July 25, 1972 G. JACQUELIN 3,679,542

METHOD OF TREATING SUSPENSION OF FIBERS TO FORM FIBROUS AGGREGATES

Filed April 1, 1970 3 Sheets-Sheet 1

FIG. 1

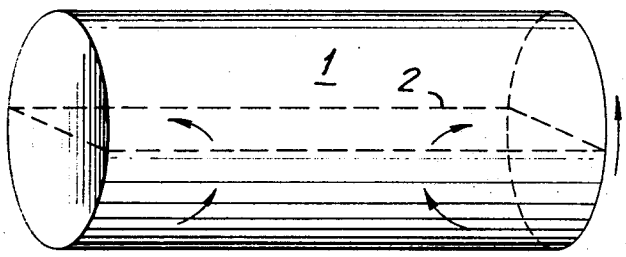


FIG. 2

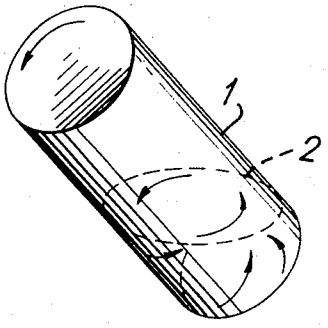
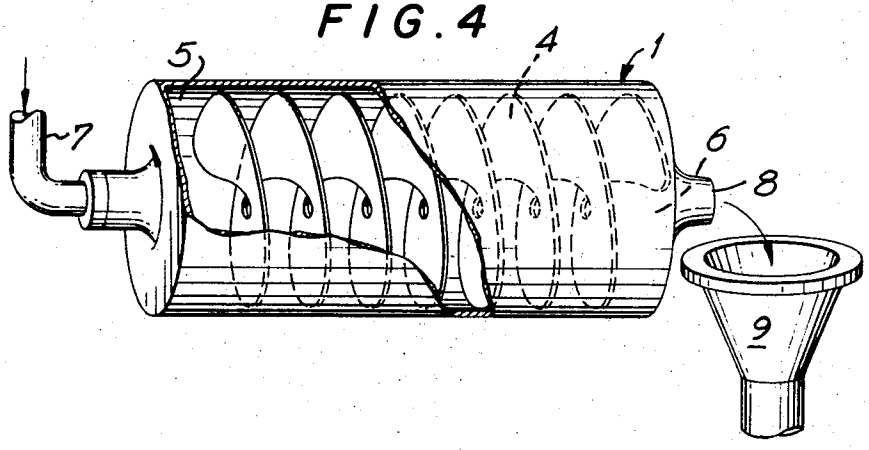


FIG. 4



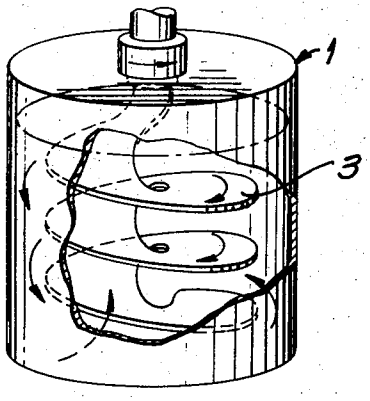
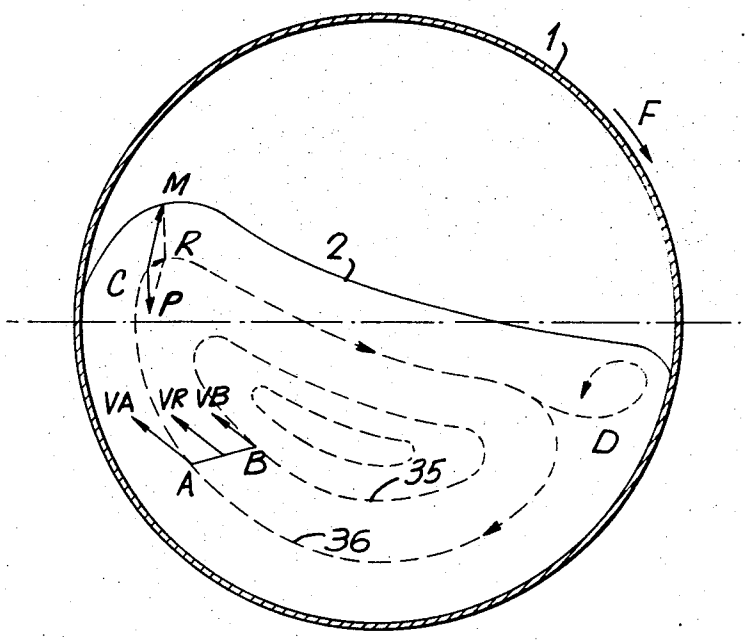


FIG. 3

FIG. 5



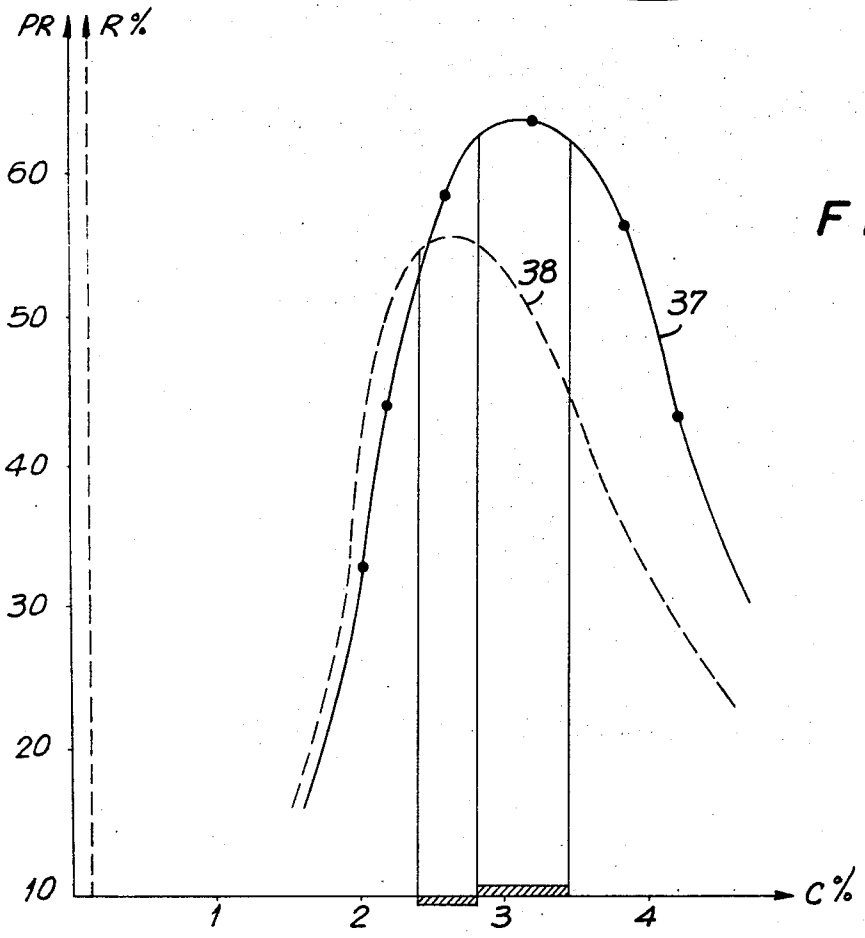
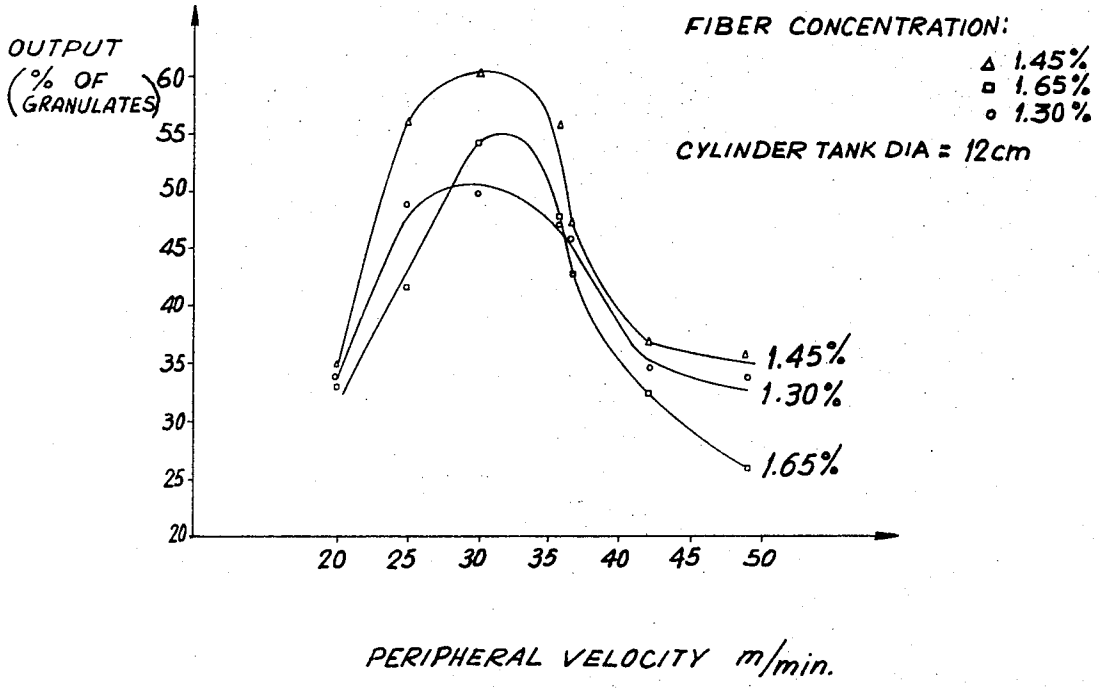


FIG. 6

FIG. 7


OUTPUT
(% OF GRANULATES)
60
55
50
45
40
35
30
25
20
FIBER CONCENTRATION:
△ 1.45%
□ 1.65%
○ 1.30%
CYLINDER TANK DIA = 12cm
1.45%
1.30%
1.65%
20 25 30 35 40 45 50
PERIPHERAL VELOCITY m/min.

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3,679,542

METHOD OF TREATING SUSPENSION OF FIBERS TO FORM FIBROUS AGGREGATES

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Continuation-in-part of application Ser. No. 557,036, June 13, 1966, which is a continuation-in-part of application Ser. No. 427,040, Jan. 21, 1965. This application Apr. 1, 1970, Ser. No. 24,764

The portion of the term of the patent subsequent to Apr. 14, 1987, has been disclaimed

Int. Cl. D21d 5/28

U.S. Cl. 162—1 1 Claim

ABSTRACT OF THE DISCLOSURE

A suspension of fibers is treated to form aggregates by subjecting a suspension of the fibers in a liquid to rotational agitation to establish a speed gradient between points in the suspension causing the formation of eddys, which result in the fibers moving together into groups. The grouped fibers cling to one another to form aggregates, the concentration by weight of the fibers in the suspension at the beginning of the treatment being relatively low.

This application is a continuation-in-part of my earlier application Ser. No. 557,036 which in turn was a continuation-in-part of my still earlier application Ser. No. 427,040, filed Jan. 21, 1965 and now abandoned, the latter applications claiming the priority of my French applications of Jan. 21, 1964 and June 14, 1965.

BRIEF SUMMARY OF THE INVENTION

The present invention relates to a method of treating suspensions of natural, regenerated or synthetic fibers in a liquid medium.

The purpose of the method of the invention is to enable the formation within a suspension of aggregates of regular fibers which are individualized and relatively consistent, said aggregates generally being of regular shape such as, for example, spheroidal, and of a size which may be of the order of the length of the fibers in suspension (0.2 to 15 mm.).

It is an object of the invention to provide a method of treating suspensions of fibers comprising causing a general agitation in a liquid bath containing fibers in suspension, said agitation being carried out under conditions which are produced by the rotating and circulating movements of the said fibers in a weak shearing or cutting field so that said fibres cling to one another and form aggregates, which are roughly grouped or sized and of regular shape.

According to a feature of the invention, the agitation of the bath is followed by filtration enabling the aggregates of the liquid medium to be separated from the non-fibrous elements and if desired from the non-aggregated fibers.

In this way, the fibers of the other solid components of a bath may be separated, this being particularly advantageous and especially applicable to the shearing of a paper pulp. At least two categories of fibers may be separated, thus providing for manufacturing from the same suspension at least two paper pulps having different properties. To this end, the aggregates separated by filtration are disintegrated and returned to homogeneous suspension by agitation in a liquid medium while the other components are removed with a filter and subjected to further treatment as desired.

The fibrous aggregates separated by filtration can also be drained and then dried in a current of hot air, which technique has the advantage of being more economical than the technique, which is currently used, of drainage

and drying the paper pulp in sheets. Moreover, by this technique, independent aggregates are obtained, which are roughly grouped or sized, light, easy to stock, and readily manipulated and treated, and which may be used for many purposes.

According to another feature of the invention, the fibrous aggregates can be agglomerated either by using the other components of the bath as bonds, or after impregnation with a deposited bond, said operation being followed by a drying of the porous agglomerate thus obtained, and if desired also by a thermal treatment. Such agglomerates thus produced can be used, depending upon the nature and amount of the bonds, as linings for walls, floors or other partitions, or for thermal or sound insulation.

According to another feature of the invention, the fibrous aggregates can be impregnated with a resin or with a prepolymer in order to constitute fibrous granules for compression by heat in order to form molded or laminated parts. In this way, a fibrous structure forming a reinforcement can be given to molded or laminated parts by heat and under pressure.

In accordance with the invention, a suspension of the fibers can be subjected in a cylindrical tank to a gentle rotational agitation by rotation at a peripheral speed of 30–40 meters per minute with the diameter of the tank about 20 cm., the angular speed of the tank being reduced with increased diameter such that the rate of increase of the peripheral speed of the tank is less than the square root of the increase of diameter and greater than the cube root of said increase.

By respecting the above conditions and restricting the concentration of fibers in the suspension at the beginning of treatment at less than 15%, a variety of different types of fibers can form the desired aggregates.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 diagrammatically illustrates cyclically-operated apparatus employed in accordance with a first embodiment of the invention;

FIG. 2 diagrammatically illustrates cyclically-operated apparatus employed in accordance with a second embodiment of the invention;

FIG. 3 diagrammatically illustrates cyclically-operated apparatus employed in accordance with a third embodiment of the invention;

FIG. 4 is a diagrammatic view illustrating a continuously operated apparatus;

FIG. 5 shows the paths and speed distributions of the fibers in the suspension produced in the above apparatus;

FIG. 6 shows the variations in production and yield of the particles as a function of the concentration of the fibers in the suspension; and

FIG. 7 is a graphical representation showing granulate output as a function of various operational parameters.

DETAILED DESCRIPTION

According to the invention, a fibrous suspension to be treated is subjected to agitation produced under conditions which cause:

(1) Rotating movements of the fibers enabling them to be hooked when they come into contact, either with each other, or with aggregates in the course of formation, independent fibrous assemblies, relatively consistent, being developed by the addition of fibers to one another.

(2) A circulation in the mass of the suspension, so that a large number of fibers and aggregates in the course of formation passes into adjacent areas having solid surfaces, where the shearing or cutting power, depending on the speed gradients of the fluid causes the rotation of the fibrous elements and the formation of eddies in the fluid propagating the above mentioned phenomenon.

Moreover, the agitation of the suspension must be less turbulent for the sole reason that the shearing or cutting power caused by the relative movements of the suspension and of the solid surfaces is sufficiently low so as not to destroy the fibrous aggregates formed in the suspension. Moreover, the surface of the solids in contact with the suspension is preferably smooth and less adherent to the fibers so that they do not cling to them nor destroy the aggregates in the course of their movement. When these conditions are combined, the changes in the structure of the suspensions also depend on the morphological and physiochemical properties of the fibers. Thus, certain fibers refuse to cling together and others, on the contrary, rapidly form regular aggregates. This aptitude of the fibers may moreover be modified by physical or chemical treatments and by the action upon them by the properties of the suspension medium.

In the case of paper fibers of substantially similar length, if the axis of the rotation torques applied to the fibers by reason of the agitation of the suspension does not have a mandatory direction, the aggregates appear in the form of separate regular pellets which are of relatively uniform dimensions which may be of the order of the mean length of the fibers. They are easy to separate by means of a rough filtration and may represent more than 80% of the total quantity of fibers. The dimensions of said spherical pellets depend not only on the sizes of the fibers, but also on their concentration and the characteristics of the agitation (form and strength).

Thus, the invention enables a new industrial product to be manufactured which is constituted by fibrous spheroids, the diameter of which may vary from 0.2 mm. to 15 mm. After draining and drying, they have a low apparent density of between 0.05 and 0.70.

The drainability of the suspension of fibrous aggregates (after treatment) is clearly improved compared with that of the initial homogenous suspension. Moreover, according to an important characteristic phase of the method, the drying of the drained fibrous pulp (in the form of independent aggregates) may be effected in a current of hot gas according to well known methods which could not be applied, up to the present, directly to paper pulp, which, in fact, had to be drained in sheets (or layers) and dried in this state or even broken into pieces before drying. It will be apparent that the drying of the pulp directly obtained in the form of small and very permeable aggregates, in a current of hot gas, is much more economical and advantageous.

The method of the invention also enables the fibers of the other elements in suspension (fillers, fine elements, vessels and accessory elements of annual plants e.g. straw, hemp, flax, cotton etc. to be separated. These non-fibrous elements are incorporated very slightly with the aggregates and consequently the majority remains in suspension. They may thus be easily separated by a rough filtration retaining the aggregates. Moreover, certain fibrous elements, the properties (strength, surface conditions, length) of which do not allow their linking to other fibers, are also separable from the rest of the other fibers, by means of this method. This is, for example, of use for modifying the properties of a paper pulp.

In order to shear a paper pulp, according to a particularly advantageous way of carrying out the method, the aggregates or fibrous spheroids are separated by filtration, then they are disintegrated and replaced in homogenous suspension by agitation in a liquid medium of suitable nature and strength, the invention extending to the new industrial product constituted by the paper pulp thus sheared.

According to another way of carrying out the method of the invention, the fibrous spheroids formed in the bath may be agglomerated together either in their humid state, the non-aggregated elements of the suspension, if desired, serving as a bond or a bonding agent, or after impregnation by a bond. Moreover, at the beginning of the treatment, the bath may contain deposited matter, serving particularly as a bond such as, for example, resins, gums, polymerizable or cross-linkable products . . . this matter being adapted for being put into solution or emulsion in order to be integrated in the fibrous aggregates during their formation and/or to be connected to the aggregates formed. A new industrial product is thus obtained, after drying and, if desired, thermal treatment, said product being constituted by a conglomerate, which is more or less porous, the apparent density of which may be still lower than that of the spheroids. It varies for example between 0.02 and 1. These spheroids, associated or not with other matter, polymeric bonds for example, enable panels and other products to be produced, the properties of which may be varied to a large extent from the point of view of density, strength, porosity, and thermal or sound insulation.

In another embodiment of apparatus for carrying out the method of the invention, the fibrous spheroids, formed and dried, may be impregnated with a resin or with a prepolymer and may thus constitute fibrous granules. By compression of said latter and thermal treatment if desired or found necessary, molded or laminated parts may be produced, the fibers of which serve as a reinforcement. The invention thus also provides new industrial semi-finished products constituted by the granules and the new industrial finished product formed by parts having a fibrous structure.

Apparatus for carrying out the method can be operated cyclically (FIGS. 1 to 3) or continuously (FIG. 4).

In the case of the apparatus of FIGS. 1 to 3, the equipment comprises a tank **1** containing the bath, i.e. the liquid, to be treated, which preferably only partially fills the said tank. This bath has in these circumstances a free surface **2** and is in contact with solid surfaces constituted by the internal wall of the tank and possibly by internal rigid elements. These solid surfaces may advantageously be smooth, i.e. without roughness, and their structure must be evolutive, i.e. without any abrupt variation of curvature, in order to prevent the fibers linking or hooking together and violent shocks on the aggregates in suspension.

The relative movement of the suspension and of the solid surfaces causing the agitation necessary for carrying out the method is produced either by the movement of the tank itself (FIGS. 1 and 2) or by the movement of a member **3** internally located (FIG. 3) or by the application of other forces (for example, by injecting gas) or by various combinations of these means.

In a particularly advantageous embodiment, the tank **1** is cylindrical and the agitation is produced by rotating the member provided for agitating the bath preferably about the axis of the member, namely either the tank **1** itself (FIGS. 1 and 2) or the rotatable member **3** (FIG. 3). The axis of the tank may be horizontal (FIG. 1), inclined (FIG. 2) or vertical (FIG. 3).

This arrangement enables a suitable circulation of the fibers to be obtained and a sufficient speed gradient on the walls to be maintained in order to produce the rotation of said fibers in different planes by compounding the action of gravity and the action of rotation.

In the embodiment illustrated in FIG. 3, the rotatable member **3** has a highly developed movable surface which is, for example, a simple spiral. It could also have other shapes.

Whatever the embodiment envisaged (FIGS. 1, 2 and 3) may be, the cyclically operated apparatus is associated with means for filling and emptying the tank **1**, put into operation at the beginning and end of the treatment.

The continuously operated apparatus comprises a tank **1** and agitation means set up and adapted to operate in such a way that the circulation of the suspension is orientated to effect a continuous progression of the suspension from the inlet to the outlet of the tank where

permanent filling and emptying means are put into operation.

In the embodiment shown in FIG. 4, the tank **1** is cylindrical and an Archimedean screw **4** is arranged therewithin along its substantially horizontal axis. This screw can moreover, constitute the agitation means.

The tank **1** may be rotatable and the screw **4** fixed, or the tank may be fixed and the screw rotatable, or the screw and the tank can even be secured and rotatable together.

In any case, the rotation of the agitation member (tank and/or screw) causes the progression of the suspension from the inlet **5** of the tank **1** to the outlet **6**. The suspension to be treated is continuously fed in through a coaxial supply pipe **7** in the inlet **5**, is subjected to the treatment during its progression through the tank **1**, and the treated suspension flows out through an emptying opening **8** to a utilization circuit **9** (for filtration and drying or agglomeration or diluting, etc.).

According to another embodiment, the continuous progression of the bath to be treated is effected by the application of a difference in pressure between the inlet and outlet ends.

The paths and distributions of speed in the fibrous suspension subjected to the above mentioned slight turbulent agitation, in the case where the tank **1** is cylindrical and is rotated in the direction of the arrow F about its horizontal axis, is shown in FIG. 5.

The solid line **2** in FIG. 5 represents the shape of the surface which is free from the suspension during this rotation. The dotted lines **35** and **36** in particular, show the shape in projection on a straight section of the cylinder of the orbits followed by the suspended particles which for the most part are generally constituted by the fibers. These orbits are not stable for various reasons (beatings due to the drive by the flat walls limiting the ends of the cylindrical curve, variations in the dimensions of the particles in the course of the aggregation, vibrations and so on), but the projection retains the general shape indicated in the drawing.

Tests have shown that a fiber AB (which is shown considerably enlarged in order to facilitate understanding and which is assumed to be in the plane of the cross section) has at its ends linear speeds V_A and V_B which are different at any given instant, on account of the shape of the orbits imposed by the shape of the tank and its movement and on account of the sliding of the layers of fluid due to the inertia of the suspension in the course of its drive under the action of the walls.

The gradient of speed thus existing between the different layers of fluid causes a shearing in the center of the suspension and produces a torque determining the rotation of the fibers. Moreover, the speed V_R applied to the center of gravity of the rotating fiber AB in question causes the circulation of this fiber along the indicated orbits.

The force M at point C communicated to the suspension by the movement of the wall of the tank is vectorially added to the action of gravity P at the same point and determines the shape of the orbit followed by the fibers as shown by the resultant R.

In the course of these rotational and circulatory movements in a shearing field, movements which undergo accelerations (positive or negative) mainly in the areas C and D, there occur shocks between the fibers if the concentration is sufficient and consequently these fibers cling together.

Apart from this experimental illustration of the method of the invention, the present invention has as an object the increasing of the efficiency of the treatment, and improving the output of the products obtained and of varying these latter and their applications.

In accordance with the invention, the concentration by weight of the fibres in the suspension, at the beginning of the treatment, is lower than 15%. In the case of conventional papermaking fibers, this original concentration is preferably between one and four percent. In connection with leafy wood fibers (i.e. fibers from leafy European type trees), the production of aggregates is maximum, based on equal durations of treatment and if the composition is not modified in the course of treatment, then the original concentration of fibers is between 2.8 and 3.4%.

According to another feature, the concentration of the fibers may be modified during the treatment. Similarly, the composition of the fibrous suspension may be modified during this treatment. Moreover, a plurality of successive additions of fibers having different qualities and properties, may be provided during the same treatment.

Further features of the invention relates to modifications in the method consisting of well determined aims in incorporating the additional products either in the suspension itself or on or in the aggregates, whether the latter be simply drained or dried. In any case, these particular features will be clearly understood from the detailed description which follows.

It is specified above that the fibrous suspension must remain sufficiently fluid in order to permit the fibers to move with respect to one another in order to be organized into aggregate form under the action of liquid currents.

In order that the fibers have a sufficient degree of freedom, their concentration in the liquid must remain relatively low. The most effective zone of concentration at the beginning of the treatment for the conventional papermaking fibers, as stated above, is between 1 and 4% by weight with respect to the fluid.

For leafy wood fibers treated for ten hours in a rotating cylindrical tank whose axis is inclined by about 45° with respect to the vertical, the peripheral speed of this tank being 35 meters per minute for a diameter of 20 cm., the variations in the production and the yield of the particles as a function of the concentration of the fibers in the suspension are given by the curves illustrated in FIG. 6.

In this figure, the x axis shows the percentage concentration (C%) which is equal to the ratio of the weight of the fibers placed originally in the suspension and of the weight of the fluid of this suspension; the solid line of the y axis shows the production (Pr) of the particles formed in four liters of suspension, this production being expressed in grams; the dotted line of the y axis shows the yield (R%) of the treatment which is equal to the ratio of the weight of the particles formed and of the total weight of the fibers placed originally in suspension.

The solid line curve **37** represents the variation in the production Pr and shows that this production is maximum, for a fixed duration of treatment (and if the composition is not modified during this treatment) when the concentration C% is between 2.8 and 3.4%. The dotted curve **38** shows the variation in the yield R% and shows that this yield is maximum, under the same conditions as previously, when the concentration C% is between 2.4 and 2.8%. Of course, for other natural or synthetic fibers, the optimum concentrations may be higher. They depend upon the length and the suppleness of the fibers. Moreover, if new fibers are added during the development of the aggregate, the optimum concentration may be moved towards denser zones. In any case, the profitable zones of concentration generally remain lower than 15%.

Thus, the concentration of the fibers may be modified during the treatment. Several successive additions of fibers of different qualities and properties may even be provided during the same treatment, for the particular purpose of obtaining a stratification.

Moreover, the fibrous suspension may comprise not only a fluid and fibers but also other products responding to the well-determined aims which are mentioned hereinafter. In any case, the composition of this fibrous suspension may be established once and for all at the beginning of the treatment, may be also maintained constant during this treatment, or may even be modified in the course of said treatment.

It is important to note that the particles obtained, whether they be constituted by simple aggregation without any binding agent or whether they are mixed or covered with other products, have a structure which is substantially isotropic, i.e. without any preferential orientation of the fibers. This property has particular interest in all the applications envisaged in the following.

In order to favor the formation and development of the fibrous aggregates, seeds or primers are introduced into the suspension at the beginning of the treatment. The latter may be constituted by mineral or organic powders, crystals, particles of natural or synthetic resins, sawdust, particles of cork or bark, fibrous agglomerates which may or may not be manufactured for this purpose during a previous operation or produced by the disintegration of paper-making pulp or old papers, disintegrated cardboard or the like.

In order to favor the agglomeration of the fibers, gaseous bubbles may be diffused in the center of the suspension.

The composition of the fibrous suspension treated for the purpose of granulation may be very complex. Concerning the fibers, they may vary considerably in dimension, shape and nature and utilized alone or in a mixture (mineral fibers; asbestos, glass, drawn rock, drawn metals; various natural, regenerated or synthetic fibers which are or are not chemically modified, and so on). Apart from these fibers, additional products may be introduced into the fluid which are intended either for facilitating or controlling the particulation, or for conferring to the particles particular properties which will substantially be useful.

Concerning the additional products intended to facilitate or control the particulation, one may use the above mentioned primers, flocculating agents, dispersing agents, moisturizing agents or others, products in solution or in suspension which are precipitable or not during the treatment, such as latex for example, agents modifying the physical or chemical properties of the liquid medium viscosity, pH, etc. or modifying the superficial or internal properties of the fibers and other elements in suspension.

Concerning the products intended to give particular properties to the granules for later use, products in solution, emulsion, suspension, encapsulated products and the like may be incorporated in the suspension, so that they become integrated by inclusion, adsorption, chemical contact, grafting, with the fibrous network of the aggregates. These products may be mineral or organic charges, adhesives, gum, polymers or prepolymers, natural or synthetic, thermoplastics or hardenable resins, various monomers, polymerizable or cross-linkable condensable products.

The fluid which is generally utilized for placing the fibers in suspension is generally water. But it is obvious that other pure or mixed liquids may be used. In particular, the fluid may be entirely constituted by polymerizable, condensable or cross-linkable products.

Reactions may also be provided either in the medium where the particles are located or in the particles after draining one part of the liquid medium which surrounds them, or even after drying the particles. Moreover, these latter may be treated in the vapor phase by polymerizable, condensable or cross-linkable products. They may also be covered by a simple projection of various products such as those mentioned above. In any case, the reactions may be triggered by any conventional means such as catalysis, irradiation and so on, possibly permitting graftings on the elements constituting the particles.

Moreover, in order to obtain particles which are expanded in part, porophores or inflating agents may be included, for the purpose of developing small bubbles, forming foam. This expansion of the alveolar product thus obtained may be caused either during the manufacture of the particles or granules, or only at the moment when they are used during later operations, and this expansion may affect all or only part of said particles or granules.

The result is that numerous modifications of the method can be carried out. They may be carried out separately from one another or in various combinations and, consequently, a very wide range of varied products can be obtained.

When the composition of the fibrous suspension is modified during the particulation or granulation by new additions, the program of the development of the operations is established as a function of the aim to be achieved and the product to be obtained. Thus, the particulation or granulation may be begun with a composition comprising cheap raw fibers: mechanical pulp, pulp made from old papers, etc. and terminated with the addition of different fibers which surround the granules by giving them a better appearance (bleached or colored fibers), or properties which are useful for later transformations of the particles or granules. Whatever is possible with the fibers is also possible with the products accompanying said fibers.

Two or more types of particles or granules can even be produced in which are included products capable of reacting together finally when particles or granules of different types are close to one another by means of an external action: mechanical, physical or chemical, irridation, catalysis, etc., for the sole purpose of producing the most varied effects: change of color, variations in size or mechanical properties, release of volatile products, etc.

Several examples are hereinafter given in a non-limiting manner to illustrate the method of the invention:

EXAMPLE 1

For treating a suspension in water of bleached beech fibers having a concentration of 3%, treatment is effected under the following conditions: the tank (FIG. 2) is made of polyvinyl chloride and is rotated about its axis, which is inclined at 45°. The ratio of the diameter of the cylinder to its height is about 1. The peripheral speed of the cylindrical wall is 40 meters per minute. After five hours of treatment, almost all the fibers of the suspension are separated into small regular pellets with a diameter of about 1 mm.

EXAMPLE 2

There is treated, under the same conditions as in Example 1, a suspension of resinous fibers. Fibrous pellets are then obtained, the diameter of which is about 3 mm.

EXAMPLE 3

For treating a suspension of spruce fibers (unbleached kraft pulp) at a concentration of 1.5%, the apparatus diagrammatically illustrated in FIG. 1 is rotated about its axis at a peripheral linear speed of 30 meters per minute. After several hours of agitation, fibrous pellets with a diameter of about 5 mm. are separated from the suspension.

EXAMPLE 4

For treating a suspension of fibers of bleached straw with a concentration of 3%, the apparatus diagrammatically illustrated in FIG. 3 is used. After six hours of treatment, the suspension contains about 80% of agglomerated fibers in the form of small pellets of different sizes, their diameters being between 0.5 mm. to 2 mm.

A great majority of the accessory elements of the straw pulp (vessels, cards, etc. . .) remains in the suspension and the fibers tend to be regrouped in substantially equal lengths and formed into pellets having corresponding diameters.

EXAMPLE 5

For the production of a very porous conglomerate, the suspension of beech pellets obtained in Example 1 is poured onto a rough sieve. The cake of pellets thus obtained is dried after being drained. The fine elements and the fibers, which remain in suspension, serve as bonds between the spheroids and thus a very light porous agglomerate is obtained, having a density of about 0.14.

EXAMPLE 6

For the production of a very resistant agglomerate, the suspension of pellets obtained in Example 1 is drained and replaced in suspension, without destroying the pellets, in a water/alcohol solution of a resorcinon-formol precondensate. After agitation, drainage and drying, and a slight thermal treatment (15 minutes at 110° C.), a very rigid agglomerate is obtained with a good porosity and good machinability.

EXAMPLE 7

If it is required to produce colored fibrous granules intended to be associated with a larger quantity of bleached granules in order to manufacture a decorative covering, granulation is begun with an aqueous suspension containing 2% by weight of raw resinous paper-making fibers produced by a highly effective baking. After the granules have been formed according to the previously described method, 10% colored fibers are added with respect to the weight of the initial fibers. The treatment is followed until the granules are suitably covered by raw fibers. Thus, granules with a diameter of 6 to 8 mm. are obtained having the coloring of the fibers which were added last.

EXAMPLE 8

In this example, the requirement is to produce very cheap supple granules for manufacturing sub-layers for covering the ground. The fibers utilized are constituted by mechanical resinous pulp (paper-making pulp constituted by rasped wood); moreover, fragments of disintegrated old paper are added in an amount of 15% and fine sawdust in an amount of 10%. In order to facilitate the granulation, 10%, with respect to the weight of the fibers, is added of a less stable styrene-butadiene latex whose flocculation will be produced during the granulation treatment.

After treatment of a few hours, granules are obtained with a heterogeneous granulometry or grain size, from about 1 mm. to 8 mm.

After draining and slight drying, these granules constitute a light raw material, of apparent density between 0.10 and 0.30, which is supple and economical for the manufacture of agglomerates.

EXAMPLE 9

For manufacturing granules covered with fibers of colored rayon for the purpose of constituting a decorative coating stratified under high pressure, after impregnation with transparent, thermosetting resins, particulation or granulation is undertaken under the same conditions as for Example 7, but when the raw granules are formed, 10% of fibers of colored rayon of 1.5 denier and 2 mm. length, are added with respect to the weight of the original fibers.

After a few hours of treatment, the granules are coated with colored fibers; they are then separated from the suspension, then dried before being impregnated for the purpose of applying them under pressure onto the surface to be coated.

EXAMPLE 10

For manufacturing granules of fibers of polyvinyl chloride, for the purpose of constituting insulating supple agglomerates, polyvinyl chloride fibers of 2.5 denier and 3 mm. length are dispersed in water in an amount of 2%. After a few hours of treatment, all the fibers are agglomerated in the form of granules whose diameter is about 5 to 6 mm. At this moment 20% of a latex which is made insoluble, on the granules, is added in order to facilitate their final agglomeration.

EXAMPLE 11

For manufacturing particles or granules containing a thermoplastics polymer for the purpose of manufacturing parts for extrusion, and an aqueous suspension containing 2% of fibers of a kraft paper-making pulp and

an equal weight of polyvinyl chloride in the form of fine powder, is treated. In order to facilitate the dispersion of the powder, 0.02% of a tension-active agent is added. In order to increase the fixing of the powder in the fibrous network, a flocculant polyethylene-amine for example may be added.

After a few hours of treatment, the particles or granules are drained and dried and can be used for supplying a machine for pressing toilet soap into cylinders.

EXAMPLE 12

For the production of particles or granules intended for manufacturing molded parts such as packing cases, an aqueous suspension containing 1% of mechanical pulp and 2% of a pulp of highly effective birch fibers is treated. A solution of soda alginate is added in an amount of 8% with respect to the fibers; when the adjuvant is well distributed in the suspension, 5% of aluminium sulphate in solution is added by fractions. There is created a precipitate of aluminium alginate which accelerates the formation of the fibrous granules and gives them after drying an increase in cohesion and rigidity.

EXAMPLE 13

For manufacturing thermoplastics granules reinforced with fibers, for extrusion or molding purposes, a suspension of bleached beech paper-making fibers is produced in an amount of 2% in a monomer, methyl methacrylate for example. After forming the granules, the excess of monomer is separated and polymerization is effected on the separated granules, by a conventional means (atomization of a catalyst, irradiation, etc.). The granules may be kept on a rotating sieve in order to limit their agglomeration. Thus reinforced granules containing a high proportion of polymer and suitable for manufacturing molded or extruded objects are thus obtained.

Reference will next be made to FIG. 7 for a consideration of the effect of the peripheral velocity of a rotating cylindrical tank of a diameter of 12 cm. To obtain proper interlock of the fibers when in granular form, the velocity gradients of the suspension must remain in a range of values depending on the fiber properties and the concentration of the medium.

In fact, if the values are too low, the impacts between fibers are ineffectual, and there is insufficient warping of the fibers. On the other hand, if the gradients are too high, the fiber aggregates are dispersed and there is no granulate formation.

The curves in FIG. 7 show the range of velocity gradients for different fiber concentration. The tests were carried out on unbleached kraft pulp in the cylindrical vat of 12 cm. diameter. Their purpose was to determine, after 10 hours processing, the variation in granulate output (plotted as ordinates and expressed in percentages) in terms of the peripheral velocity of the tank (plotted as abscissas in meters per minute), the efficiency being the ratio of the dry-granulate weight obtained to the gross dry-fiber weight put into the test.

The three curves in FIG. 7 represent the aforesaid variation for three different starting concentrations (1.30, 1.45 and 1.65%) of fibers in the suspension.

FIG. 7 shows:

(a) the optimum peripheral velocity range is approximately from 25 m./min. to 35 m./min.

Processing must therefore be effected in this range in order to obtain optimum granulate efficiency.

(b) the aforesaid range varies slightly in terms of the fiber concentration in the suspension; nevertheless it may be said to tend to diminish as the concentration increases.

Tests have been conducted in which the diameter of the tank has been varied with the following results as given in Table I.

TABLE I

Tank diameter, cm.:	Optimum range of peripheral velocity, m./min.
12	25–35
18	30–40
36	35–45
46	40–50
59	45–60

These results show:

(a) The difference between the maximum and minimum values of the optimum range of velocities, as well as the mean value of the range increases if the tank diameter is made larger.

(b) The relationship governing this variation is that the optimum range of peripheral velocity increases at a rate somewhere between the square root and the cube root of the increase in tank diameter. Expressed mathematically $V_p=f(D_t)^n$ wherein V_p is the optimum range of peripheral velocity, D_t is the tank diameter and n is between ⅓ and ½.

To illustrate the foregoing, the following example is given:

EXAMPLE 14

In a cylindrical tank of 60 liters capacity and inside diameter 36 cm., 50 liters of a 2% concentration of a suspension of monosulfite resin-impregnated fibers in water was introduced. The tank was rotated horizontally about its axis at a speed of 65 r.p.m.

After 10 hours agitation, 550 g. of granulate was separated, this being equivalent to a 55% output in relation to the weight of fiber used.

Under the same conditions, if the speed of rotation is reduced to 45 r.p.m., the output rises to 75%.

The same suspension processed in a 59 cm. diameter tank filled with 200 liters gives an optimum output for a peripheral velocity of 55 m./min.

It has been explained hereinbefore and demonstrated by tests that an extremely varied type of fiber can be used. These include the following:

Natural organic fibers

Vegetable fibers from coniferous and deciduous trees (high-efficiency or "chemical" pulp), bleached or unbleached;

Fibers from Annular plants such as straw, hemp, flax, linters, cotton, etc. Animal fibers such as hide, hair or bristles, wool etc.

Natural mineral fibers

Asbestos.

Artificial organic fibers

Glass, borax bead.

Synthetic fibers

Polyesters, polyamides, polyvinyls (chlorides, alcohols, etc.) acrylic fibers, polycarbonates, etc.

Experience teaches that the *concentration or strength of the suspension varies* with respect to the nature of the fibers (all the various examples) so as to obtain the best interlay of these fibers.

The aforesaid tests also demonstrate the following with respect to the enumerated properties:

(1) FIBER DENSITY

This must not differ too greatly from that of the liquid, so that (having regard to the subsidence of the liquid during rotation) the agitation may enable a sufficient dispersion of fiber to be kept in the fluid.

Under the conditions referred to regarding the tank diameters and the peripheral velocities, the fiber density must be in the range of 0.5 to 2.

(2) DIMENSIONS AND WARPABILITY OF THE FIBERS

These parameters have considerable influence in the formation of spheroid systems.

According to the moduli of elasticity of the fibers, the length-to-diameter ratio may vary from 10 to 10^3 and falls between 3 and 50 p. $N/m.^2$

When the concentration of the suspension has been adjusted to the character of the fibers, the optimum peripheral velocity of the tank is selected to give maximum granulation efficiency in a minimum time, taking into account the strength of the suspension, the sizes of fiber, fiber warpability, etc.

It is important to note that this optimum velocity lies in the range defined in Table I.

The above examples are given only by way of indication in order to show the possibilities of the method and to give an idea of the very wide range of the new industrial products which may be obtained by carrying out said method. Moreover, various modifications may be given to the different variations of the method without departing from the scope of the invention as defined by the appended claim.

What is claimed is:

1. A method of treating a suspension of fibers to form aggregates comprising subjecting the suspension of the fibers in a liquid in a cylindrical tank to a gentle rotational agitation, whereby a speed gradient is estabilsheI between different points in the suspension causing the formation of eddies, which result in the fibers moving together into groups and becoming mechanically interlocked, the grouped fibers being constituted so as to cling to one another to form aggregates, said tank having a diameter and thereby a peripheral speed so that with respect to a tank whose diameter is about 20 cm. its peripheral speed will range from about 30 to 40 meters per minute, and when a tank of increased diameter is used, the range of peripheral speed is increased such that the rate of increase of the peripheral speed of the tank is less than the square root of the rate of increase of its diameter and greater than the cube root of the rate of increase of its diameter, the concentration by weight of the fibers in the suspension, at the beginning of the treatment, being less than 15%.

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