July 4, 1972 HARUO MIYAMOTO ET AL **3,674,621**

PROCESS OF MAKING A SHEET PAPER

Filed Feb. 17, 1970 2 Sheets-Sheet 1

Fig. 1

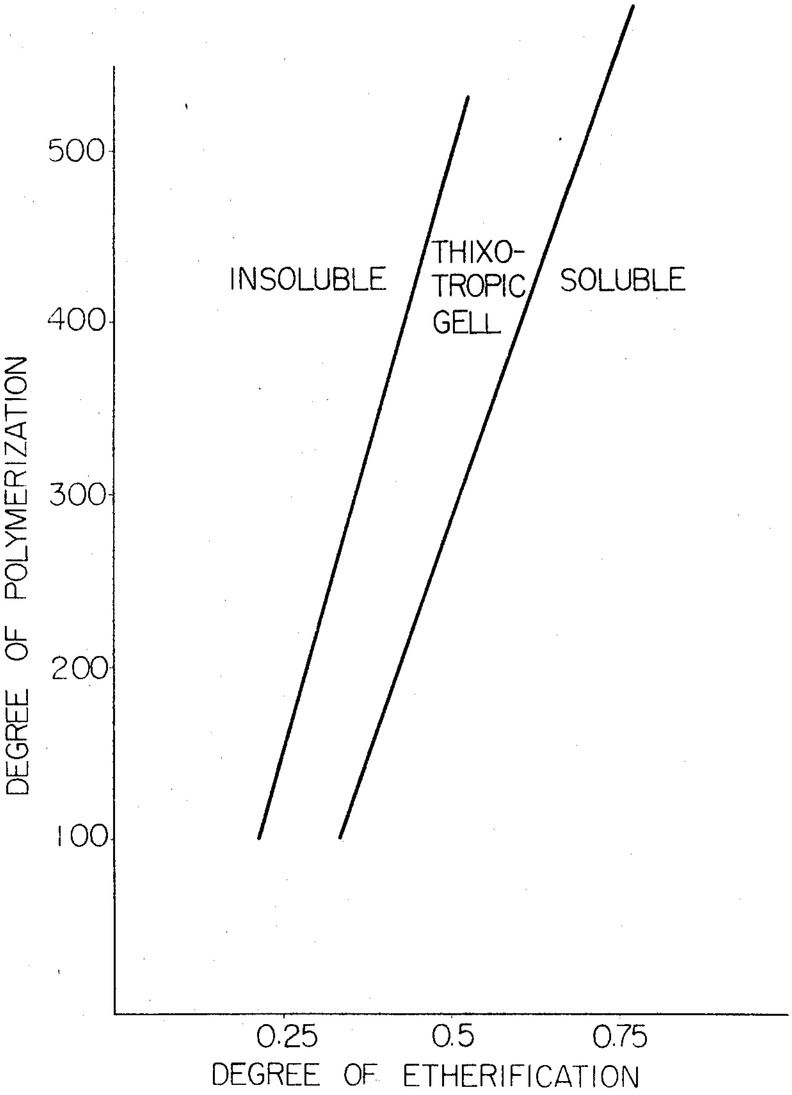
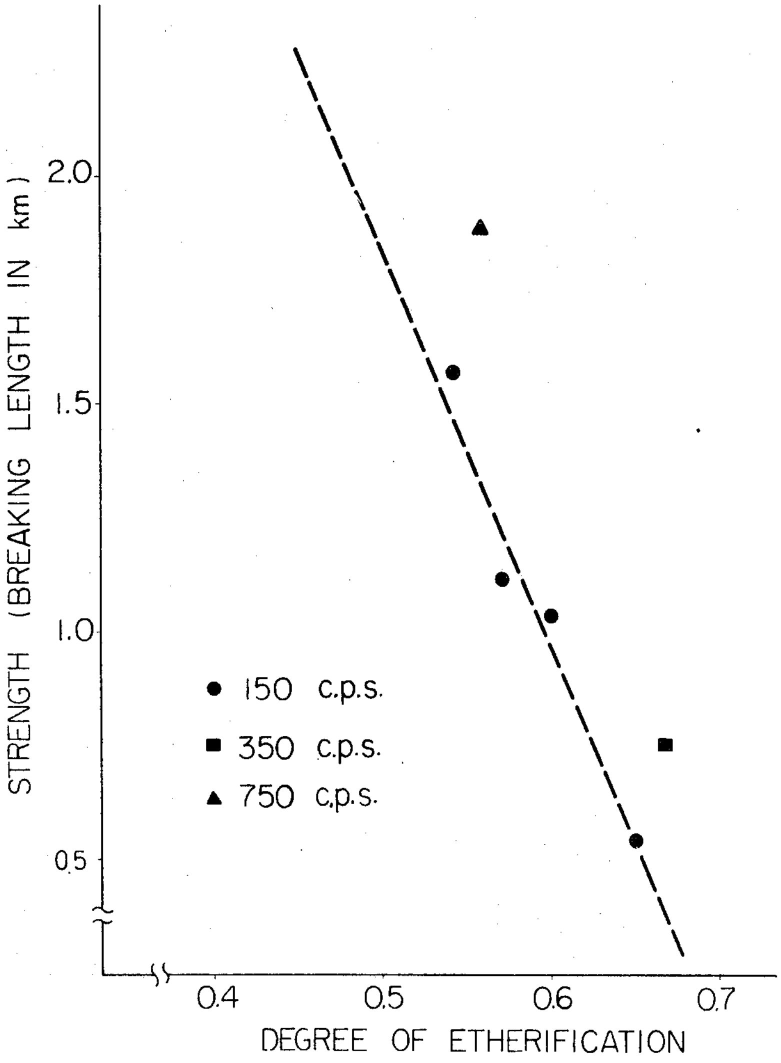


Fig. 2


STRENGTH (BREAKING LENGTH IN km)
2.0
1.5
1.0
0.5
0.4
0.5
0.6
0.7
DEGREE OF ETHERIFICATION
● 150 c.p.s.
■ 350 c.p.s.
▲ 750 c.p.s.

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PROCESS OF MAKING A SHEET PAPER

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U.S. Cl. 162—146 24 Claims

ABSTRACT OF THE DISCLOSURE

A process of making a sheet paper in which an aqueous dispersion containing synthetic fiber, a hot water soluble fiber binder and carboxymethyl cellulose is prepared and subsequently, a sheet paper is formed from the aqueous dispersion. The aqueous dispersion may contain a fibrous material having a lower melting point than that of the synthetic fiber in addition to the above ingredients. A sheet paper from the latter aqueous dispersion is subjected to heat treatment.

The present invention relates to a process of making a synthetic fiber paper, more particularly, relates to a process of making a synthetic fiber paper largely or entirely composed of hydrophobic synthetic fiber, for example, polyolefine fiber, polyester fiber, etc., by using a hot water soluble fiber binder such as polyvinyl alcohol fiber binder, which results in the provision of hydrophobic sheet paper having especially excellent mechanical properties at dry conditions.

Further, the present invention relates to a process of making a synthetic fiber paper which is characterized by a selection of paper stock and conditions of after-treatment, especially heat-treatment conditions which results in the provision of synthetic fiber paper having various prominent appearances or shapes and excellent physical properties.

Recently, a development of papers composed of chemical or synthetic fiber, for example, rayon, vinylon, nylon, polyester fiber, etc., has been achieved and many patents and technical papers concerned with the above have been published. These fibers, however, have many disadvantages in the production of chemical or synthetic fiber papers as paper stock for manufacturing, that is, they are not so fibrillated without difficulties, which forms a striking contrast with wood pulp, and they have little or no hydrogen bonding force or bonding force due to their intertwining properties. Therefore, every effort to create the bonds among fibers and thusly improve tenacity and other mechanical properties of the paper has been spent, for example, by improving the surface property of fibers, by searching for an adequate binder, or by blending a small quantity of synthetic fiber having a lower melting point with the fiber composing a paper as the principal ingredient and heating them to melt or adhere. These methods, however, have both merits and demerits, and it is indeed difficult to make them fit for practical use in the existing paper forming processes.

On the contrary, an appearance of a temperature and humidity sensitive fiber binder, in other words, hot water soluble fiber binder made from a compound easily soluble in hot water, which was represented by a polyvinyl alcohol fiber binder, has enabled the industrial production of vinylon paper or rayon paper. Such a fiber binder, in case it is added at an amount from 5 to 25% O.W.F. to fibers composing a paper as the principal ingredients, is melted by heat of the dryer (approximately 100° C.) and moisture in the wet web on web forming process and forms bonds among the fibers.

However, in polyolefine or polyester fiber which is hydrophobic in itself, even in case such a hot water soluble fiber binder is added to the principal fiber, so little bonding force may be, contrary to expectation, practically gained regardless of an amount of the fiber added, and therefore, it has also been difficult to produce a paper having excellent mechanical properties from the above synthetic fiber.

The above difficulties are thought to arise from the fact that the wet web on web forming process retains so little water and it has also less density among fibers at a dryer part of the process, additionally the above hydrophobic fiber has little adhering force to the fiber binder. In the process of forming the web containing hydrophobic fiber as the principal ingredient, even though suction and drainage may be reduced, the fiber cannot retain so much water in its inner structure that the wet web just formed contains considerably less water through a dryer part than that of other chemical or synthetic fibers such as rayon and vinylon, needless to say pulp. Therefore, density of the wet web decreases and the hot water soluble fiber binder cannot fulfill its function as a binder, so that the sheet has an appearance of so-called "web" in the production of non-woven fabric by a dry process, not being similar to water leaf. That is, even though the wet web containing from 10 to 20% by weight of polyvinyl alcohol fiber binder, in which fibers composing the web as the principal ingredient are so less densified to each other and do not have much contact amongst themselves or with the fiber binder, is subjected to wet and heat conditions at a dryer part so as to melt the fiber binder, the fiber binder shrinks by itself or adheres only to a slight degree to the principal fibers or among them and forms insignificant intertwists. Consequently, utilizing efficiency of the fiber binder is cut down and possibility of an expected strength would not be gained, whatsoever.

After due consideration of the above, we inventors first gave attention to the fact, in a mechanical papermaking process from hydrophobic fiber stock, that it is necessary to make the web retain enough moisture, before the wet web is led to a dryer part, for increasing the efficiency of the hot water soluble fiber binder. And, we have obtained satisfactory results in producing a synthetic fiber paper or sheet having excellent mechanical properties in dry conditions from synthetic fiber having a moisture regain of not more than 5% by using water soluble viscous material having good moisture retainability together with the above hot water soluble fiber binder.

Secondly, after prosecuting further studies as to various after-treatments, especially heat treatment utilizing thermal characteristics of synthetic fiber paper thus formed, we achieved success in producing a fabric-like paper which has characteristic properties we could hardly expect from the paper just made, and moreover, in order to make the best use of the effect of the heat treatment, we have established a new method for producing the paper, which comprises, first, forming a sheet paper from a mixed aqueous dispersion of the above hydrophobic fiber with a fiber or fiber-like material made from thermoplastic resin having a lower melting point than that of the hydrophobic fiber by using a hot water soluble fiber binder and thereafter, subjecting the sheet paper to heat treatment.

Further, we also have scored a success in the provision of another synthetic fiber paper having superior physical properties, in which a network structure was laminated together with the above synthetic fiber papers.

Therefore, it is a main object of the present invention to provide an improved process of making a synthetic fiber paper having especially excellent mechanical properties.

It is another main object of the present invention to provide an improved process of making a synthetic fiber paper having various prominent appearances or shapes and excellent physical properties.

The present invention provides a process of making a sheet paper comprising preparing an aqueous dispersion containing synthetic fiber having a moisture regain of not more than 5%, a hot water soluble fiber binder and carboxymethyl cellulose, and subsequently, forming a sheet paper from said aqueous dispersion. The term "moisture regain" is defined as the amount of moisture in a synthetic fiber under prescribed conditions expressed as a percentage of the weight of the moisture-free specimen (see JIS L0208–1108 and ASTM D 123–68a). The moisture regain value is thus a measure of the hydrophobic property of synthetic fibers. The term is herein used to indicate the moisture regain value determined under a moisture equilibrium condition at a relative humidity of 95% and a temperature of 20° C.

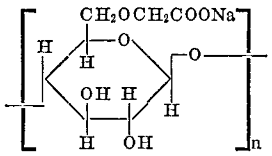
According to the present invention, as the wet web containing so much moisture, in which bonds or intertwists among the fibers composing a wet web are raised and which is more densified, is moved to a dryer part, utilizing efficiency of a hot water soluble fiber binder added into the wet web, is raised, and consequently, hydrophobic synthetic fiber paper having especially excellent mechanical properties in dry conditions may be obtained.

As a water soluble viscous material, water soluble natural high polymer such as gelatin, casein, sodium alginate, etc.; water soluble semi-synthetic high polymer such as starch phosphate, cyanoethylated starch, carboxymethyl cellulose, hydroxypropylmethyl cellulose; water soluble synthetic high polymer such as polyvinyl alcohol, poly-sodium acrylate, polyacrylamide; and polyethylene oxide, polyphosphate, etc., which recently have been used as viscous materials for making rayon paper, vinylon paper, etc., as a substitute for natural hibiscus are listed. However, from repeated tests for paper making concerning the above-listed adhesive materials, it was found, as shown in the examples, that the effect of carboxymethyl cellulose was much higher than that of any other adhesive material, and if other adhesive material was used to achieve the same effect as that of carboxymethyl cellulose, a higher concentration was needed, and that particularly, polyethylene oxide, polyphosphate, etc. failed to bring about the desired effect because they readily formed a film having an adverse effect on a sheet formation.

However, if necessary, use of polyethylene oxide or polyphosphate in combination with carboxymethyl cellulose is allowable. Further, if a nonionic surface active agent having a low foaming action is used together with these materials in order to increase the affinity between these hydrophilic viscous materials and hydrophobic synthetic fibers, the above effect is even more raised.

A method for adding carboxymethyl cellulose of the present invention should be properly selected so as to be adapted for a paper-making machine, thickness of paper, paper-making speed, etc. A superfluous addition of the material results in many drawbacks, for example, scummed material, too much moisture content of the wet web, inactive dehydration, pollution of felt, etc. So, there is a limit to the addition amounts of the material. Carboxymethyl cellulose having a viscosity from 20 to 5000 centipoise (cps.), preferably from 200 to 2000 cps. (measured by B type viscosimeter) in 2% aqueous solution at 25° C., is used in amounts from 0.003 to 0.1% based on the weight of the aqueous dispersion of fiber.

Carboxymethyl cellulose (hereinafter referred to as "CMC" for short) is one of the derivatives of cellulose ether formally called sodium cellulose glycolate having a following structural formula and is utilized for various purposes due to its moisture retainability and protective colloidal property.



The above formula indicates CMC only having a degree of etherification of 1, that is, one carboxymethyl group per an anhydrous glucose unit. But, theoretically, a degree of etherification may take a numerical value not more than 3. In the above formula, *n* represents a degree of polymerization, both which and degree of etherification define the characteristics of CMC. Particularly, flow characteristics of an aqueous solution of CMC largely depend on both the degree of polymerization and the degree of etherification, for example, CMC of a certain grade has such a relation to them as shown in FIG. 1.

FIG. 2 shows a relation between a degree of etherification and a breaking strength of sheet paper, in which viscosities of CMC (cps.) are measured in 1% aqueous solution at 25° C. by using B type viscosimeter. As shown in FIG. 2, breaking strength of sheet paper is nearly in an inverse proportion to a degree of etherification in case the viscosity is constant and the breaking strength remarkably increases at the degree of etherification below 0.6. On the other hand, as shown in FIG. 1 a reduction of the degree of etherification exercises an undesirable effect on water solubility and stability of solution. And, in the present invention, from a view of water retainability, it is preferable that the aqueous solution of CMC has a flow characteristic corresponding to thixotropic gell or the like. From the above reasons, the degree of etherification should be more than 0.3, preferably from 0.4 to 0.6. As to a degree of polymerization from a consideration of the relation with flow characteristics of an aqueous solution as shown in FIG. 1 it is preferably less than 1000, more preferably from 200 to 700. Moreover, CMC may contain salts or moisture to some extent.

It is known that CMC has been utilized in a process of making paper, for example, nylon paper. However, it was merely utilized as a primary binder in order to make use of its adherent property, which differs entirely from an object for utilizing CMC according to the present invention. On the contrary, the present invention makes a great feature of utilizing CMC together with a hot water soluble fiber binder, that is based on the fact that, in case CMC is added alone to a hydrophobic fiber such as polyolefine and polyester fiber, it cannot achieve any effect as a binder, but, in case of using both the two together, a synergistic effect can be gained.

Hot water soluble fiber binder, referred to as in the present invention, such as polyvinyl alcohol fiber, polyethylene oxide fiber, etc. is preferably modified so as to melt at a wet-heat condition from 30° C. to 100° C., for example, in the case of a polyvinyl alcohol fiber by adjusting a degree of formalization, and in the case of polyethylene oxide fiber by blending water insoluble substance. When the fiber binder does not melt in a wet-heat condition below 100° C., it also does not melt in an actual sheet forming process. On the contrary, in case the fiber melts in a wet-heat condition below 30° C., there is the possibility that it melts in a process of preparing the dispersion of paper stock. In both cases, an expected fiber binder effect cannot be obtained.

These fiber binders have a fineness from 1 to 15 denier, preferably, not more than 5 denier and a cut length of less than 20 mm., preferably from 3 to 10 mm. If necessary, besides the fiber binder and CMC, addition of other adhesives, sizing agents, defoaming agents, binders, releasing agents, etc. into a fiber dispersion or a sheet forming bath is allowable.

It goes without saying that the process of the present invention may be applied to not only polyolefine fiber, polyester fiber, but also other chemical and synthetic fibers. The latter fibers are also processed in the same manner as the former using a hot water soluble fiber binder such as polyvinyl alcohol fiber. Moreover, the hot water soluble fiber binder may be previously subjected to a treatment so that the fiber binder is made insoluble by heat treatment subsequent to the above-described process.

Further, the present invention provides a process of after-treating a sheet paper, which makes it a great feature that the sheet paper, formed by the above-described process, or a sheet paper, formed from an aqueous dispersion containing synthetic fiber having a moisture regain of not more than 5%, a fibrous material having a lower melting point than that of the former fiber, a hot water soluble fiber binder, and CMC is subjected to heat treatment at a temperature below the melting point of the former fiber.

More particularly, the above process comprises, first, forming a sheet paper from an aqueous dispersion containing synthetic fiber having a moisture regain of not more than 5% and a fibrous material having a lower melting point than that of the former fiber, which melts by being subjected to heat treatment subsequent to sheet forming process and achieves an adhesive effect. The fibrous material is made of various synthetic resins having a lower melting point than that of polypropylene fiber or polyester fiber, for example, polyethylene, chlorinated polypropylene, chlorinated polyethylene, chlorosulphonated polyethylene, ethylene/vinyl acetate copolymer, etc. for polypropylene fiber, and polypropylene, chlorinated polypropylene, polyethylene, chlorinated polyethylene, chlorosulphonated polyethylene, ethylene/vinyl acetate copolymer, etc. for polyester fiber.

The above process further comprises subjecting the sheet paper thus formed, to heat treatment at a temperature range of above a melting point of the fibrous material and below a shrinking temperature of the former fiber having a moisture regain of not more than 5%. Through the above heat treatment, the fibrous material melts and intertwists physically and chemically with the principal fibers, which result in good adhesive effect among the principal fibers.

The fibrous material in the present invention involves (1) so-called fiber made by a conventional spinning process such as a melt, dry, or wet spinning process, and fiber-like material, for example (2) fibrous fibril or split piece made from synthetic split film by heating the same, (3) fibrous structure having an average fineness of not more than 2 denier and a cut length of not more than 10 mm. and having a rugged surface with many fluffs made from synthetic foam material by applying shearing force to the foam material, and (4) composite fiber composed of two or more kinds of synthetic fibers in which at least one kind of synthetic fiber has a lower melting point than that of polypropylene or polyester fiber, and composite fiber-like structural material.

Up to now, bonding of fibers in a non-woven fabric has been achieved chiefly by applying an adhesive solution or dispersion, or mechanical punching or stitching. However, a thin sheet having a hard hand-feeling or appearance and good homogeneity could not be obtained. On the contrary, in the present invention, the use of fibrous material as a temperature sensitive binder has given such success that the utilizing efficiency of binder was raised to approximately 100%, and consequently, thin sheets having a good hand-feeling and homogeneity were obtainable. Moreover, according to the present invention, various fibrous binders, for example, broken chips of foam material, split pieces of film, etc. may be utilized besides conventional fiber.

Further, another process of after-treating a sheet paper comprises subjecting the sheet paper composed of a synthetic fiber having a moisture regain of not more than 5% or composed of both synthetic fibers having a moisture regain of not more than 5% and a fibrous material having a lower melting point than that of the synthetic fiber to heat treatment at a higher temepratuire, that is, a temperature range from a shrinking temperature of at least 5° C. below a melting point of the synthetic fiber without applying any substantial tension (or applying slight tension) for a short time. Through the above process, a finely creped non-woven fabric having softness, excellent strength and good homogeneity can be produced.

The above process is effective for the non-woven fabric by a dry process. But, especially on the synthetic fiber sheet of the present invention, that is, the synthetic fiber non-woven by a wet process, it has a marked effect; good softness, which we could hardly expect from the so-called "paper-like hand-feeling" quite peculiar to the conventional wet process, is obtainable.

Of course, the shrinking behaviour of fiber depends upon its material, but, even among the same materials, it also largely depends upon molecular orientation, which is surmised from the amount of tension applied to the fiber in a process of manufacture, and upon conditions of annealing. For example, vinyon fiber, not yet heat treated, shrinks to amounts of 25% under a dry heat condition of 120° C. But, in contrast to the above, vinyon fiber, already subjected to annealing at 110° C. for 6 hrs., shrinks only 2.2% under the same condition.

Therefore, by selecting the condition of treatment in the process of manufacture, the synthetic fiber used in the present invention, may have any shrinkage by the heat treatment of the invention, and so, any desirable effect could be expected. However, the shrinkage of fiber is usually proportionate to a temperature of the shrinking treatment (heat treatment). The higher the temperature, the more the shrinkage. But, in case the thermoplastic synthetic fiber is treated at a higher temperature range in which the fiber melts or intensely softens or shrinks, the fiber's feeling is rather hardened after the treatment. From the above reason, the heat treatment of the above process is preferably carried out at a temperature range from a shrinking temperature to a temperature of at least 5° C. below a melting point or an intensely melt-shrinking temperature.

The above heat treatment is intended as the wet non-woven fabric softens due to its shrinkage. But, it is also noticeable that the shrinkage depends on the construction of the fabric.

On the other hand, in synthetic fiber paper or wet non-woven fabric, which contains so much paste or binder having no thermoplastic property or having a softening temperature higher than a melting point of the principal fiber, shrinkage is considerably limited. So, in case the sheet paper is printed with a paste pattern having little or no substantial thermoplastic properties, and thereafter, subjected to the heat treatment, a three-dimensional paper with a remarkably raised pattern may be obtained.

Prior to the above shrinking treatment, a synthetic fiber paper may be subjected to a heat treatment at a temperature below the shrinking temperature by a hot air heater or infrared heater, or to a heat treatment at a temperature below the melting point under tension or by calendering.

Through the above-shrinking treatment, synthetic fiber paper or wet non-woven fabric loses its surface smoothness and has a bulky and soft hand-feeling. Further, as the web density increases due to shrinkage, the bonding of intertwisted fibers and the utilizing efficiency of the binder, in case the binder is used, is remarkably raised so that the resultant paper or non-woven fabric has excellent mechanical properties such as tensile strength and elongation, bursting strength, tearing strength, and especially, has a more improved strength in a wet condition.

Further, the present invention provides a process of making a patterned sheet paper in which a network structure is laminated together with a dispersion of fiber into a sheet paper. More particularly, a network structure such as an unfolded synthetic split film is stuck on a wet web just formed from a dispersion of fiber, or, at the same time of the wet web forming, laminated together with the dispersion of fiber into a sheet paper.

Up to now, in order to produce a reinforced paper, a yarn network structure such as victoria lawn has been stuck on or laminated together with the dispersion of fibrous material. In preparation of the yarn network structure, however, a weaving process and a warping process are needed and further, if colouring is needed, complicated processes such as dyeing and finishing are added, so the cost is inevitably raised. On the contrary, in the synthetic split film of the present invention, the cost may be cut, and a more varied pattern is obtainable.

Moreover, as the split film has a surface with so many fluffs, which, in case the film is laminated with a wet web, intertwist with the web and is united by drying, peeling off between the web layers cannot be created. In case the split film having a lower melting point than that of the principal synthetic fiber is laminated together with the synthetic fiber into a sheet, and thereafter, the sheet is subjected to pressing or calendering at a temperature above a melting point of the film, patterned paper having a graceful look and a still higher tenacity is obtained. The effect may be achieved in the synthetic fiber paper having a large transparency and less density. The larger fineness the synthetic fiber has and the less the density is, the more prominent it is. In the case of cellulose pulp paper, which is more densified, it would not be expected.

Synthetic fiber having a moisture regain of not more than 5%, as referred to in the present invention, that is, polyester fiber and polyolefine fiber, means fiber of the polymer in which the principal constituent unit is polyester and polyolefine, respectively. In the case of polyester, it may be a copolymer of two or more components, and in the case of polyolefine, it may be a homopolymer of ethylene, propylene, styrene, etc., or a copolymer of two or more components. These polymers may contain additives such as a stabilizer, antistatic agent, colorant, perfume, etc. A most effective synthetic fiber in accordance with the present invention, is polypropylene fiber, which is hydrophobic in excess and has the least water retainability.

As to the formation of the synthetic fiber, any section, shape of surface and crimp does not constitute an obstacle. But, from a viewpoint of paper-making ability in using the conventional paper-making machine, the fiber usually has a fineness from 1 to 30 denier, preferably not more than 15 denier and a cut length not more than 35 mm., preferably from 4 to 15 mm. The synthetic fiber may not only be polyester fiber or polyolefine fiber alone, but also, if necessary, blended with other synthetic or natural fiber. In the case of blending, blends composed of synthetic fibers and composed of more than 60% by weight of synthetic fiber and natural fiber, are most effective. But, the above-synthetic fiber sometimes means the blend of a principal synthetic fiber and a synthetic fibrous material.

A paper-making machine, as referred to in the present invention, may be of a conventional type such as Fourdrinier machine, Short wire paper machine, cylinder machine and of a new type such as Rotoformer, Vertiformer, etc.

As to a machine for executing a heat treatment at a higher temperature, that is, shrinking treatment, any machine, for example, a pin tenter, clip tenter, roller setter, infrared dryer or hot air heater such as a suction drum dryer may be used, but of the types in which width and feeding speed may be adjusted with ease, are preferable. The suction drum dryer type in which the width and feeding speed are always restricted, is not preferable.

A synthetic fiber sheet paper thus obtained, a fabric-like sheet obtained by after-treating the sheet paper and a patterned sheet paper have excellent mechanical properties due to a high utilizing effect of the fiber binder, and superior chemical properties such as hydrophobic property, insulating property, chemical resistance, due to its own nature. A sheet paper except a patterned sheet paper, has a lower density, soft hand-feeling and good gas transmission. From the above features, these sheet papers have various uses, for example, medical supplies, filters, padding cloths, insulation tape, surface mats for reinforced plastic, protecting paper for dyeing, packing paper, heat-sealing paper, base paper for coating, interlining cloth for synthetic leather and other materials.

The following examples illustrate specific embodiments of the present invention.

Characteristics of paper were measured in accordance with Japanese Industrial Standards. Viscosities of an aqueous solution of CMC and other viscous materials were measured by a B type viscosimeter.

All parts and percent are by weight.

EXAMPLE 1

100 parts of polypropylene fiber having a fineness of 1.5 d. and a cut length of 5 mm. and 20 parts of polyvinyl alcohol (hereinafter referred to as "PVA" for short) fiber binder (trademark "Fibribond No. 241"; 1.5 d., 5 mm.) were dispersed in an aqueous solution containing 0.01% nonionic surface active agent (trademark "Emulgen 905," HLB=9.2). To this aqueous dispersion, an aqueous solution of CMC having a viscosity from 150 to 250 cps. in 1% aqueous solution at 25° C. and a degree of etherification of 0.54% was added to prepare an aqueous dispersion containing 0.006% CMC. A hand sheet of polypropylene fiber was made from the dispersion by a Tappi standard method and the sheet was adhered to a photographic ferrotype plate and subjected to infrared drying at a surface temperature of 110° C.

Strength of the paper is shown in Table 1 column (A) in comparison with those of various papers which were made in the same manner as the above except (B) using CMC without the PVA fiber binder, (C) using 20% of PVA fiber binder without CMC, (D) not using either binder now CMC (E) using 20% of PVA fiber binder and sodium alginate as a substitute for CMC (F) using 20% of PVA fiber binder and polyethylene oxide as a substitute for CMC. The polyethylene oxide having a viscosity of 500 cps. in 1% aqueous solution was used at a concentration of 0.02% based on the weight of the aqueous dispersion of the fiber.

TABLE 1

	Invention,	Control				
	A	B	C	D	E	F
PVA fiber binder (parts)	20	0	20	0	20	20
CMC (percent)[1]	0.006	0.006	0	0		
Sodium alginate (percent)[2]					0.006	
Polyethylene oxide (percent)						0.02
Basis weight (g./m²)	32.8	30.0	35.6	32.0	34.1	29.4
Break strength (km.)	1.57	0.30	0.18	0.15	0.15	0.15

[1] Viscosity of 200 cps. (viscosimeter type B) in 1% aqueous solution.
[2] Viscosity of 370 cps. in the same.

From the table it will clearly be understood that, in both cases of (C) not using CMC in the least, admitting that the web contains 20% of PVA fiber binder and (F) using polyethylene oxide as viscous material, strength of the paper could hardly be gained, and, in case (E) of using sodium alginate, which being less sticky in itself as viscous material, little effect of increasing the strength is gained, also. On the contrary, when PVA fiber binder and CMC are used together (A), the effect of the PVA fiber binder is remarkably enhanced and the strength is exceptionally increased.

EXAMPLE 2

100 parts of polypropylene fiber having a fineness of 1.5 d. and a cut length of 5 mm. and 20 parts of PVA fiber binder were dispersed in an aqueous solution containing a 0.01% nonionic surface active agent. To this dispersion, (G) an aqueous solution of CMC having a viscosity from 300 to 350 cps., in 1% aqueous solution at 25° C. and degree of etherification from 0.6 to 0.67 and (H) aqueous solution of CMC having a viscosity from 500 to 1000 cps. and a degree of etherification from 0.55 to 0.57 were added separately to prepare two kinds of aqueous dispersions, both containing 0.006% CMC. Hand sheets of polypropylene fiber were made in the same manner as in Example 1. Strength of the papers is shown in Table 2.

TABLE 2

	G	H
PVA fiber binder (parts)	20	20
Sticking material, CMC (percent)	0.006	0.006
Basis weight (g./m.^{2})	31.0	32.9
Break strength (km.)	0.55	1.88

EXAMPLE 4

75 parts of polypropylene fiber having a fineness of 1.5 denier and a cut length of 5 mm., 15 parts of polyethylene fiber having a fineness of 6 denier and a cut length of 5 mm., and 15 parts of PVA fiber binder (trademark "Fibribond No. 241") having a fineness of 1 denier and a cut length of 4 mm. were dispersed with a nonionic surface active agent to prepare an aqueous dispersion containing 2% fibers. To the dispersion, an aqueous solution of CMC having a viscosity from 150 to 250 cps. in 1% aqueous solution at 25° C. and a degree of etherification of 0.65% was added to prepare an aqueous dispersion containing 0.01% CMC, and further, small quantities of a sizing agent and defoaming agent, respectively, were added. The dispersion was put into a paper making bath and the concentration of CMC was adjusted to 0.006%. From the bath, paper was made at a speed of 160 m./min. by using a cylinder paper machine.

A surface temperature of the Yankee drier of the machine was approximately 100° C.

The paper, thus obtained, had a soft hand feeling like non-woven fabirc and excellent mechanical properties. The paper was subjected to heat treatment at 125° C. for 4 min. so that the polyethylene fiber was melted.

Thusly obtained polypropylene fiber paper was remarkably increased in its strength and had little difference of strength between dry and wet conditions. Mechanical properties of the papers are given in Table 4.

TABLE 4

	Before thermal treatment		After thermal treatment	
	Machine direction	Lateral direction	Machine direction	Lateral direction
Basis weight (g./m.^{2})	33.9	33.9	34.9	34.9
Dry tenacity (g./15 mm.)	1,080	250	1,390	406
Dry elongation (percent)	3.0	3.5	3.9	4.2
Wet tenacity (g./15 mm.)	200	100	750	320
Wet elongation (percent)	1.9	1.5	3.1	3.8
Tear factor	3,500	2,110	4,300	2,520
Burst factor	1.27		1.62	

From a result of the above and Example 1, it will be proven that the lower the degree of etherification of CMC, and the higher the viscosity, that is, the higher the degree of polymerization, the more CMC enhances the effect of increasing strength of the paper.

EXAMPLE 3

100 parts of polyester fiber having a fineness of 2.0 denier and a cut length of 5 mm. and 20 parts of PVA fiber binder were dispersed into an aqueous solution containing 0.01% nonionic active agent. To this aqueous dispersion, an aqueous solution of CMC having a viscosity from 150 to 250 cps. in 1% aqueous solution at 25° C. and a degree of etherification of 0.54% was added to prepare an aqueous dispersion containing 0.006% CMC. A hand sheet of polyester fiber was made from the dispersion in the same manner as in Example 1 and the sheet was adhered to a photographic ferrotype plate and subjected to infrared drying at a surface temperature of 110° C.

Strength of the paper was shown at Table 3 column (A) in comparison with paper (B) which was made in the same manner as the above except for adding only PVA fiber binder without CMC.

TABLE 3

	A	B
PVA fiber binder (parts)	20	20
CMC (percent)	0.006	0
Basis weight (g./m.^{2})	33.0	32.0
Break strength (km.)	1.95	0.30

The paper had strong hydrophobic and oleophilic properties and good insulating resistance due to the specific characteristics of the original polypropylene fibrous material and displayed excellent dimensional stability.

Further, in a process of web forming from the dispersion of fiber in the above Example 4, a spread split film made from coloured polypropylene film was laminated together with dispersed fiber into a paper layer. The resultant paper had a graceful looking-coloured network which could be seen through the paper layer and had a still higher tenacity.

On the other hand, to the aqueous dispersion of fibrous material in the above Example 4, as a substitute for CMC, an aqueous solution of polyethylene oxide having a viscosity of 500 cps. in 1% aqueous solution at 20° C. was added to prepare an aqueous dispersion containing 0.03% polyethylene oxide, and further, small quantities of a sizing agent and defoaming agent were added, respectively, to the dispersion. From a bath filled with the dispersion, paper was made at a speed of 160 m./min. by using a cylinder paper machine. A surface temperature of the Yankee dryer of the machine was approximately 100° C. Web-like loose structure of polypropylene could barely be formed from the dryer, which had not enough strength to maintain a sheet-like shape.

EXAMPLE 5

Polyethylene foam sheet (made from low-density polyethylene) having a bulk density of 0.03 g./cm.^{3} and a thickness of 10 mm. in which individual foam was basically independent but partially connected at portions to each other, was cut into chips of approximately 60 mm.^{3} by a cutter. 20 g. of the chips were put into a mixer

(NATIONAL MX-120; number of revolutions, 1800 r.p.m.) together with 2 litres of water and 0.2 g. of a nonionic surface active agent (trademark "Emulgen 905," HLB=9.2) and stirred violently for 30 min. From the stirring, the chips were broken into pieces having a shape similar to wood pulp. The stirring was repeated 4 times. Broken chips, thus obtained, were put into a Niagara test beating machine (capacity, 10 litres; number of revolutions 450 r.p.m.) together with 1 g. of nonionic surface active agent (Emulgen 905), and, in a concentration of 80 g./litre, subjected to beating for 30 min. under an unbound condition. Thus, polyethylene fibril was obtained from the foam sheet.

From an examination of the polyethylene fibril by a microscope, the fibril was found to be a piece having a slender shape with many fibrillated fluffs. All the pieces had a length of less than 10 mm. and a fineness of less than 2 denier.

On the other hand, 2 g. of polypropylene fiber having fineness of 1.5 denier and a cut length of 5 mm. and 0.2 g. of PVA fiber binder (trademark "Fibribond No. 243") were put into a water bath (2 litres) together with 0.2 g. of nonionic surface active agent (trademark "Emulgen 905," HLB=9.2), and stirred to prepare a uniform dispersion of fibers.

To the dispersion, 0.5 g. of the above polyethylene fibril was added. After uniform mixture and dispersion were realized by further stirring, an aqueous solution of 0.2 g. CMC having a viscosity from 150 to 200 cps. in 1% aqueous solution and a degree of etherification of 0.54% as a viscous material was added. A hand paper of polypropylene fiber was made from the dispersion by the Tappi standard method. The paper, thus obtained, was dried under a predetermined condition, and then, subjected to heat treatment in a hot air dryer at a temperature of 130° C.

Mechanical properties of the paper are shown in Table 5, in comparison with those made in the same way as the above except not adding the polyethylene fibril.

TABLE 5

	Invention	Control
Breaking strength, km.:		
Dry	2.40	1.01
Wet	1.50	(1)
Elongation, percent:		
Dry	4.00	1.3
Wet	3.80	(1)
Tear factor	4,200	2,500
Basis weight (g./m.)	50	44

(1) Impossible to measure.

EXAMPLE 6

A foam sheet having a bulk density of 0.51 g./cm.^{3} and a thickness of 3.0 mm. in which individual foam was basically independent but partially connected at portions to each other, was made by using a blowing agent from ethylene/vinyl acetate copolymer containing 28% vinyl acetate (trademark "Evaflex 260," made by Mitsui Polychemical Co.). From the sheet, ethylene/vinyl acetate copolymer fibril was prepared in the same manner as Example 5. A formation of the fibril was confirmed by a microscope.

On the other hand, 2 litres of the same dispersion of polypropylene fiber and PVA binder fiber as that in Example 5 was prepared. 0.5 g. of the above ethylene/vinyl acetate copolymer fibril was added to the dispersion and after a uniform mixture and dispersion were realized by stirring, an aqueous solution of the same CMC as in Example 5 was added as a viscous material. A hand-made paper of polypropylene fiber was made from the dispersion by the Tappi standard method. The paper, thus obtained, was dried under a predetermined condition, and then, subjected to heat treatment in a hot air dryer at 100° C. for 10 min.

The resultant paper had a basis weight of 50 g./m.^{2}, dry-breaking strength of 3.2 kms., wet-breaking strength of 2.1 km., dry elongation of 5.6%, and tear factor of 5100.

A ratio of ethylene/vinyl acetate in the copolymer of the present invention may be varied in compliance with an adhesion to the fiber composing the principal ingredient of paper and other requirements. However, it is preferable that the copolymer contains from 15 to 45% by weight of vinyl acetate, and, in case a content of vinyl acetate in the copolymer exceeds 45% by weight, a melting point of the resultant copolymer drops below 60° C. and a blocking resistance is reduced, that is, the copolymer loses its function as a binder.

EXAMPLE 7

Polyethylene foam sheet (low-density polyethylene) having a bulk density of 0.03 g./cm.^{3} and a thickness of 7 mm. in which individual foam was basically independent but partially connected at portions to each other, was cut into chips of approximately 50 mm.^{3} by a cutter. 200 g. of the chips were put into a mixer (mono phase four pole motor, number of revolutions 2000 r.p.m.) which was provided with rotating blades of thickness 5 mm. and of a pointed head 1 mm. and which had a capacity of 30 litres, together with 2 litres of water and 2 g. of nonionic surface active agent (trademark "Emulgen 905") and stirred violently for 30 min. By the stirring, the chips were broken into pieces having a shape similar to wood pulp. Broken chips, thus obtained, were subjected to beating by using a Hollender beater (capacity of 3000 litres, roll diameter of 1250 mm., roll blade thickness of 7 mm., number of blades 84, prop-up blade thickness 4 mm.) at a concentration of 1% under an unbound condition for 60 min. From an examination by a microscope, the polyethylene fibril, thus obtained, was found to be a piece having a slender shape with many fibrillated fluffs. The piece also had a length of less than 10 mm. and a fineness of less than 2 denier.

On the other hand, polypropylene fiber having a fineness of 1.5 denier and a cut length of 5 mm., 20% of the above polyethylene fibril and 15% of PVA fiber binder both based on the weight of polypropylene fiber were put into a chest (capacity 5000 litres) at a concentration of 2%, and then predetermined amounts of a nonionic surface active agent as a dispersing agent and CMC having a degree of etherification of 0.65 as a viscous material were added. Paper was made from the dispersion by a cylinder machine. The paper had a basis weight of 32 g./m.^{2}, uniform dispersion of fibers, good quality and soft feeling.

Further, the paper was subjected to heat treatment using a heat calender (temperature of roll surface, 120° C.; roll pressure, 5 kg./cm.^{2} (gage press)) or using a tenter (at 130° C., for 4 min.), which resulted in the paper having excellent strength and a slight difference between dry- and wet-tenacity. The mechanical properties are shown in Table 6.

TABLE 6

	Direction	Tenacity (g./15 mm.)		Elongation (percent)		Basis weight (g./m.^{2})
		Dry	Wet	Dry	Wet	
Head calender treatment	Machine	1,520	820	5.1	4.5	35
	Traverse	418	360	2.3	2.4	
Tenter treatment	Machine	1,400	745	3.0	3.1	33
	Traverse	406	318	1.5	1.7	

All the fibrils used in the above Examples 5, 6 and 7 usually appear as fibrous structures having a rugged and fluffed surface, although they may be of various forms to some degree chiefly depending on a foam structure of sheet material. In view of its efficiency as a binder, the fibril has an average denier preferably less than 2 and a cut length less than 10 mm. As the fibril has so few vesicles in its inner structure, if any, it scarcely displays elasticity and its bulk specific gravity nearly equals that of the polymeric material itself composing the foam material.

EXAMPLE 8

Polypropylene fiber having a fineness of 1.5 denier and a cut length of 5 mm., 20% of polyethylene fiber fibril and 10% conventional PVA fiber binder (trademark "Fibribond No. 243"), both based on the weight of the polypropylene fiber, were put into a chest, and then, predetermined amounts of a nonionic surface active agent (HLB=9.2) as a dispersing agent and CMC having a degree of etherification of 0.65 were added. Paper was made from the dispersion by a conventional cylinder machine. The paper had a basis weight of 30 g./m.², and displayed uniform dispersion of fibers, good quality and soft feeling.

Further, the paper was subjected to heat treatment using an infrared heater at 140° C. Tenacity and elongation of the paper thus obtained, were as shown in Table 7.

TABLE 7

	Direction	Tenacity (g./15 mm.)		Elongation (percent)		Basis weight (g./m.²)
		Dry	Wet	Dry	Wet	
Before heat treatment	Machine	1,120	1,060	1.5	1.8	30
	Traverse	620	480	2.1	2.5	
After heat treatment	Machine	1,320	1,180	1.3	1.6	33
	Traverse	710	570	1.8	1.3	

The above measurements were made on a test piece of 1.5 cm. (width) x 20 cm. (length) in accordance with Japanese Industrial Standards.

Polyethylene fibril, which may be used in the present invention, is prepared as follows: low density or medium- or high-density polyethylene film (high density polyethylene film of 20μ thickness was used in the above Example 8) are split into tapes as thinly as possible, preferably in a thickness from 10 to 100μ, by a conventional method, and the split tape is cut into chips of lengths from 1 to 15 mm., preferably from 3 to 10 mm. by a cutter, and then subjected to beating under predetermined conditions using a beater usually used in paper making from pulp, and thusly, transformed into small fibrous chips of an average fineness from 0.1 to 10 denier, preferably 2 denier.

EXAMPLE 9

Polypropylene fibers of a fineness of 1.5 denier and a cut length of 5 mm., 40% based on the weight of polypropylene fiber, of a side-by-side type composite fiber having a fineness of 3 denier and a cut length of 6 mm., which was composed of polypropylene (PP #2000, made by Mitsubishi Petroleum Chemical Co.) and polyethylene (DNDJ–0405, made by Nitto Unikar Co.) at a ratio of 1:1, and 10% based on the weight of both above fibers, of conventional PVA fiber binder (Fibribond No. 243) were put into a poacher at a fiber concentration of 1% together with predetermined amounts of a nonionic surface active agent as a dispersing agent and CMC (trademark "Cellogen WSC" made by Daiichi Kogyo Seiyaku Co.) having a degree of etherification from 0.6 to 0.7 and a viscosity from 150 to 250 cps. at 1% aqueous solution as viscous material, respectively. Paper was made from the dispersion by a cylinder machine. The paper had a basis weight of 35 g./m.², and displayed a uniform dispersion of fibers good quality and soft feeding.

Further, the paper was subjected to heat treatment at 140° C. for 1 min. by using a roller setter without giving any tension to the width direction. The paper thus obtained, had remarkably improved physical properties and a feeling and appearance like fabrics. The properties are shown in Table 8.

TABLE 8

	Immediately after forming sheet		After heat treatment	
Direction	Machine	Traverse	Machine	Traverse
Tensile strength (g./15 mm.):				
Dry	577	295	3,703	1,716
Wet	320	160	2,500	1,200
Elongation (percent):				
Dry	9.3	11.4	13.1	29.7
Wet	10.1	9.3	11.7	20.3
Bursting strength (kg./cm. ²)	0.65		1.80	
Tearing strength (g.)	121		271	

A composite fiber as is referred to in the present invention, is not limited to the one in the above example which was a side-by-side type and had a composite ratio of 1:1. A composite ratio may be varied from a viewpoint of composite-spinnability, that is, a content of polymer having a lower melting point may decrease according to a proportional ratio. In the above case, however, the content cannot decrease so much that the polymer having a lower melting point has a composite ratio of less than 20% by weight based on the whole web sheet. Also, a section of composite fiber may be of various forms, for example, side-by-side type, sheath-core type such as concentric-circular type, random type, etc. Particularly, a concentric-circular type composite fiber, in which the polymer of a lower melting point is located at the outer side in its section, is most preferable.

EXAMPLE 10

Polypropylene fibers ("Pylene," made by Mitsubishi Rayon Co.) having a fineness of 1.5 denier and a cut length of 5 mm. and 15% by weight of PVA fiber binder (Fibribond No. 423) based on the above fiber were put into a poacher to prepare a 2% dispersion of fiber together with a nonionic surface active agent (Emulgen 905) as a dispersing agent and CMC having a degree of etherification from 0.6 to 0.7 and a viscosity from 150 to 250 cps. at 1% aqueous solution, the added amount of both were 500 g. and 1 kg., respectively, both based on 5000 kg. of water. From the dispersion, a paper having a basis weight of 37 g./m.² was made by a cylinder machine.

The polypropylene fiber paper was subjected to a continuous heat treatment without giving any tension in a hot air dryer at 140° C. for 1 min. The paper thus obtained, had a basis weight of 85 g./m.² and a soft hand-feeling like dry nonwoven fabric, which were due to shrinkage by the above heat treatment. The mechanical properties were as shown in Table 9.

TABLE 9

	After heat treatment	Before heat treatment
Tensile strength (g./15 mm.), dry:		
Machine	3,100 [2.38]	727 [1.31]
Traverse	650 [0.50]	228 [0.41]
[Breaking strength (km.)], wet:		
Machine	1,800 [1.38]	201 [0.36]
Traverse	400 [0.30]	50 [0.09]
Basis weight (g./m.^{2})	87	37
Hardness, G Value [1]:		
Machine	0.51	0.25
Traverse	0.06	0.20
Tear factor	560	250
Burst factor	2.51	1.80
Surface abrasion resistance (times) [2]	1,800	500

[1] $G=C^3 \times W \times 0.482 \times 10^{-4}$—C=Drape stiffness; W=Weight in oz./sq. yd. of cloth (according to CCC–T–1916).

[2] Emery paper No. 600 was used.

On the other hand, when the polypropylene fiber paper, not yet subjected to a continuous heat treatment in the above example, was printed, a pattern with paste having no substantial thermoplastic properties, for example, starch paste, and thereafter, subjected to heat treatment, three-dimensional paper with a remarkably raised pattern was obtained.

EXAMPLE 11

80 parts of polypropylene fiber having a fineness of 1.5 denier and a cut length of 5 mm., 20 parts of polyethylene fiber having a fineness of 6 denier and a cut length of 5 mm., and 20% by weight of PVA fiber binder (Fibribond No. 243) based on the above two fibers were used as stock for paper-making. The paper, made in the same manner as in Example 10 by using a cylinder machine, was directly subjected to, or, after preheated by a hot calender (surface temperature 110° C., roll pressure 15 kg./cm.^{2} (gage press)) so that the polyethylene fiber just melted, and then, subjected to a continuous heat treatment at 155° C. for 1 min. by using a pin tenter adjusted at a feed of 25% and a width-directional shrinkage of 30%. Through the heat treatment, the paper shrank to the amount of 25% in the machine direction and 30% in the width direction and lost its paperlike or film-like feeling, that is, the former had a raw paperlike appearance and the latter had a paper-after-calendering type appearance, respectively. It had a soft hand-feeling like fabric. The mechanical properties were as shown in Table 10.

TABLE 10

	Raw sample		Preheated sample by calender	
	After shrinking	Before shrinking	After shrinking	Before shrinking
Basis weight (g./m.^{2})	56.0	35.0	53.0	33.2
Tensile strength (g./15 mm.), dry:				
Machine	1,750 [2, 10]	1,190 [2.32]	1,190 [2.47]	1,204]2.43]
Traverse	335 [0.40]	206 [0.39]	552 [0.69]	336 [0.67]
Breaking strength (km.) wet:				
Machine	1,120 [1.34]	545 [1.00]	1,748 [2.20]	985 [1.98]
Traverse	210 [0.25]	118 [0.22]	365 [0.46]	205 [0.41]
Tearing factor	420	285	510	256
Bursting factor	2.10	1.83	2.41	1.96
Hardness, G Value:				
Machine	0.75	0.87	0.73	0.90
Traverse	0.06	0.09	0.05	0.20
Surface abrasion resistance (times)	2,100	550	2,600	1,150

On the other hand, in the case where the raw paper, just made in the above Example 11 was subjected to heat calendering by using an embossed calender roll having a surface temperature from 110° C. to 130° C. and a linear pressure of more than 1 kg./cm.^{2} (gage press), three-dimensional embossed paper, which had many dimensionally stable projections and no fluffs, was obtained.

EXAMPLE 12

50 parts of polypropylene fiber having a fineness of 2 denier and a cut length of 5 mm., 15 parts of polyethylene fiber having a fineness of 6 denier and a cut length of 5 mm., 35 parts of beaten pulp (NBKP 35°SR), and 5% by weight of PVA fiber binder based on the weight of the above three fibrous materials were used as stock for paper making. The paper, made in the same manner as in Example 4 by using a cylinder machine, was subjected to a continuous heat treatment at 155° C. for 1 min. by using a pin tenter similar to that of Example 10.

The paper, thus obtained, had a soft and bulky hand feeling, and little difference in strength between dry and wet conditions. Mechanical properties are shown in Table 11.

TABLE 11

	Before shrinking	After shrinking
Basis weight (g./m.^{2})	25	40
Breaking strength (km.):		
Dry:		
Machine	2.10	5.10
Traverse	(1)	1.68
Wet:		
Machine	0.50	3.20
Traverse	(1)	1.10
Hand feeling	(2)	(3)

[1] Impossible to measure.

[2] Paper-like.

[3] Soft non-woven fabric-like.

What we claim is:

1. A process of making a sheet paper comprising preparing an aqueous dispersion containing synthetic fiber having a moisture regain of not more than 5%, hot water soluble polyvinyl alcohol fiber binder in amounts from 5 to 25% based on the weight of said synthetic fiber and carboxymethyl cellulose, in amounts from 0.003 to 0.1% based on the weight of said aqueous dispersion and subsequently, forming a sheet paper from said aqueous dispersion.

2. A process as claimed in claim **1**, wherein said carboxymethyl cellulose has a degree of etherification from 0.4 to 0.6.

3. A process as claimed in claim **1**, wherein said synthetic fiber having a moisture regain of not more than 5% is polyolefine fiber.

4. A process as claimed in claim **1**, wherein said synthetic fiber having a moisture regain of not more than 5% is polyester fiber.

5. A process as claimed in claim **1**, wherein a network structure is laminated together with said dispersion of fiber into said sheet paper.

6. A process as claimed in claim **5**, wherein said network structure is an unfolded synthetic split film.

7. A process as claimed in claim **1**, wherein said sheet paper is formed from an aqueous dispersion containing said fiber having a moisture regain of not more than 5%, a fibrous material having a lower melting point than that of said former fiber a hot water soluble fiber binder and carboxymethyl cellulose, and then subjected to heat treatment.

8. A process as claimed in claim **7**, wherein said heat treatment is carried out at a temperature range of above a melting point of said fibrous material and below a shrinking temperature of said fiber having a moisture regain of not more than 5%.

9. A process as claimed in claim **7**, wherein said fibrous material having said lower melting point is polyethylene or its derivatives.

10. A process as claimed in claim **7**, wherein said fibrous material having said lower melting point is an ethylene/vinyl acetate copolymer containing from 15 to 45% by weight of vinyl acetate.

11. A process as claimed in claim **7**, wherein said fibrous material having said lower melting point is a fibrous fibril made from synthetic split film by beating same to be fibrillated.

12. A process as claimed in claim **11**, wherein said fibrous fibril is polyethylene fibril.

13. A process as claimed in claim **7**, wherein said fibrous material having said lower melting point is a fibrous structure having an average fineness of not more than 2 denier and a cut length of not more than 10 mm. and having a rugged surface with manyl fluffs, which is made from synthetic foam material by applying a shearing force to said synthetic foam material.

14. A process as claimed in claim **7**, wherein said fibrous material having said lower melting point is a short length staple having a fineness of not more than 15 denier, which being made by a melt-spinning process.

15. A process as claimed in claim **7**, wherein said aqueous dispersion contains polypropylene fiber as said fiber having a moisture regain of not more than 5% and from 10 to 35% by weight of polyethylene fiber as said fibrous material having a lower melting point based on a weight of said former fiber.

16. A process as claimed in claim **15**, wherein said sheet paper, which being formed from said aqueous dispersion, is subjected to printing of a three-dimensional pattern by applying heat and pressure.

17. A process as claimed in claim **7**, wherein said aqueous dispersion contains polypropylene fiber as said fiber having a moisture regain of not more than 5% and from 20 to 50%, based on a weight of said former fiber of a short length staple of a composite fiber composed of polypropylene and polyethylene having a fineness of not more than 15 denier as said fibrous material having a lower melting point.

18. A process as claimed in claim **1**, wherein said sheet paper is subjected to heat treatment at a temperature range from a shrinking temperature to a temperature of at least 5° C. below a melting point of said fiber having

said moisture regain of not more than 5% without applying any substantial tension.

19. A process as claimed in claim **7**, wherein said sheet paper having been formed from said aqueous dispersion is subjected to heat treatment at a temperature range from a shrinking temperature to a temperature of at least 5° C. below a melting point of said fiber having said moisture regain of not more than 5% without applying any substantial tension.

20. A process as claimed in claim **7** wherein said fibrous material having said lower melting point is used in amounts from 5 to 60% based on a weight of said synthetic fiber having a moisture regain of not more than 5%.

21. A process as claimed in claim **18**, wherein said sheet paper is printed with a paste pattern, said paste having little or no substantial thermoplastic properties and thereafter, subjected to heat treatment.

22. A process of making paper comprising preparing an aqueous dispersion containing principal fiber selected from the group consisting of polypropylene and polyester with the addition of 5% to 25% by weight of polyvinyl alcohol fiber and an aqueous solution of carboxymethyl cellulose in an amount from 0.003 to 0.1% based on the weight of the aqueous dispersion of fiber, and subsequently forming a sheet of paper from said aqueous dispersion.

23. A process according to claim **22**, further comprising briefly heating said sheet of paper to a temperature of the order of 110° C. to 155° C.

24. A process according to claim **22**, in which the principal fiber used is polypropylene, further comprising the steps of treating foam of a composition selected from the group consisting of polyethylene and ethylene/vinyl copolymer to convert said composition to fibril form and including said fibril in said dispersion in an amount of approximately 20% to 25% by weight of said polypropylene fiber.

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