(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 150 777 B2**

(12) **NEW EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of the new patent specification: **30.11.94**

(51) Int. Cl.⁵: **D21F 11/00**

(21) Application number: **85100470.5**

(22) Date of filing: **17.01.85**

(54) **Method for the manufacture of a non-woven fibrous web.**

(30) Priority: **26.01.84 US 574287**
09.02.84 US 578431

(43) Date of publication of application:
07.08.85 Bulletin 85/32

(45) Publication of the grant of the patent:
06.11.91 Bulletin 91/45

(45) Mention of the opposition decision:
30.11.94 Bulletin 94/48

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI NL SE

(56) References cited:
EP-A- 0 101 319
GB-A- 1 329 409
LU-A- 48 831
US-A- 4 443 297

(73) Proprietor: **JAMES RIVER CORPORATION OF VIRGINIA**
2218 Tredegar Street
Richmond, VA 23217 (US)

(72) Inventor: **Cheshire, James O.**
Neenah
Wisconsin (US)
Inventor: **Lindgren, Douglas L.**
3585 West Allenville Rd.
Appleton Wisconsin 54911 (US)
Inventor: **Marinack, Robert J.**
Oshkosh
Oshkosh Wisconsin 54901 (US)
Inventor: **Janda, Bruce W.**
Neenah
Wisconsin (US)
Inventor: **Thut, Robert S.**
Green Bay
Wisconsin (US)
Inventor: **Larkey, John T.**
Green Bay
Wisconsin (US)
Inventor: **Jostad, Ray E.**
Green Bay
Wisconsin (US)

(74) Representative: **Cropp, John Anthony David et al**
MATHYS & SOUIRE
10 Fleet Street
London, EC4Y 1AY (GB)

Rank Xerox (UK) Business Services
(3.10/3.09/3.3.3)

Description

This invention relates to improvements in paper and other non-woven fibrous webs. In one of its more specific aspects, this invention is directed to a method of making improved non-woven fibrous webs and to the resulting products of the process. By the process of this invention, non-woven fibrous webs, e.g. paper towels and facial or toilet tissue, having superior uniformity and controlled tensile strenght may be produced on high speed paper making machines.

High quality facial and toilet tissue are usually produced from refined high grade wood pulp on a fourdrinier type paper making machine wherein a dispersion or furnish of bleached wood pulp in an aqueous carrier is uniformly dispensed onto a moving belt to form continuous web. Conventionally the wood fibers are dispersed in water to form the furnish; recently foam forming processes have been developed in which the fibers are dispersed in a foamed aqueous solution of a surfactant which forms a relatively stable foam capable of supporting the fibers.

Among the prior art processes for producing fibrous webs by various foam-forming methods are those disclosed in U.S. patents Nos. 3,716,449; 3,938,782; 3,871,952; and 3,837,999 incorporated herein by reference. The method of this invention produces foamed liquid having the desired air content, viscosity, specific gravity, and related characteristics required for forming a fibrous web without the need for a special foam forming or turbulence generating device of the earlier patents and without the need for a foam storage silo.

Fig. 1 is a diagrammatic perspective view, with portions fragmented, of apparatus suitable for carrying out the process of this invention.

Fig. 2 is a sectional view with portions fragmented taken generally along the line of 2-2 or Fig. 1.

With reference to Fig. 1 of the drawings, a preferred form of apparatus of the twin-wire type for making a non-woven fibrous web, such as paper, is illustrated wherein reference numerals 11 and 12 designate first and second endless, woven, fluid permeable forming wires of substantially similar weave and type used in the forming of the non-woven webs. Forming wire 11 is supported in a conventional manner on rolls, including those designated generally by the numerals 13, 14, 15, and 16. Similarly, forming wire 12 is supported on rolls of conventional design, two of which are illustrated and designated by reference numerals 18 and 18a. The support rolls for forming wires 11 and 12 are so positioned as to cause the wires to converge to form a nip 17 just ahead of cylindrical forming roll 19 as illustrated in Fig. 2. The wires 11 and 12 are driven so that the wrapped portions on forming roll 19 move undirectionally, at the same speed, in the direction of rotation A of roll 19.

As illustrated in Fig. 2, wires 11 and 12 converge on forming roll 19, at slightly different angles, forming a wedge-shaped nip 17 therebetween into which a jet 20 of a foamed liquid-fiber dispersion is directed from a pressurized headbox 21 as illustrated. The surface of roll 19 is smooth and fluid impervious, and wires 11 and 12 are so tensioned that they are operative to squeeze the foamed liquid-fiber dispersion between them to force liquid 20a through the wire 11, hereinbelow also referred to as the outer wire. Liquid 20a forced through the outer-wire 11 is directed through the open inlet port 23 of a saveall 22, and, with the aid of defectors 22a, collected therein as seen at 20b. Wire 12, the inner wire on the forming roll, supports web W as it is carried away from the forming roll for drying and further conventional treatment.

Again with reference to Fig. 1, the foamed liquid and fiber furnish is supplied to headbox 21 through a conduit 24, and the residual liquid removed from the web W is withdrawn from saveall 22 through a conduit 25, to a pump 28 for recirculation through conduit 24 leading to headbox 21. A parallel liquid flow circuit comprises conduit 29 connected to conduit 25, a pump 30, a conduit 31 leading into the top of mix tank 32, and a conduit 33 leading from the bottom of mix tank 32 provided with a pump 34 which a dispersion of fibers in foamed liquid through conduit 35 to conduit 24. A water-surfactant solution is supplied to the mix tank 32 from a source 36 through conduit 40. Pulp comprising fibers of the type used in paper making is supplied to tank 32 through conduit 37a leading from a de-watering press 37 to which a pulp slurry is supplied from a suitable source (not illustrated). An agitator 38 is positioned in and operative to mix the contents of tank 32. The rate of pulp feed to the de-watering press is controlled to produce webs of the desired basis weighs at the production speed of the machine. Typical basis weights are in a range of from about 3.6 kg/ream (279 m^2) [8 lbs/ream (3000 ft^2)] to about 17.2 kg/ream (38 lbs/ream).

In a typical startup procedure, water from a suitable supply source 46 is introduced into mix tank 32 through supply conduits 45 and 45a. A concentrated aqueous solution of surfactant is added to tank 32 through conduit 40 in the amount necessary to provide a predetermined surfactant concentration in mix tank 32 required to produce a foamable liquid capable of producing a relatively stable foam which will support the fibers making up the foamed fiber furnish supplied to the headbox. The mix tank 32 is partially filled, e.g., to about one half to three fourths its capacity, with sufficient foam forming liquid to fill the pumps, conduits, headbox, and saveall when circulation is initiated and to provide a residual volume in the mix tank in the range of one fourth to one third of its capacity. An aqueous solution of a suitable anionic surfactant, e.g., an alpha olefin sulphonate has been used successfully at a preferred concentration of about 300 ppm by volume. A number of other surfactants are suitable as a water additive for purposes of the present invention, being generally classified as nonionic, anionic, cationic, or amphoteric.

Selection of a suitable class of surfactant is dependent upon chemical characteristics of such other commonly used additives which may be present in the manufacture of fibrous webs. These other additives include, singly or in homogeneous mixtures thereof, latexes, binders, debonding agents, dyes, corrosion inhibiting agents, pH controls, retention aids, creping aids, and other substances used in papermaking processes.

U.S. Patent Nos. 3,716,449 and 3,871,952 discloses specific nonionic, anionic, and cationic surfactants that have been found suitable in the art of forming fibrous webs from dispersions of fibers in foam. U.S. Patent No. 4,056,456 discloses additional surfactants, including some classified as amphoteric, that are suitable for practice of the present invention. The disclosures of these patents are included, by reference, in the present application for their teachings of surfactant materials.

The forming wires 11 and 12 are driven at a speed of about 762 m per minute [2500 fpm (feet per minute)]. The pumps 28, 30, and 34 are energized to pump foamable liquid from saveall 22 and the suspension of fibers in foam from mix tank 32 to headbox 21, from which jet 20 is directed into nip 17 at the juncture of the forming wires 11 and 12. The rotational speeds of pumps 30, 34 and 28 are regulated to establish fluid flow rates through the system which result in a preferred materials balance at typical flow rates, pump 28 handles about three fourths of the desired volume of flow to the headbox 21 while pump 34 handles the remainder. Pump 30 is regulated to maintain a substantially constant level in mix tank 32. The flow rate of foamed fiber furnish is regulated to achieve a jet velocity in the range of from about 90% to about 150% of the speed of the forming wires. Usually a jet velocity of about 110% of the speed of the wires is preferred. Forming wire speeds may be in the range of from about 305 m per minute (1000 fpm) to about 2134 m per minute (7000 fpm), or more, depending upon the operating conditions and the physical properties of the foamed fiber furnish and the forming wires.

When the foamed fiber furnish impinges on the forming wires 11 and 12, the furnish is uniformly distributed over the width of the wires. As the outer wire 11 converges with the inner wire 12, at nip 17, pressure is applied to the furnish which, combined with the force of liquid jet 20, causes the foamable liquid to flow through interstices of outer wire 11. The inner wire 12 has its interstices closed to fluid flow by the underlying solid surface of forming roll 19. As the expressed foamable liquid passes through the outer wire, air travelling with the wire as well as air in its interstices is entrained, thereby generating foam in the foamable liquid so that, once started, the foam generation (or regeneration) is a self sustaining operation.

Foam 20a is collected in saveall 22 and directed to the mix tank 32 via conduits 25, 29 and 31 and to headbox 21 By way of conduits 25, 27, and 24. The method of generating and regenerating foam is so effective that no other means of foam generation is required. In test operations, starting up without any fiber addition to mix tank 32, during an operating period of about 5 minutes, the air content of the foamable liquid increased from nearly zero to a preferred value of about 67 volume percent. Maximum bubble size of the foam during operation is, for example, in a range from about 20 µm to about 200 µm, which is less than the lengths of the suspended fibers. Optimum relationships of bubble dimension to fiber dimensions are dealt with in the referenced U.S. Patent Nos. 3,716,449 and 3,871,952, and are readily achieved by the apparatus and method of the present invention.

A pulp of papermaking fiber in water is prepared conventionally to a consistency about 1.0 to 4.0% fiber by weight. The conventionally prepared pulp is dewatered in a stock press 37 and then introduced into mix tank 32. Leaving the stock press 37 through line 37a, the pulp has a consistency sufficient to require the addition of makeup water and surfactant solution to the system via lines 40 and 40a respectively. The desired consistency of the pulp in line 37a can be calculated easily by material balance on the basis of limiting the loss of surfactant from the system to that amount inevitably carried away in the wet web 12. In general, the pulp consistency is between 8 and 50 weight percent fiber, preferably between 15 and 35 weight percent. Water removed by press 37 may be recycled. The dewatered high consistency pulp from line 37a is introduced to the mix tank 32 well below the liquid level therein at a rate dependent upon the material balance. About 2 kg/t to 11 kg/t (4 to 22 pounds per ton) of surfactant of dry fiber in web W is lost from the system and is made up through lines 40 and 40a.

Fiber is introduced from the dewatering press 37 to mix tank 32 at a rate corresponding to the desired web production rate. A slurry of about 3 weight percent fibers normally is fed to press 37, and a slurry of from about 25 to about 50 weight percent, preferably about 35 weight percent fibers, leaves the press 37 as feed to mix tank 32. If desired, dry fibers may be introduced directly to the foamed liquid in mix tank 32 in suitable proportions for achieving desired basis weights. With all pumps energized, the foam-fiber mixture is directed by pump 34 from mix tank 32 through conduits 33 and 35 into conduit 24, where it combines with foamed liquid from saveall 22, through conduits 25, 27 and 24, and the resulting foamed fiber furnish supplied to headbox 21 from which it is fed onto wires 11 and 12. Fibers and some of the liquid remain on the wires forming the product web. The major portion of the foamable liquid passes through wire 11. Foam is regenerated by air from the wires as explained above. Control of air content of the foam is achieved by controlling the amount of surfactant added to the system in mixing tank 32.

In operation, a balance of air loss through foam degradation and air gain through regeneration is necessary to maintain proper foam air content and bubble size. The surfactant concentration is the primary factor determining the rate of foam degradation. The bubble size of the foam becomes the primary controlling factor on air gain through regeneration. The bubbles in the 20 to 200 µm size are significantly smaller than the openings in the weave of the forming wire thus passing through without the fluid film surrounding the bubble being broken into smaller bubbles. Bubbles of 20-200 µm size thus expell the air in the forming wire interstices without excessive foam generation.

Another naturally occurring phenomenon assists air content control. When the air content of the foam exceeds 67% air by volume, the foam becomes progressively more viscous with increasing air content. As the viscosity of the foam increases, it becomes more difficult to remove the foam from the web. Thus more surfactant is lost from the system with the web as it is formed tending to restore the surfactant concentration balance.

The actual concentration of surfactant needed is a function of many variables and is best determined by trial, some of the variables are surfactant type, water hardness, water temperature, furnish ingredients and circulation time in the system.

A loss of foam occurs following the introduction of fiber and its deposition on the forming wires, since liquid is removed from the system with the fibrous web. The foamable liquid lost in this manner is continuously replenished, the water being replenished by water contained in the pressed pulp from press 37 supplemented by water supplied through conduit 45 and the surfactant solution replenished through supply conduit 40. The relative proportions of water and concentrated surfactant solution are suitably regulated in the range of 150 to 450 ppm (parts per million) surfactant by weight, to maintain air content of the foam in the desired range of from about 55 to about 75 percent. For example, in test runs, a concentration of about 340 ppm of an alpha olefin sulfonate (Arco A-OK) in water in the circulating foamable liquid was sufficient to maintain the air content in the foamed liquid at a preferred value of about 67% air by volume. It is well known in the art, as exemplified by the referenced U.S. Patent Nos. 3,716,449 and 3,871,952, that air contents below about 55% are conducive to fiber agglomeration, and air contents above about 75% are conducive to fiber bundling, both undesirable.

Control of air content is achieved by maintaining a predetermined concentration of surface active agent in the foamable liquid. The requisite concentration of surfactant depends on many factors including the particular choice of surfactant, the temperature of the system, the hold up time, i.e. time required to make one complete cycle of foam through the system and the speed of the wires, and is best determined for any given system by trial. By controlling the surfactant concentration, other factors remaining constant, the air content of the foam can be held substantially constant without the need for a foam generating device or for metering of air by separate means.

Foamed liquid from the saveall 22 is transferred by pump 30 through lines 25, 29 and 31 to mix tank 32. Pump 30 preferably is of the twin screw type capable of transferring low density liquids such as the foamed liquid. The volume of foamed liquid thus transferred is that amount necessary to obtain a mix tank consistency of between about 0.3 to about 4 percent fiber by weight, preferably between 1.5 to 4 percent. An agitator 38 provides the requisite energy to disperse the fibers in the foamed liquid. The foamed liquid furnish leaves the mix tank 32 by line 33, a twin screw pump 34 providing the motive energy therefor. The discharge from pump 34 through line 35 is passed through line 24 to headbox 21.

In a preferred embodiment, that is, where the mix tank consistency is between 1.5 to 4.0 percent fiber by weight, additional foamed liquid is pumped from the saveall 22 by twin screw pump 28 through line 24, and is combined with the mix tank discharge line 35, the combined streams flowing through line 24 to headbox 21. The flow rates in lines 24 and 35 are such that the furnish of line 24 is diluted to a final (headbox) consistency of between about 0.3 to about 1.2% by weight. Where the mix tank consistency is less than 1.2% fiber by weight, further dilution is not required.

In mix tank 32, the foamed liquid has substantially the same air content and bubble size quality as in the foam recovered in saveall 22 as the amount of water added with the untreated fibers through line 45 is minor in comparison to the water in recycled foamed liquid added through line 31. At the viscosity values of the foamed liquid in mix tank 32, the fibers from press 37 can be dispersed rapidly.

At a consistency above 1.5% in mix tank 32, several advantages are realized. First, the size of the mix tank and accompanying equipment is reduced, the ability to rapidly disperse the fibers enhanced, and mixing energy is reduced. The foamed liquid is subjected to shearing action in the mixer 38 which helps maintain fine foam structure while, at the same time, the fibers are subjected to less intensive shearing action than in a conventional water dispersion system so that less alteration of the fiber structure takes place. Consistency of the foamed liquid is ensured by blending the dispersion of fibers in foamed liquid from mix tank 32 with foamed liquid from line 24 to that in line 35 is in the range of from about 6:1 to about 1:1 in the preferred process embodiment. Hence, when foam from line 27 is combined with the dispersion from mix tank 32, the foamed liquid in line 24 will have substantially the same quality as that in the saveall 22.

The final (headbox) furnish in line 24 is at a consistency of about between 0.3 to about 1.2% fiber by weight, and has a viscosity of about 10 cP to about 35 cP on a fiber free basis. Because of the head induced by pumps 38 and 34, the bubble size of the foamed liquid, which is a compressible fluid, is reduced to about 20 to about 200 μm, the averaging bubble size being in the range of about 50 to about 100 μm. The pressure drop through nozzle 22 is about 0.3 to 1.7 bar [5 to 25 psi (pounds per square inch)-], preferably 0.7 to 1.4 bar (10 to 20 psi). As the foam expands across the nozzle, the bubbles become larger and the density and viscosity of the foam decreases. The foamed fiber furnish is injected into nip 17 and uniformly across the wires 11 and 12. It has been found that the velocity of the jet from nozzle 22 relative to the speed of the forming wire is a critical factor in the production of a web having a high degree or uniformity of fiber distribution and the desired tensile or tear strength relationships.

In the method of this invention, twin forming wires are employed with forming wire speeds in the range of from about 306 m per minute (1000 fpm) to about 2134 m per minute (7000 fpm) or more. It is essential that the pressure and flow rate of the furnish be regulated to achieve a jet velocity from nozzle 22 of from about 90% to 150% of the speed of the forming wires. The jet is directed into the nip 17 in a direction of travel of the forming wires.

As the foamable liquid impinges on the forming wires 11 and 12 within the confines of the nip 17, the kinetic energy of the jet is converted to potential energy building up sufficient pressure between the wires to lift wire 11 away from wire 12 and at the same time distribute the foam furnish uniformly along the wires without comb or drag relative to the headbox. The relationship of velocity of the jet relative to speed of the wires effectively prevents striation of the fibers in the web. The pressure created as the outer wire 11 moves onto the inner wire 12, combined with the force of liquid jet 20, causes the foamable liquid to flow through interstices of outer wire 11. Substantially no liquid flows through the inner wire 12 which has its interstices closed to fluid flow by the underlying solid surface of forming roll 19. Pressure resulting from closure of the nip between wires 11 and 12, together with centrifugal force resulting from movement of the wires about forming roll 19 and the forces resulting from impingement of liquid jet 20 on the wires, cooperate to produce combined compressive and shear forces on the liquid passing through the outer wire. These forces combine to deposit the dispersed fibers uniformly on the forming wires and permit control of relative tensile strengths in the machine direction and in the cross machine direction of the resulting web. At the same time air traveling with the wire and air in its interstices, simultaneously generates the desired foamed liquid for recirculation in the process.

By the process of this invention, the formation of the product web is greatly improved as compared with webs produced by conventional processes, that is, the uniformity of the distribution of individual fibers comprising the web is enhanced as observed by absence of flocs in the web upon visual inspection. A better formed web characteristically improves subsequent web processing operations inasmuch as the web is less likely to tear during drying, creping, embossing and the like on a high speed fourdrinier machine.

Formation of the web may be measured in a Thwing formation tester under Method No. 525 of the Institute of Paper Chemistry. In this procedure, the degree of uniformity of the web is ascertained by the degree of uniformity of light transmission through an area of the web. The Thwing Index (TI) is the ratio of localized variations in transparency to average transparency. Low basis weight products obtained by conventional web processing methods, e.g., tissue, towel, and napkin products having a basis weight between about 3.6 kg to 13.6 kg/ream (279 m^2) [8 to 30 lbs/ream (3000 sq ft)], have a TI of between 5 and 15, which values are, of course, dependent upon process conditions and operations. At slower wire speeds, TI values are higher while at faster speeds, the formation is affected adversely. For webs prepared on a high speed pilot machine in accordance with the process of the present invention, TI values were measured at between about 20 to 25, significantly higher than comparative wet laid webs.

The tensile strengths in the machine direction of the product webs produced by the process of this invention are generally comparable to those produced by conventional wet pulp papermaking processes employing a water slurry of papermaking fibers and considerably greater in the cross machine direction than those produced with conventional processes employing foamed liquid as the carrier liquid for the fiber furnish. Conventionally foamed fiber furnish processes produce a product having a low tensile strength in the cross machine direction. The relatively low tensile strength in the cross machine direction in conventional foamed liquid systems apparently occurs because the fibers in the web are combed or striated as they are laid on the carrier wire from the headbox by reason of the speed of the wire relative to the headbox and the thickness and relative stability of the foamed fiber furnish laid on the carrier wire. In our process, the foamed fiber furnish is jetted into the nip in a twin wire system at a velocity nearly equal to or in excess of the wire speeds avoiding combing or striation. Sufficient hydrogen bonding of the fibers is obtained to provide a product web of adequate strength in both the machine direction and the cross machine direction.

The geometric mean tensile strengths of webs produced by the process of the present invention are equivalent to those produced by conventional water-formed fourdrinier webs when the furnish, refining and basis weights are equivalent. In certain products, for example, low basis weight tissue and towel products, a selected ratio of machine direction (MD) to cross machine direction (CD) tensile strengths is advantageous. Machine direction tensile strength is important for processing webs through operations, such as embossing, slitting, perforating and rewinding into consumer rolls, whereas in the end use by the consumer, equal tensile strengths in cross machine and machine direction may be desireable. The process of this invention allows the tensile ratio to be optimized to fill the needs of tensile ratio demands.

With some fibers, a bonding agent may be necessary to provide adequate tensile strength as required by the ultimate end use. Suitable bonding agents include cationic starch; polyvinyl alcohol; pearl starch; natural gums (tragacanth, karaya, guar); natural and synthetic latex, including polyacrylates, e.g., polyethylacrylate, and copolymers; vinyl acetate-acrylic acid copolymers; polyvinylacetates; polyvinyl chlorides; ethylenevinyl acetates; styrene-butadiene carboxylates; polyacrylonitriles; and thermosetting cationic resins, e.g., urea formaldehyde resins, melamine formaldehyde resins, glyoxal-acrylamide resins and polyamide-epichlorhydrin resins as disclosed in U.S. 3,819,470. Bonding materials are desirable where the fibers used in the web are not self-bonding, as in certain synthetic and chemically modified cellulosic fibers.

In the process of this invention, the fiber furnish may be made up of unrefined softwood fibers of a type which readily floc on water-forming papermaking equipment, and may comprise in addition to wood pulp, synthetic fibers, e.g. rayon fibers up to 6 denier in diameter and 1.9 cm (3/4 inch) long which do not yield satisfactory tissue products in conventional water laid papermaking processes.

The advantages of the present process and products produced thereby will be evident from the following examples.

Example 1

A run was made on a high speed twin wire paper machine at about 305 m per minute (1000 fpm) using repulped Ontario Soffwood Kraft (OSWK) fibers that had been refined to 400 CSF. The fibers were added directly to the mix tank, the furnish therein being at 1.8% consistency. Headbox consistency was adjusted to 0.45% by dilution with foamed liquid from the silo. Arco "Ultrawet A-OK" surfactant was used to generate the foam. The webs were wet pressed and subsequently dried and creped or a Yankee dryer, but were not calendered.

Web properties for each run are tabulated in Table 1:

Table 1

Run No.	1
Fiber Type Basis Weight, kg/ream(lb/ream) 8-Ply Caliper, µm(mils) Bulk, µm/kg/ream(mil/lb/ream)	100% OSWK 16.148 (35.6) 1969 (77.5) 15.23 (0.272)
Percentage Solids on Wire:	
Before Vacuum After Vacuum % Solids on Felt % Solids on Yankee	8.8 15.7 19.8 43.7
Instron Dry Tensile g/7.62 cm	
MD CD MD/CD CD, %MD	9840 3148 3.1 32
Instron Elongation, percent:	
MD CD Oil Holding Capacity Ratio g oil/g fiber	31.2 3.6 3.13

As above indicated, the ratio of the machine direction (MD) tensile strength to cross machine direction tensile strength was 3.1, i.e., the tensile strength in this cross machine direction is about 32 percent of the tensile strength in the machine direction.

Example 2

Test runs were made on a high speed twin wire paper machine operation at 458 m per minute (1500 fpm). In each run a pulp of 3.5% consistency was made comprising 50% OSWK and 50% OHWK (Ontario Hardwood Kraft) fibers. After pulping, the slush pulp was pressed to 28 weight consistency and added to the mix tank, and a foamed liquid furnish of about 0.6% percent fiber by weight delivered to the headbox. Air content ranged between 58 to 70%. The webs were wet pressed, dried and creped. In Runs 2 and 3 the webs were calendered.

Properties of these webs are shown in Table 2:

Table 2

Run No.	2	3
	50% OSWK/50% OEWK	
Calender Roll Pressure, bar (Psig)	1.35 (5.0)	1.30 (4.3)
Basis Weight, kg/ream(lb/ream)	6.4 (14.2)	8.0 (17.6)
8 Ply Caliper, µm(Mils)	1166 (45.9)	1196 (47.1)
Bulk, µm/ kg/ream(mil/lb/ream)	22.6 (0.404)	18.8 (0.335)
Instron Dry Tensile, g/7.62 cm		
MD	429	732
CD	275	542
MD/CD	1.6	1.35
CD, %MD	62.5	74
Instron Elongation, %:		
MD	26.4	24.3
CD	4.8	3.7

Example 3

Three runs were made on the high speed machine operating at 305 m per minute (1000 fpm) using a foamed liquid furnish comprising 100% OSWK fibers refined to 480 CSF.

Table 3

Run	4	5	6
Fiber Type	100% OSWK		
Calendered	No	No	Yes
Basis weight, kg /ream(lb/ream)	6.8(14.9)	12.4(27.4)	6.5(14.3)
8-Ply Caliper, µm(Mils)	1461(57.5)	1847(72.7)	1295(51.0)
Bulk µm/ kg/ream (Mils/lb/ream)	27.0(0.482)	18.6(0.332)	25.0(0.446)
Dry Tensile, g/7.62 cm			
MD	1172	4148	999
CD	619	2133	565
MD/CD	1.89	1.96	1.77
CD/%MD	53	51	57
Elongation, %			
MD	35.7	36.5	32.5
CD	4.6	3.1	4.7

Example 4

Several test runs were made on a high speed twin wire papermaking machine at wire speeds of 610 m per minute (2000 feet per minute).

In these runs, the furnish was repulped baled fiber without any refining consisting of 50% Ontario hardwood and 50% Ontario softwood bleached sulfate wood pulp. The air content of the foam was maintained at 60% while wire tension was 536 kg/m (30 pli). The product was creped and calendered and samples were removed from a rewound roll for testing. The product tensile strength at a theoretical efflux ratio of 1.09 tested 298 g/7.62 cm (298 g/3 inch) machine direction and 300 g/7.62 cm (300 g/3 inch) cross machine direction for a web of 4,082 kg (9 pounds) per ream basis weight.

The efflux ratio is defined as the ratio of the calculated velocity of the jet of foam fiber furnish from the headbox to the velocity of the forming wires. In this example, at a theoretical efflux ratio of 1.0, the jet and the wires have a velocity of 610 m (2000 feet) per minute.

Results of these tests are shown in Table 4.

Table 4

Run No.	Efflux Ratio	Tensile Ratio MD/CD
A	0.94	2.5
B	1.00	1.75
C	1.09	1.0
D	1.20	1.4
E	1.28	1.95
F	1.38	2.7
G	1.47	3.98

It will be seen from the above table that the product tensile strength in the machine direction and in the cross machine direction may be varied relative to one another to meet product user requirements.

Claims

1. A method for the production of a non-woven fibrous web on a moving foraminous support from a foamed fiber furnish comprising fibers dispersed in a foam comprising water and a surface active agent and containing 55 - 75% air by volume, and wherein liquid passing through the foraminous support is collected and recirculated to a foamed fiber furnish production step, characterised in that the method comprises the steps of:

(i) forming a foamed liquid by entraining air into a foamable liquid comprising water and surfactant passing through said foraminous support,

(ii) dispersing fibers in said roamed liquid containing 55 - 75% air by volume to form the foamed fiber furnish,

(iii) without substantial further foam-generating turbulence or agitation, supplying the foamed fiber furnish to the moving foraminous support web-forming means where fibers of the furnish are deposited on the support to form said fibrous web, liquid from the furnish being passed through the support with entrainment of air thereby regenerating foamed liquid in accordance with step (i) for recirculation, and

(iv) maintaining the air content of the foam at a desired level solely by controlling the concentration of surface active agent in the foamable liquid.

2. A method according to Claim 1 wherein the foamed fiber furnish contains 0.3 to 1.2 weight percent fibers.

3. A method according to any of the preceding claims wherein said air in said foamed liquid is in the form of bubbles having an average diameter in the range of from about 20 to 200 µm (microns).

4. A method according to any of the preceding claims wherein said foamed fiber furnish is brought into contact with said moving foraminous support as a jet of liquid having a velocity in the range of 90 to about 150 percent of that of said moving foraminous support.

5. A method according to claim 4 wherein the velocity of said jet is about 110 percent of that of said moving foraminous support.

6. A method according to any of the preceding claims wherein the aqueous foam containing from about 55 to 75 percent air by volume is prepared by passing said foamable liquid substantially free from fibers to and through the moving foraminous support web-forming means producing a foamed liquid by entrainment of air therein and the foamed liquid passing through said foraminous support is collected and recirculated to and through the foraminous support until the foamed liquid contains from about 55 to 75 percent air by volume in the form of bubbles having an average diameter in the range of 20 to 200 µm (micron).

Patentansprüche

1. Verfahren zur Herstellung einer Faservliesbahn auf einer bewegten porösen Auflage aus einem geschäumten Faserstoffeintrag, der Fasern aufweist, die in einem Schaum, der Wasser und ein grenzflächenaktives Mittel aufweist und 55-75 Vol.-% Luft enthält, dispergiert sind, und wobei durch die poröse Auflage tretende Flüssigkeit gesammelt und erneut zu einer geschäumten Faserstoffeintrag-Herstellungsstufe umgewälzt wird, dadurch gekennzeichnet, daß das Verfahren die folgenden Schritte aufweist:
   (i) Bilden einer geschäumten Flüssigkeit durch Mitreißen von Luft in eine schäumbare Flüssigkeit, die Wasser und grenzflächenaktives Mittel aufweist und durch die poröse Auflage tritt,
   (ii) Dispergieren von Fasern in der geschäumten Flüssigkeit, die 55-75 Vol-% Luft enthält, um den geschäumten Faserstoffeintrag zu bilden,
   (iii) Zuführen des geschäumten Faserstoffeintrags ohne wesentliche schaumerzeugende Verwirbelung oder Bewegung zu der bewegten porösen, bahnbildenden Auflage,wo Fasern des Faserstoffeintrags auf der Auflage abgelagert werden,um die Faservliesbahn zu bilden, wobei Flüssigkeit aus dem Eintrag unter Mitreißen von Luft durch die Auflage geleitet wird, um dadurch geschäumte Flüssigkeit nach Maßgabe von Schritt (i) zur erneuten Umwälzung zu regenerieren, und
   (iv) Aufrechterhalten des Luftanteils des Schaums auf einem gewünschten Wert ausschließlich durch Einstellen der Konzentration von grenzflächenaktivem Mittel in der schäumbaren Flüssigkeit.

2. Verfahren nach Anspruch 1,
   dadurch gekennzeichnet, daß der geschäumte Faserstoffeintrag 0,3-1,2 Gew.-% Fasern enthält.

3. Verfahren nach einem der vorhergehenden Ansprüche,
   dadurch gekennzeichnet, daß Luft in der geschäumten Flüssigkeit in Form von Blasen mit einem mittleren Durchmesser von ca. 20-200 µm (Mikron) vorliegt.

4. Verfahren nach einem der vorhergehenden Ansprüche, wobei der geschäumte Faserstoffeintrag mit der bewegten porösen Auflage als ein Flüssigkeitsstrahl, der eine Geschwindigkeit im Bereich von 90 bis ca. 150 % derjenigen der bewegten porösen Auflage hat, in Kontakt gebracht wird.

5. Verfahren nach Anspruch 4,
   dadurch gekennzeichnet, daß die Geschwindigkeit des Strahls ca- 110 % derjenigen der bewegten porösen Auflage beträgt.

6. Verfahren nach einem der vor hergehenden Ansprüche,
   dadurch gekennzeichnet, daß der ca. 55-75 Vol.-% Luft enthaltende wäßrige Schaum erzeugt wird durch Leiten der im wesentlichen faserfreien schäumbaren Flüssigkeit zu der und durch die bewegte poröse bahnbildende Auflage unter Erzeugung einer geschäumten Flüssigkeit durch Mitreißen von Luft darin, wobei die durch die poröse Auflage tretende geschäumte Flüssigkeit aufgefangen und erneut zu der und durch die poröse Auflage umgewälzt wird, bis die geschäumte Flüssigkeit ca. 55-75 Vol.-% Luft in Form von Blasen mit einem mittleren Durchmesser von 20-200 µm (Mikron) enthält.

Revendications

1. Procédé pour la production d'une feuille continue fibreuse non tissée sur un support poreux en mouvement à partir d'une charge de fibres àl'état de mousse comprenant des fibres en dispersion dans une mousse comprenant de l'eau et un agent tensio-actif et contenant 55 à 75 pour cent d'air en volume, et dans lequel un liquide passant à travers le support poreux est collecté et recyclé vers une étape de production de la charge de fibres à l'état de mousse, le procédé étant caractérisé en ce qu'il comporte les étapes qui consistent :
   i) à former un liquide à l'état de mousse en entraînant de l'air dans un liquide pouvant mousser comprenant de l'eau et un surfactant passant à travers ledit support poreux,
   ii) à disperser des fibres dans ledit liquide à l'état de mousse contenant 55-75 pour cent d'air en volume pour former la charge de fibres à l'état de mousse,

iii) sans turbulence ou agitation supplémentaire importante générant de la mousse, à amener la charge de fibres à l'état de mousse aux moyens de formation d'une feuille continue sur un support poreux en mouvement où des fibres de la charge sont déposées sur le support pour former ladite feuille continue fibreuse, du liquide provenant de la charge passant à travers le support avec l'entraînement de l'air, régénérant ainsi du liquide à l'état de mousse conformément à l'étape i) pour le recyclage, et

iv) à maintenir la teneur en air de la mousse à un niveau souhaité uniquement en réglant la concentration de l'agent tensio-actif dans le liquide pouvant mousser.

2. Procédé selon la revendication 1, dans lequel la charge de fibres à l'état de mousse contient 0,3 à 1,2 pour cent en poids de fibres.

3. Procédé selon l'une des revendications précédentes, dans lequel ledit air dans ledit liquide à l'état de mousse se présente sous la forme de bulles ayant un diamètre moyen dans la plage d'environ 20 à 200 μm (micromètres).

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite charge de fibres à l'état de mousse est amenée en contact avec ledit support poreux en mouvement sous forme d'un jet de liquide ayant une vitesse dans la plage de 90 à environ 150 pour cent de celle dudit support poreux en mouvement.

5. Procédé selon la revendication 4, dans lequel la vitesse dudit jet est d'environ 110 pour cent de celle dudit support poreux en mouvement.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel la mousse aqueuse contenant environ 55 à 75 pour cent d'air en volume est préparée par passage dudit liquide pouvant mousser, sensiblement sans fibres, vers et à travers les moyens de formation de feuille continue à support poreux en mouvement, produisant un liquide à l'état de mousse par entraînement de l'air dans ce liquide, et le liquide à l'état de mousse traversant ledit support poreux est collecté et recyclé vers et à travers le support poreux jusqu'à ce que le liquide à l'état de mousse contienne environ 55 à 75 pour cent d'air en volume sous la forme de bulles ayant un diamètre moyen dans la plage de 20 à 200 μm (micromètres).

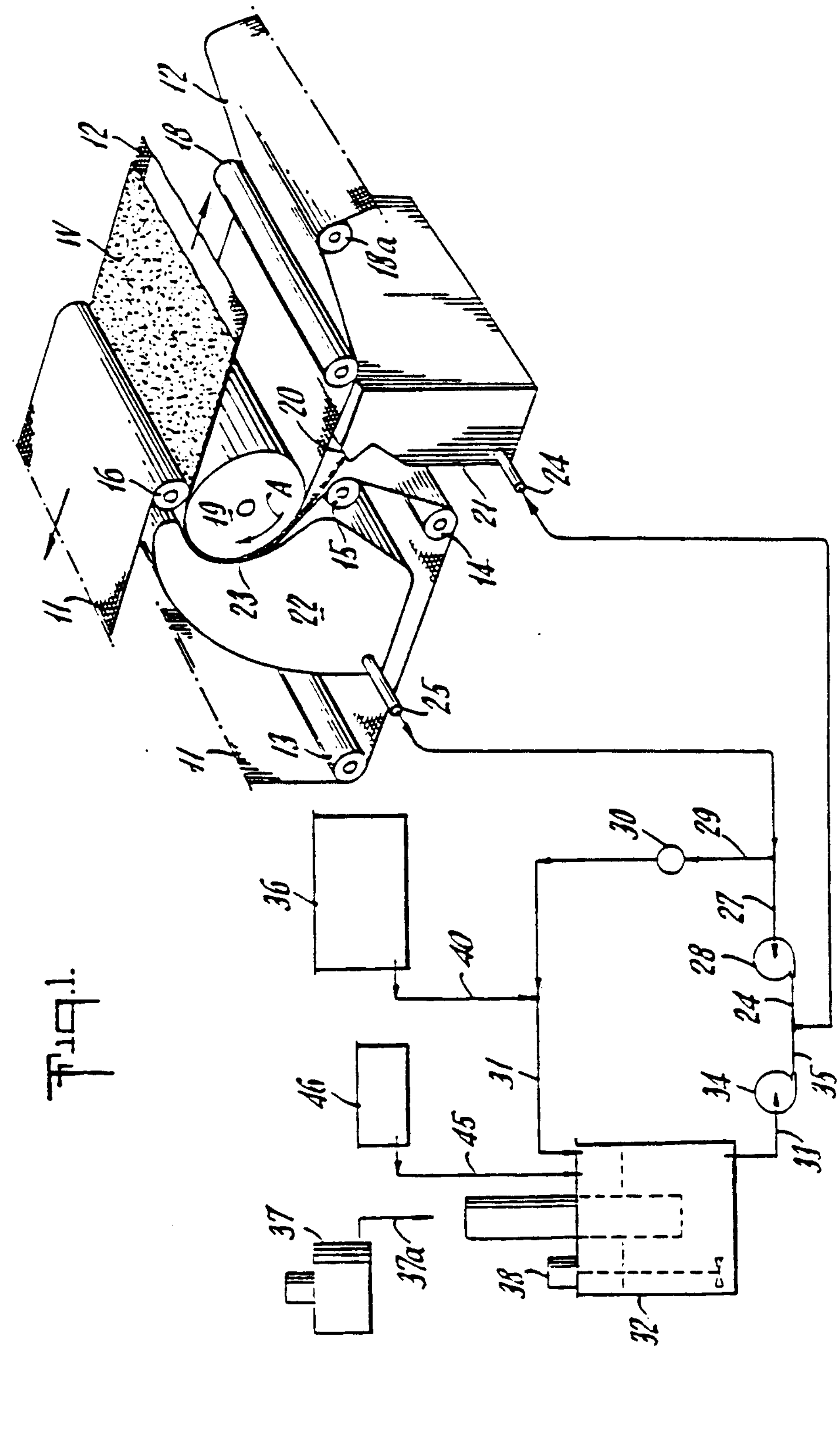
11
12
13
14
15
16
18
18a
19
20
21
22
23
24
25
27
28
29
30
31
32
33
34
35
36
37
37a
38
40
45
46
A
W

Fig.1.

Fig. 8.