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PROCESS OF AND APPARATUS FOR PRODUCING CONTINUOUS
LAYERS OF FIBER MATERIAL

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PROCESS OF AND APPARATUS FOR PRODUCING CONTINUOUS LAYERS OF FIBER MATERIAL

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The present invention relates to an improved process of producing sheets, plates, or parts of sheets, plates and the like products, and more particularly to a process of producing sheets, plates, or parts of sheets, plates and the like products comprising fibers of inorganic materials, such as mineral wool, rock wool, slag wool, stone wool, glass wool, asbestos, or the like inorganic fiber material, of fibers of plastic materials, of textile fibers, or of mixtures of various fiber material of the above given composition, as well as to an apparatus for carrying out such a process.

There are known a number of processes of converting fiber material into sheets, fleece- or mat-like masses, plates, felts, and similar sheet-like products by felting and/or bonding a plurality of fibers with each other.

The problem to mix, as homogeneously as possible, the fiber material which, usually, is present in irregularly oriented form, for instance, in flocculent form, with a suitable dispersive or suspending agent and to separate from the resulting dispersion or suspension the fiber material in the form of layers, for instance, of felts or felts, heretofore, has been solved in two principally different ways. According to the wet-process, a liquid suspending or dispersing agent, mainly water, is employed while the dry-process makes use of a gaseous suspending or dispersing agent and mainly of air.

Heretofore, the fibers were precipitated and deposited from the suspending or dispersing medium by uniformly applying, in the wet-process, the fiber paste or mix on the longitudinal or drum-like screens or filtering membranes and removing the suspending or dispersing agent by the application of negative pressure, i. e., of a vacuum. Recently it has been suggested to apply positive air or gas pressure, above atmospheric pressure, to the surface of the deposited fiber paste or mix and to the deposited layer so as to rapidly force the liquid from the deposited layer through the screen or filtering membrane.

In the dry-process a continuous stream of substantially individualized fibers is injected into a depositing chamber whereby suspending said fibers in air or other gaseous medium in said chamber. The suspended fibers are deposited by gravity fall and form a felt at the bottom of said chamber on an endless conveyer slowly moving therethrough. Said dry-process has the disadvantage that it does not yield satisfactory sheet-like products with a number of fiber materials.

It is one object of the present invention to provide an improved dry-process of depositing fiber sheet, plate, felt, or similar sheet-like products, said process permitting continuous production of such sheet-like products of a uniformity heretofore unattainable.

Another object of the present invention is to provide a novel and improved construction of the apparatus and combination of the devices required for carrying out said improved dry-process according to the present invention.

Other objects of the present invention and advantageous features thereof will become apparent as the description proceeds.

The process according to the present invention, as stated above, makes use of the dry-process whereby a uniform suspension or dispersion of the fiber material composing the sheets, plates, or parts of such sheets, plates, or similar sheet-like products, is produced in a stream of a gaseous suspending agent, for instance, of air, and separating said suspension, on the one hand, into a fiber layer of greater or smaller thickness and, on the other hand, into the gaseous suspending agent. The gaseous medium is preferably recirculated. If desired, the fiber suspension in said gas is mixed with a binding agent, especially with a thermosetting synthetic resin.

The present invention is of special advantage in the formation of sheets, plates, and similar sheet-like products from mineral fibers, such as slag-wool fibers and others and permits continuous operation of comparatively thick sheets, plates, and similar sheet-like materials of light weight which can be handled and further processed with great ease, especially if comparatively small amounts of a phenol-formaldehyde condensation product of the resol type are admixed thereto, for instance, in powder form.

The process according to the present invention yields sheet-like products of excellent qualities in an economical manner even when using fiber material that ordinarily can be handled and processed only with difficulty.

According to the present invention the fiber material or mixtures of fiber material are uniformly suspended in a gaseous medium, for instance, in air, so as to form a suspension therein. Said uniform suspension is deposited, preferably in continuous operation, upon a separating surface, for instance, a screen, by the action of positive, i. e., superatmospheric pressure. On said separating surface, separation of the gaseous suspending agent from the fibers is effected by simultaneous application of a negative pressure, i. e., a vacuum, to that side of said separating surface which is opposed to the side on which the fiber material is deposited. Thereby a thin fibrous web or a comparatively thick layer of fiber material is deposited upon and removed from said separating surface.

If required, the fiber layer is cut into sections and the desired final product, for instance, a fiber plate, is produced by superimposing and uniting a plurality of such sections. It is an essential and very advantageous feature of the present invention that depositing and separating of the fiber material from the gaseous suspending agent is effected by the combined action of positive and negative pressure, i. e., of superatmospheric pressure on the side of deposition and of vacuum on the side opposite thereto.

According to a preferred embodiment of the present invention binding agents are added to the fiber suspension in the gaseous medium. They may be admixed, for instance, before the formation of the suspension. Especially suitable binding agents for this purpose are plastic materials and especially thermosetting synthetic resins, such as phenol-formaldehyde condensation products. Said resins have proved to be of particular advantage for binding mineral or inorganic fiber material, such as rock wool, slag wool, and the like.

The amount of binding agent added may be comparatively small. Thermosetting synthetic resins, especially phenol-formaldehyde condensation products of the resol type are added, for instance, in amounts varying between about 4% and about 10%, calculated for the fiber material. Such resins are especially suitable for slag wool fibers of comparatively large fiber length as they are used in the production of light-weight fiber plates, such as insulating plates and the like.

According to a preferred embodiment of the present invention the suspension of the fiber material in the
gaseous medium is prepared at elevated temperature. For this purpose the gaseous medium, for instance, air, is heated to the required temperature and the fiber material is suspended in the heated gaseous medium. Of course, temperature which might cause complete hardening of the hardenable binding agent during its presence in the suspended state and before deposition of the fiber material from the suspension must be avoided. On the other hand, the temperature should be high enough so that adhesiveness is imparted to the binding agent employed to the fiber material having adhesive properties.

A preferred embodiment of the apparatus for carrying out the process according to the present invention comprises a preferably conical mixing and whirling chamber wherein the fiber suspension is produced. The fiber material to be suspended and the gaseous suspending agent, for instance, air, are introduced into said chamber at its lower bottom part. Preferably, the mixture of gaseous suspending agent and fibers are conducted into and through said conical chamber in tangentially helical upward direction. The upper part of said chamber is connected with a semicircularly curved pipe-like attachment. The depositing opening at the downwardly directed opposite end of said duct is arranged so that it ends directly above the separating surface. Said separating surface, preferably, is formed by a cylindrical drum-shaped screen which is subdivided, by means of radially extending partition walls, into a number of sectorial chambers. Particularly, each sectorial chamber of the screen which is located with its surface opposite to the depositing opening of the pipe-like attachment to the whirling chamber, is connected by means of an opening in the drum shaft with a vacuum pipe line which, in turn, is also connected with said shaft.

Preferably, the apparatus for carrying out the process according to the present invention, furthermore, comprises a take-off attachment provided with a slit. Said take-off attachment serves to detach the fibrous web or layer from the separating surface.

In a preferred embodiment of the apparatus for carrying out the process according to the present invention, the vacuum pipe line connected to the lower side of the depositing opening is also connected to the suction side of the pump which forces the gaseous suspending agent under positive pressure into the mixing and whirling chamber. In this manner a closed cycle is created whereby the gases under positive pressure are separated from the fiber material suspended therein, are conducted into said blower pump, and are returned by said blower in the mixing and whirling chamber.

Preferably an endless screen belt is provided after the take-off attachment or stripper device. Said screen belt receives the fibrous web or layer removed by said stripper device from the separating surface and advances it towards a cutting and lifting device adapted to cut said fibrous web or layer into sections.

If plates of greater thickness than the thickness of the depositing are to be produced, a rhythmically operating cutting and lifting device is provided which permits lifting each section cut by said device, depositing the lifted section upon another section, and repeating said cutting, lifting and depositing until a plate of the required thickness is obtained. Thereafter the removed plate is lifted by means of a lifting device and depositing means to the pressure side of said pump. A by-pass with a valve is arranged between pressure pipe and suction pipe of said pump.

It is an important feature of the present invention that whirling of the fibers and formation of the fiber suspension takes place under positive pressure, i.e. above atmospheric pressure, because in this manner effective felting of the fiber material on the separating surface is achieved. When providing a closed gas cycle according to a preferred embodiment of the present invention, proper adjustment of the difference in pressure on both sides of the separating surface is of great importance for proper operation.

The mixing and whirling chamber may be designed in any manner. A conical design has proved to be very effective. The connection between the discharge end of said whirling chamber and the separating surface by means of a semicircularly curved pipe effects a certain purification of the fiber suspension inasmuch as heavy contaminations are caused to return to and settle in the whirling chamber. They collect at the bottom of said chamber and can intermittently be removed therefrom.

Working at elevated temperature is especially recommended if a certain bonding of the fibers is desired. When using inorganic fibers and plastic material as binding agent, it is advisable to mix the mixture of fibers and binding agent with the gas, for instance, with air, and to produce a suspension of said fibers and binding agents in said gas, for instance, at a temperature of about 100° C. because at such a temperature the small particles of said plastic material are rendered adhesive and stick to the fibers upon which they are uniformly distributed. As a result thereof a uniform layer is produced on the separating surface, for instance, on the screen surface and especially on the surface of a drum-like screen. It is advisable to harden the binding agent after plate formation. For this purpose a plate of the desired thickness and composed of several fiber layers is heated to hardening temperature. Thereby the incompletely hardened binding agent assists in the combination and union of the individual layers with each other to form said plate. In this manner plates are obtained which are singularly suitable as insulating plates. The remarkable cohesion of the individual layers of such plates permits to ship, handle, and process such plates with great ease.

The attached drawings illustrate diagrammatically a preferred embodiment of the various steps of procedure according to the present invention and an apparatus adapted to carry out said steps with preferred embodiment of parts of said apparatus.

Since the general construction and many of the details of pumps, endless belts, conveyer belts, heating devices, screens and screen drums and the like apparatus as they are used in the apparatus according to the present invention are known and familiar to those skilled in the art, it is only necessary for an understanding of this invention to illustrate and describe so much thereof as will disclose the present invention. It will be understood that in this disclosure many details of construction are omitted as unnecessary and as interfering with a consideration of the embodiment of the invention, and will readily be supplied by those skilled in the art. It is, of course, understood that the invention is not limited to the precise structure shown and described more in detail hereinafter, as the invention, as defined in the appended claim, can be embodied in a plurality and variety of forms and can be practiced in a plurality and variety of ways.

Fig. 1 is a side elevation of the apparatus used for carrying out the process according to the present invention, and

Fig. 2 is a top view of said apparatus.

Fig. 3 is an enlarged fragmentary view of part of the apparatus of Figs. 1 and 2.

Like reference numerals are applied to like parts of all figures of said drawings.

In Fig. 1 the fiber material to be converted into sheet-
like products is introduced into the apparatus through feeding hopper 1 and the binding agent, if required, through feeding hopper 2. Adjacent to said feeding hoppers, and as stated above, is not always necessary, but is required if bonding, by adhesion, is desired and the fiber material itself does not possess sufficient adhesive power. The gas, ordinarily air, which serves as suspending agent in the production of an intimate mixture, i.e. suspension, of the fiber material with or in, respectively, said gas and enables continuous deposition of equal amounts of fiber material per time unit or of a fiber layer of equal thickness per unit area, is introduced into the apparatus through pipe 6. Said gas or air is supplied under positive pressure by means of blower pump 4 and may be heated by passing through heating element 5 which, for instance, is electrically heated. It is, of course, also possible to heat the gas or air by passing the uniform mixture of gaseous suspending agent and fiber material after its preparation through a heating element (not shown) and heating the fiber suspension, for instance, to 100°C.

Feeding hopper 2 for the binding agent is preferably provided at its outlet with sluice valve 6 through which the binding agent is supplied in the desired predetermined quantity to duct 7. The fiber material passes from feeding hopper 1 through extension duct 8 into chamber 9 where it is mixed with the binding agent. The mixture of fiber material and binding agent is discharged from said chamber 9, passes through sluice valve 10, and is supplied in the required quantity to duct 11. Said duct 11 empties into whirling chamber 12.

A certain mixing of fiber material, gaseous suspending agent and, if present, binding agent takes a place on said duct 11. However, final preparation of the intimate mixture and suspension of fiber material, gas, and, if present, binding agent is effected in whirling chamber 12.

Said whirling chamber 12 is of conical shape. As a result of the mixing of gas, fiber material, and, if present, binding agent passes through whirling chamber 12 in a helical upwardly directed path the spirals of which become narrower and narrower towards the apex of said conical whirling chamber 12. Thereby intimate and homogeneous mixing of fiber material, gas, and, if present, binding agent is achieved.

The resulting homogeneous mixture or suspension is discharged from said whirling chamber 12 and is conducted towards separating surface 40 which causes separation of the fiber material from the gaseous conveying and suspending agent.

The condition of removal and removal of heavier particles contaminating the suspension and not being uniformly distributed therethrough, the connection between whirling chamber 12 and the place of deposition on separating surface 40 consists of comparatively wide, semicircularly curved duct 13 serving as a fractionating column. Said duct 13 is tapered and narrowed near and at the place of deposition to form depositing opening 14 directly above separating surface 40 of screening drum, i.e. cylindrical-shaped screen 15.

Said cylindrical-shaped screen 15 which is closed at both sides and is adapted to be rotated around its axis, is subdivided by means of partition walls 16 into separate chambers 17. Stationary pipe 18 is arranged in said drum 15. Said pipe 18 is connected to suction pipe 19 and is provided with slits or perforations 20 which are located so that the respective part of the surface of drum 15 which is opposite opening 14, is exposed to the action of a vacuum applied thereto by means of pipe 19. The suction vacuum is applied through the suction pipe 27 in the manner that the opposite opening 14 forms separating surface 40 upon which fiber material is deposited in the form of layer 21.

Rotation of said drum 15 continuously advances layer 21 of fiber material thereby causing continuous deposition of further layers of fiber material on said separating surface 40. In this manner a continuous and coherent sheet or sheet-like layer of fiber material is formed. Said sheet or layer passes idler pressure roller 22 and is removed from separating surface 40 through the slit of stripping device 23.

Vacuum pipe 19 is connected to the suction side of pump 4 so that a closed gas cycle is formed by pipe 19, pump 4, ducts 3 and 11, whirling chamber 12, semicircularly curved duct 13, depositing opening 14, depositing surface 40 of the particular chamber 17 of screening drum 15 opposite opening 14, and the interior of hollow shaft 18.

Fibrous web or layer 21 consists of a felted mixture of fibers deposited on separating surface 40. Said web or layer 21 may also consist of a bonded fiber mixture, if a binding agent which, at the temperature employed on mixing, has an adhesive effect or to which adhesive properties are imparted at said temperature, is admixed to the suspension of fibers in gas or if adhesive properties are imparted to the fiber material itself at said mixing and suspending temperature.

Said fibrous web or layer 21, on leaving stripper device 23, is placed upon endless screen belt 24 driven by two rollers 25 and 26. Hood 27 is arranged above said screen belt 24. Said hood 27 has at its side facing screening drum 15 a rhythmically operating cutting knife which cuts the continuously produced web or layer into fiber material so as to form single pieces or sections corresponding in their length to the length of said hood. Said hood 27 rhythmically lifts said pieces or sections of fiber material from screening belt 24 by applying a vacuum thereto.

If the fibrous web or layer is to be wound up to form a continuous strip of predetermined length, screening belt 24 and hood 27 are omitted and a winding spool is arranged following slitted stripping device 23.

If plates of a thickness greater than the thickness of layer 21 are to be produced, hood 27 is constructed in such a manner that if lift by suction the desired number of cut sections of said layer 21 and places them one upon the other. As soon as the desired plate thickness is obtained, i.e. as soon as the required number of separate sections of fiber layer 21 is superimposed upon each other and are lifted by suction from screening belt 24, hood 27 holding said superimposed sections of layer 21 is caused to swing around and multi-layer plate 28 is deposited upon endless belt 29.

According to a preferred embodiment of the present invention pressure hood 30 is provided below screening belt 24. Said pressure hood 30 facilitates lifting of the cut sections of fiber layer 21 by applying pressure to the underside of screening belt 24 and said section of fiber layer 21.

According to a preferred embodiment of the present invention, there is also provided a closed cycle of pressure and suction gas in this aggregate part of the apparatus. For this purpose pump 31, on the one hand, draws off the air from vacuum hood 27 through pipes 32, 33, and 34 and, on the other hand, supplies said air to opposite pressure hood 30 through pipes 35 and 36.

Between pipe 33 and pipe 36 there is provided connecting pipe 37 having arranged therein rhythmically operating automatically controlled short-circuit valve 38 which opens pipe 37 after hood 27 has been lifted from belt 24. Thereby the vacuum applied to hood 27 and the positive pressure applied to opposite hood 30 are interrupted and section or plate 28 lifted by the action of vacuum applied to hood 27 is released and drops unto belt 24 to be superimposed upon another section of fiber layer 21. Means may also be provided to cause the standing web or layer of fiber material is deposited on the vertical axis of pipe 33, as indicated by the arrow and in dotted lines, and to deposit plate 28, upon opening of valve 38 and breaking the vacuum, on endless belt 29 driven by rollers 43 and 44.

Plates 28 can be conducted by means of endless belt 29 to further processing stations, for instance, to a cal-
The amount of gas or air supplied to produce the suspension of fiber material is, of course, dependent upon the pressure under which the gas or air is introduced into the air chamber and also upon the type of fiber material used. As an example but without limiting the invention to said example, it may be mentioned that, for instance, 1 kg. of rock wool requires about 20 cubic meters of air of a water-column pressure of about 300 mm.

As stated above, the process according to the present invention can be carried out with any type of natural or synthetic fiber material of inorganic or organic nature. A number of inorganic fiber materials have been mentioned hereinbefore. Cotton, flax, hemp, jute, sisal hemp, or other natural fiber material of vegetable origin, silk, wool, synthetic fibers, such as cuprammonium silk, viscose rayon, cellulose acetate fibers or fibers of cellulose acetate butyrate and other fatty acid esters or mixed esters of cellulose, casein-formaldehyde, superpolyamide fibers, or fibers on the basis of vinyl chloride, such as copolymers of vinyl chloride and vinyl acetate, known as "vinylon," or copolymers of vinylidene chloride and vinyl chloride, known as "vinylon," and others may also be used as fiber material in carrying out the present invention.

The proportions of fiber material and binding agent may vary widely. Ordinarily, especially when producing mats and plates, the binding agent is present in the mixture of fiber material and binding agent in an amount between about 2% and about 10% depending, of course, upon the type of fiber material used. When producing well flowing molding compositions for the manufacture of molded articles, the amounts of binding agent may be greatly increased, for instance, to between 15% and 35% and even higher.

In place of thermosetting phenol-formaldehyde condensation products there may be used other suitable binding agents which are hardened either by chemical reaction or by heat or in any other desired manner. For instance, molding compositions of urea and thiourea with formaldehyde, melamine or melamine derivatives, such as methylated hydroxyl methyl melamine, with formaldehyde, alkyd resins and air-drying modified alkyd resins, unsaturated polyester resins, epoxy resins, amine-formaldehyde resins, such as aniline-formaldehyde resins, and many others may be employed as such binding agents. Especially advantageous binding agents, however, are thermosetting synthetic resins since they permit bonding of the fibers with great ease.

The mixing and whirling chamber may be provided with baffles, plates, deflectors, and other installations increasing the mixing and whirling effect of said chamber.

It may be mentioned that hood 27 of the attached drawings is provided with a wire screen, perforated plate, or the like at its opening facing fibrous web or layer 21 or plate 28. Said web, layer or plate are forced by suction against said screen, perforated plate, or the like and, thus, are lifted with said hood 27 from screening belt 24.

I claim:

1. In a process of producing sheets, plates, and other sheet-like products composed of fiber material and hardened synthetic resins, the steps comprising conducting a gaseous suspending agent carrying the fiber material and a finely divided hardenable, fiber-binding synthetic resin admixed thereto with a high speed into the lower part of a conical mixing and whirling space, causing the suspension to spirally ascend from said lower part of the mixing and whirling space to the upper apical of said mixing and whirling space, the resulting uniform suspension of fiber material and synthetic resin in gaseous suspending agent from said upper apical part through a curved duct and in downward direction under positive pressure upon a separating surface, thereby subjecting the side of said separating surface opposite to the side of deposition to the action of a vacuum, and separating the
uniform mixture of fiber material and synthetic resin from the gaseous suspending agent.

2. In a process of producing sheets, plates, and other sheet-like products composed of fiber material according to claim 1, wherein the gaseous suspending agent is air.

3. In a process of producing sheets, plates, and other sheet-like products composed of fiber material according to claim 1, wherein the fiber-binding synthetic resin is added in an amount between about 4% and about 10% calculated for the fiber material employed.

4. In a process of producing sheets, plates, and other sheet-like products composed of fiber material according to claim 1, wherein the fiber-binding synthetic resin is a phenol-formaldehyde condensation product of the resol state and the fiber material is a mineral fiber material of comparatively large fiber length.

5. In a process of producing sheets, plates, and other sheet-like products composed of fiber material according to claim 1, wherein the fiber-binding synthetic resin is a thermosetting synthetic resin and the fiber material is suspended in air at an elevated temperature insufficient to cause hardening of the thermosetting synthetic resin but sufficient to impart adhesive properties thereto.

6. In a process of producing a uniformly and intimately mixed, felted composition of fiber material and hardende synthetic resin as binding agent, the steps comprising uniformly suspending the fiber material and a finely divided, hardenable, fiber-binding synthetic resin in a gaseous suspending agent, flowing the suspension with a high speed in tangential direction into the lower part of a conical mixing and whirling space, flowing the suspension with a high speed in a spirally ascending whirling motion through said mixing and whirling space, flowing the suspension from the upper apical part of said mixing and whirling space through a curved duct and in downward direction under positive pressure upon a separating surface adapted to separate the mixture of fiber material and synthetic resin from the gaseous suspending agent, thereby subjecting the side of said separating surface opposite to the side of deposition to the action of a vacuum, and removing said mixture from the separating surface.

7. In a process of producing molding powders containing fiber material, the steps comprising conducting a gaseous suspending agent carrying the fiber material and a finely divided, hardenable, fiber-binding synthetic resin admixed thereto with a high speed in tangential direction into the lower part of a conical mixing and whirling space, thereby causing the suspension to spirally ascend from said lower part of the mixing and whirling space to the upper apical part of said mixing and whirling space, flowing the resulting uniform suspension of fiber material and synthetic resin in gaseous suspending agent from said upper apical part through a curved duct and in downward direction under positive pressure upon a separating surface adapted to separate the mixture of fiber material and synthetic resin from the gaseous suspending agent, thereby subjecting the side of said separating surface opposite to the side of deposition to the action of a vacuum, and removing said mixture from the separating surface.

8. An apparatus for producing sheets, plates, and other sheet-like products composed of fiber material, said apparatus comprising a mixture and whirling chamber of conical shape, means for tangentially introducing, under pressure, a mixture of fiber material and gaseous suspending agent into said mixing and whirling chamber at the bottom part thereof and imparting to said mixture a whirling and spirally ascending movement, said mixing and whirling chamber causing said mixture of fiber material and gaseous suspending agent to form a uniform suspension, a curved pipelike duct, the one opening of said duct being attached to and connected with the apical upper part of the mixing and whirling chamber and the other opening of said duct being directed towards and arranged near and opposite to a separating surface, said duct conducting said suspension from the apical upper part of said mixing and whirling chamber in downward direction to a separating surface, a perforated separating surface provided opposite to the discharge depositing opening of said conducting means, said perforated separating surface being adapted to separate the fiber material from said gaseous suspending agent thereby causing formation of a layer of said fiber material upon said separating surface, and means for removing the resulting layer of fiber material from said separating surface.

9. An apparatus for producing sheets, plates, and other sheet-like products composed of fiber material according to claim 8, wherein the means for removing the resulting layer of fiber material from the separating surface is a stripping device provided with a slit.

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