose fiber. The pH of the furnish in the chest was adjusted by the addition of 2–3 pounds of paper makers' alum so as to begin the run at pH of about 5, although this figure varied in the several runs from about 4.5 to 5.5. About 0.1% "Triton CF–10" non-ionic wetting agent was added simultaneously with alum. "Parez 607" melamine-formaldehyde precondensate in amounts between 3 and 6% of the dry viscose fibers, varying in the different runs, was added and a substantial portion of the starch precipitated. The final consistency in the chest was about 1% solids.

The viscose furnish plus additives was allowed to remain in the chest at least 10 minutes and in some runs as long as 30–40 minutes, after which the stock was put on the wire in the usual manner. In the first run, some stock lumps were apparent and accordingly in subsequent runs the Jordan was operated at between 110 and 130% of the no load current, with from about 110 to 120% adequately breaking up stock lumps without impairing final strength in the saturated web. At 130% of no load current a substantial loss in final strength was noted.

Wet end operations were normal on the viscose web with little, if any, sticking of the fibers to the pressing and drying rollers although it was noted that at lower basis weight there was a decrease in picking of the fibers.

Following these pilot runs, a run was conducted with Obbola unbleached kraft which had only a minimum of refining and to which approximately 5% "Uformite 700" by weight of the fibers was added. The web produced from this material picked very badly on the press rollers and the web broke several times. Increased refining alleviated this picking somewhat, but picking was more serious with the kraft than with any of the viscose webs.

These pilot runs demonstrated that an all viscose non-woven fabric can be run on a conventional Fourdrinier without any major modification. The resulting sheets were almost equivalent to laboratory prepared hand sheets when refining of the furnish was kept at a minimum. A typical sheet produced during the pilot runs weighed approximately 56 pounds per 3000 sq. ft. The application of approximately 16 pounds of Rohm and Haas' P 1509 (per 3000 sq. ft.) in a post binding operation followed by calendering produced a smooth sheet of non-woven fabric having the following properties:

Mullen	54
Elmendorf Tearing Strength (16 sheets)	MD–400 CMD–844
Tensile (lbs./inch)	MD–16.1 CMD– 8.2
Percent Stretch	MD–13.0 CMD–17.8
M.I.T. Folding Endurance	MD–24,900 CMD– 7,300

Subsequent laboratory conversions demonstrated that the above post bonded fabric sheets were receptive to clay-acrylic binder coatings as well as to polyethylene extrusion coating.

While the present invention has been described as it relates to the production of a viscose rayon non-woven fabric, it is to be understood that other fibers of the types mentioned above can be employed alone or in combination. Although concerned primarily with the production of a fabric of man-made fibers, it is of course within the scope of the present invention to incorporate small amounts of natural fibers with the man-made fibers.

What is claimed and desired to be secured by Letters Patent is:

1. A process for producing a non-woven fabric web consisting essentially of organic man-made fibers, which comprises slurrying said fibers with water, incorporating at least about 8% by weight of the dry fibers of a carbohydrate binding agent with said slurry, subsequently incorporating therewith a cationic bonding resin capable of facilitating sorption of said binder onto said fibers comprising a melamine-formaldehyde precondensate and feeding the resulting aqueous medium to a papermaking machine.

2. A process as set forth in claim 1 wherein the melamine-formaldehyde precondensate is added in amounts equal to about 1 to 6% by weight of the fibers.

3. A non-woven fabric web consisting essentially of organic man-made fibers produced by the process of claim 1.

4. A process for producing a non-woven fabric web consisting essentially of viscose fibers, which comprises slurrying viscose fibers with water to a consistency of about 1 to 6% fibers, incorporating a starch binding agent with said slurry in amount equal to about 8 to 25% by weight of the dry fibers, subsequently incorporating therewith about 1 to 6% by weight of the dry fibers of a melamine-formaldehyde resin precondensate, and feeding the resulting slurry to a papermaking machine.

5. A process as set forth in claim 4 wherein the pH of the slurry is adjusted to between about 4 and 6 prior to addition of the melamine-formaldehyde precondensate.

6. A process for producing a non-woven fabric web consisting essentially of regenerated cellulose fibers, which comprises slurrying said fibers with water, incorporating

at least about 8% by weight of the dry fibers of a starch binding agent with said slurry, subsequently incorporating therewith a cationic bonding resin capable of facilitating sorption of said binder onto said fibers comprising a melamine-formaldehyde precondensate and feeding the resulting aqueous medium to a paper making machine.

7. A process for producing a non-woven fabric web consisting essentially of organic man-made fibers, which comprises slurrying said fibers with water, introducing at last about 8% by weight of the dry fibers of a starch binding agent thereto, subsequently incorporating simultaneously a cationic bonding resin capable of facilitating sorption of said binder onto said fibers comprising a melamine-formaldehyde precondensate and a cationic dispersing agent capable of preventing agglomeration of said fibers in the presence of said bonding resin comprising a water-soluble urea-formaldehyde precondensate, and subsequently feeding the resulting aqueous medium to a paper making machine.

8. A process for producing a non-woven fabric web consisting essentially of regenerated cellulose fibers, which comprises slurrying said fibers with water to a consistency of about 1 to 6% fibers, introducing at least about 8% by weight of the dry fibers of a starch binding agent thereto, incorporating a cationic dispersing agent comprising a water-soluble urea-formaldehyde precondensate, adjusting the pH of said mixture to between about 4 and 6, adding thereto a melamine-formaldehyde resin precondensate capable of reacting with said starch and facilitating sorption of the same onto said fibers and feeding the resulting mixture to a paper making machine.

9. A process as set forth in claim 8 wherein the starch binding agent is added in amounts equal to about 8 to 25% by weight of said fibers.

10. A process as set forth in claim 8 wherein the melamine-formaldehyde resin precondensate is added in amounts equal to about 1 to 6% by weight of the fibers.

11. A process as set forth in claim 8 wherein following addition of the melamine-formaldehyde resin precondensate the resulting aqueous medium is allowed to stand for at least 10 minutes prior to feeding to the paper making machine.

12. A process for producing a non-woven fabric web consisting essentially of viscose fibers, which comprises slurrying viscose fibers with water to a consistency of 1 to 6% fibers, adding about 8 to 25% based on the weight of the dry fibers of a starch binding agent, incorporating about 3 to 10% based on the dry fibers of a cationic dispersing agent comprising a water-soluble urea-formaldehyde precondensate subsequently adding about 1 to 6% based on the dry fibers of a melamine-formaldehyde precondensate capable of reacting with said binding agent and facilitating sorption of said binding agent onto said fibers, said dispensing agent serving to reduce the tendency of said fibers to agglomerate in the presence of said bonding agent, and feeding the resulting aqueous medium to a paper making machine.

13. A process as set forth in claim 12 wherein the pH is adjusted to between about 4.5 and 5.5 prior to addition of said melamine-formaldehyde precondensate.

14. A process as set forth in claim 12 wherein the length of said viscose fibers is between about ¼ and ½ inch.

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