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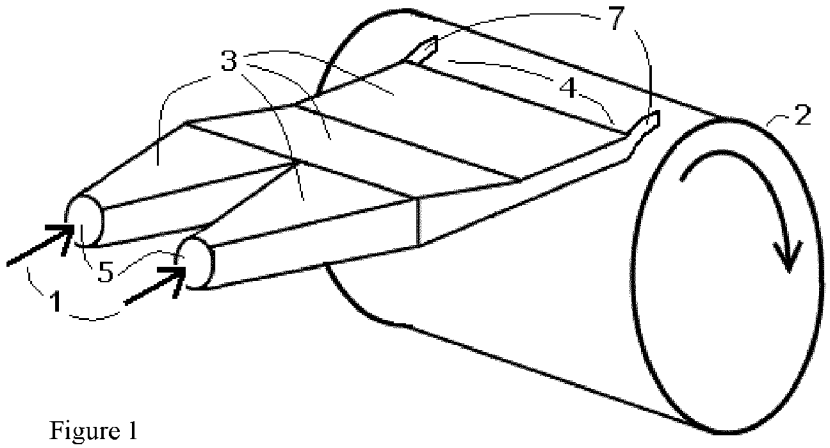


Figure 1

(57) Abstract: A process for the manufacture of fiber reinforced cement material comprising a step of discharge of the cementitious slurry comprising fibers onto the surface of a rotating cylindrical sieve.

Process for the production of fibercement products and fibercement products obtained

Field of the invention

The invention concerns a process for the manufacture of fiber reinforced cement sheets, whereby the cementitious slurry comprising fibers is discharged onto the surface of a rotating cylindrical dewatering sieve and accumulated onto a forming cylinder.

The invention also relates to fiber reinforced cement sheets obtained with the process.

State of the art

The Hatschek process is most widely used for the manufacturing of fiber cement products. It was initially applied to asbestos-cement, and is exhaustively described in the book "Asbestzement" by Harald Klos (Springer Verlag, 1967).

The Hatschek technique consists in forming a sheet, by filtration using a fluid aqueous suspension obtained by mixing essentially cement, fibers and water and which is supplied to a vat in which a rotating sieve covered by a cloth is located. The sheet or a superposition of sheets, is then drained of water by suction and/or pressure. The fibers hold to the filter (or sieve), forming an additional screen retaining the particles, even fine particles, of cement or of other binder or additive, together with an important amount of water which contributes to the cohesion of the layer formed on the sieve. The sieve consists of a open cylindrical drum covered with a filter cloth and is installed in a tank (vat) containing the suspension (slurry); since the drum rotates in the tank, the hydrostatic

pressure forces some of the water to pass through the filter cloth, whereas the solids, that is to say notably the fibers, the cement particles and other additives, build up on the screen of the drum as a thin layer whose thickness increases with the rotation of the drum. This layer is transferred, usually by means of a felt belt and further dewatered by suction through the belt, to a forming cylinder, onto which generally several layers are superposed until the desired thickness of sheet material has been reached. The production rate of the Hatschek line can be increased by the use of several consecutive vats operating simultaneously.

The sheet on the forming cylinder is then cut, and subsequently subjected to a forming step, which consists of putting it between templates, for instance metal templates which have been oiled. Afterwards, it is submitted to a hardening stage at room temperature (air curing) or by autoclaving (steam-curing under specific pressure and temperature conditions).

The Hatschek process generally provides fiber cement panels characterized by a low ratio between the mechanical strength in the crosswise to the longitudinal direction. The reason for that is that the fibers are not uniformly or randomly oriented but are aligned predominantly in the direction of rotation of the rotary screen (i.e. the lengthwise axis of the sheet, also called the machine or longitudinal direction). The resulting sheet is consequently not isotropic, and the strength in the cross direction (i.e. the direction normal to the machine direction, also called the transversal direction) is lower than the strength in the machine direction. Higher production speeds increase the pronounced tendency of fiber orientation in the machine direction.

Several attempts were made in the past to overcome the problem of preferential machine direction orientation of the fibers, with the aim to produce fiber reinforced cement panels having more uniform mechanical properties in the various directions. Disorientation screws are frequently used within the vats of Hatschek machines. Most often, these are Archimedes screws which are installed in pairs with symmetrical and opposite effects. However, the orientation factor (OF), which is defined as the ratio of a given mechanical property in the cross direction to the same mechanical property in the machine direction is fixed for a given disorientation screw, which implies that the setup of the disorientation screws has to be modified when the production changes to fiber cement products with other specified mechanical properties. Moreover, as the action of the disorientation screws is limited, the OF of the maximum bending strength is systematically lower than 0.65 while the OF of the work of fracture is lower than 0.5 on such industrial machines. US2644373 discloses a process for the production of fiber cement sheets comprising a step of discharge of the cementitious slurry comprising fibers onto the surface of a rotating cylindrical sieve. However, as the fiber cement mixture is discharged downwardly by gravity onto the cylinder, it is subject to shear; this process induces consequently a preferential alignment of the fibers in the direction of rotation of the sieve. Moreover, this process is only suitable for fiber cement mixtures comprising short fibers such as asbestos fibers: as the fiber cement mixture is not agitated, long fibers such as synthetic organic polymer fibers or the cellulose fibers generally used in the current manufacture of fiber cement materials cannot be properly dispersed. Also, the fiber cement sheets manufactured according to this process are formed directly on the rotating

sieve, contrary to the Hatschek process including additional dewatering on the conveyer belt and subsequent accumulation of several layers constituting the final sheet on the forming cylinder. The process described in US2644373 is consequently limited to pasty fiber cement mixtures of high concentration which are distinct from the diluted slurries used in a Hatschek process.

DE19824604C1 discloses a process for the manufacture of fiber reinforced cement boards characterized by an enhanced isotropy obtained by random orientation of the fibers through the use of a slot die. The process described in DE19824604 concerns a one-layer process which suffers from several disadvantages such as difficult dewatering of the thick cementitious layer through the porous felt and consequently a slow line speed, low mechanical strength due to the low efficiency of the reinforcing fibers which are three-dimensionally oriented (i.e. in the machine direction, the cross direction and the z direction (thickness)), and an irregular surface aspect related to the spring back of the fibers such as cellulose fibers and synthetic fibers which are not homogeneously dispersed (as the consistency of the cementitious slurry is high, flocking problems lead to micro-anisotropy) and the use of a rake oscillating perpendicularly to the machine direction in order to improve the dewatering and the homogeneity of the cementitious slurry comprising fibers. The object of the invention described in DE19824604C1 is a continuous process for the manufacturing of a fiber reinforced cement sheet and to provide a suitable means for controlled dewatering of a thick and consistent cementitious slurry comprising fibers without disturbing the initial uniform fiber distribution. Moreover, the process described in DE19824604C1 can not be implemented on an existing Hatschek machine. It is

complicated to operate and to maintain as it needs two dewatering belts, a dewatering control sheet and a moveable rake.

DE207540C describes a process for the manufacturing of fiber reinforced sheets made of hydraulic binder. The latter is poured in its solid state (either as powder or damped) by gravity from a vessel in an area between a guide plate and the surface of a rotating sieve. The aqueous slurry of fibers is added to the hydraulic binder upon its discharge. This process does not result into a uniform and homogeneous distribution of the fibers in the sheet, and leads consequently to fiber reinforced cement sheets with inferior mechanical properties.

The systems described in the state of the art documents either do not allow the control of the orientation factor in a significant way or imply severe drawbacks leading to fiber cement products of inferior quality. They are also not compatible with existing Hatschek lines and require the investment of a complete new line.

Summary of the invention

We have now found a process to control the fiber orientation in a fiber cement sheet by using a particular cementitious slurry feeding system which replaces the vat of a conventional Hatschek line, and hence is easy to implement on existing Hatschek production lines; moreover it allows the production of fiber reinforced cement sheets at the usual production rate and without impairing the other product properties.

The present invention concerns a process for the manufacture of a layered fiber reinforced cement sheet comprising the following subsequent steps :

a) formation of at least one fiber cement monolayer by continuous discharge of a cementitious slurry comprising reinforcing fibers onto the surface of at least one rotating cylindrical dewatering sieve through at least one device with a slot shaped outlet,

b) transfer of the at least one fiber cement monolayer formed in step a) to a dewatering conveyer felt,

c) transfer of the at least one dewatered monolayer obtained in step b) on a forming cylinder, until the desired thickness of the layered fiber reinforced cement sheet on said forming cylinder is obtained.

The process according to the present invention allows the manufacturing of fiber reinforced cement sheets which are characterized by a controlled fiber orientation in the products. According to the present invention, more uniform mechanical properties in the machine (or longitudinal) and cross (or transversal) direction and hence a high orientation factor (defined as the ratio of a mechanical property of the cross or transversal direction to the same mechanical property in the machine or longitudinal direction), due to fiber randomization, can be achieved compared to the existing production methods, such as a conventional Hatschek machine. Surprisingly, the products manufactured with the process according to the present invention are characterized by a high orientation factor and a higher average strength without increasing the fiber content, and without impairing the machine direction strength, the production speed and the other properties of the fiber cement product.

Brief description of the drawings

The invention will be explained in detail below, referring to the accompanying drawings. Figures 1 and 2 show typical examples of suitable devices which are implemented on fiber cement manufacturing machines using a rotating sieve as primary dewatering surface; figures 3 and 4 are explained below. The figures are not drawn to scale.

Description of the invention

Conventional Hatschek lines are vat feeding machines, implying a strong orientation of the fibers in the machine direction. Even when disorientation screws are used, strength cross/machine direction ratios of bending strength of lower than 0.65 are very often observed. This means that the fiber content in the cross direction may fall below the volume needed to achieve effective reinforcement (critical volume), and the fiber cement product is liable to longitudinal cracking.

The object of the invention is a process for the manufacture of a layered fiber reinforced cement sheet comprising the following subsequent steps:

a) formation of at least one fiber cement monolayer by continuous discharge of a cementitious slurry comprising reinforcing fibers onto the surface of at least one rotating cylindrical dewatering sieve through at least one device with a slot shaped outlet,

b) transfer of the at least one fiber cement monolayer formed in step a) to a dewatering conveyer felt,

c) transfer of the at least one dewatered monolayer obtained in step b) on a forming cylinder, until the

desired thickness of the layered fiber reinforced cement sheet on said forming cylinder is obtained.

The present invention provides a process for the manufacture of layered fiber reinforced cement sheets comprising a step of discharge of the cementitious slurry comprising reinforcing fibers (1) onto the surface of a rotating cylindrical dewatering sieve (2) as shown e.g. in figures 1 and 2.

Step (a) is performed using device (3) which has a slot-shaped outlet (4). Suitable geometries of the device (3) have straight or curvilinear walls, approaching and/or moving away walls connecting the inlet (5) to the slot shaped outlet (4), preferably in a continuous way such that the said device has a closed channel between its inlet (5) and its outlet (4). The device (3) comprises preferably at least one section with continuously moving away (i.e. the widening or divergence is not stepwise) sidewalls (i.e. the walls between the upper and lower surface from the inlet to the outlet). We have found that when a cementitious slurry containing fibers passes through the section with moving away sidewalls of the device previously described, fibers tend to align in the cross direction.

The device can comprise one or more inlets, as shown e.g. in figure 1.

The inlet can have any shape. According to the present invention circular pipes and rectangular horizontal slots are preferred.

Preferred devices are characterized by a width of the slot outlet which is larger than the total width of the inlets.

The width of the outlet is measured as the cross-directional distance between the left and right sidewall of the outlet. The width of a rectangular inlet is defined as the cross-directional distance between the left and right sidewall of the inlet; the

width of a circular inlet equals its diameter. In case there are several inlets, the total width of the inlets is the sum of the widths of the several inlets.

According to the present invention, the width of the slot outlet is preferably at least 2.5 times the total width of the inlets and most preferably 5 times the total width of the inlets. If the width of the slot jet is less than 2.5 times the width of the inlet, the effect of the section with the moving away sidewalls on fiber orientation is too small.

The length of the device for the discharge of the cementitious slurry is preferably at least 2.5 times the total width of the inlets, and most preferably at least 4 times the total inlet width. The length of the device for the discharge of the cementitious slurry is defined as the longitudinal distance between the inlet and the outlet.

Moreover the device can further comprise converging parts, diverging parts, and their combinations, constraint sections creating pressure drops to improve the dispersion of the fibers in the cementitious slurry.

Internally, the channel can be partitioned totally or partially by horizontal, vertical or inclined walls.

In figure 1, a device transforming the flow of two inlets into one slot-shaped outlet covering the entire width of the rotating cylindrical dewatering sieve is shown. The device used in the process brings about a uni- or biaxial stretching or elongation of the fluid fiber cement slurry in a direction different from the machine direction, thereby creating a deformation path within the fluid cementitious slurry which orientates the fibers in the elongation direction(s).

The impingement point of the cementitious slurry on the surface of the rotating cylindrical dewatering sieve can be anywhere provided sufficient dewatering capacity is ensured.

The impingement angle (the angle between the velocity vector of the slurry at the outlet and the tangent to the rotating cylindrical dewatering sieve at the impingement point) is preferably in the range of from 0° to 75°, and most preferably in the range of from 0° to 45°.

Several devices as the one depicted in figure 1 can be aligned side by side in order to cover the width of the rotating cylindrical dewatering sieve. In order to assure a homogeneous distribution of the slurry over the whole width of the rotating cylindrical dewatering sieve, the devices depicted in figures 1 and 2 are preferably linked to a system which provides an equal flow through each inlet. A suitable device for the homogeneous distribution of fiber cement slurry is a tapered cross direction manifold or radial system; an example of the latter is depicted in figure 3.

In the present invention, the geometry of the device is preferably adjustable to control the speed difference between the forward moving jet of slurry (Vj) which is defined as the ratio between the flow rate of slurry delivered on the rotating cylindrical dewatering sieve and the peripheral speed of the rotating cylindrical dewatering sieve (Vs).

The outlet jet forward speed is preferably in the range of 0.2 to 1.8 times the peripheral speed of the rotating cylindrical dewatering sieve. A range of Vj/Vs from 0.6 to 1.5 is particularly preferred to obtain a maximum OF.

The cementitious slurry which is discharged on the surface of the rotating cylindrical dewatering sieve comprises synthetic and/or natural reinforcing fibers. Both autoclaved and air-cured

fiber reinforced cement sheets can be produced according to the process of the present invention. Natural fibers are preferably cellulose fibers, more preferably chemical wood pulp. They are used as reinforcing and process fibers. Cellulose fibers produced by the Kraft or sulphate process are particularly preferred. Good results are obtained with bleached or unbleached cellulose fibers from softwood or from hardwood. Cellulose fibers characterized by a Kappa number in the range from 14 to 40, more particularly in the range from 25 to 30 are especially preferred. Cellulose fibers refined to a Shopper Riegler degree (°SR) in the range from 15 to 35, more particularly in the range from 20 to 30 give satisfactory results for the manufacture of autoclaved fiber cement sheets, while cellulose fibers refined to a °SR in the range from 35 to 70, more particularly in the range from 40 to 65, are preferably used for the production of air-cured fiber cement sheets. The latter comprise preferably, except cellulose fibers, other reinforcing fibers, such as synthetic polymeric fibers. Examples of synthetic polymeric reinforcing fibers which can be used in air-cured fiber cement sheets are polypropylene, polyethylene, polyvinylalcohol and polyacrylonitrile.

In step a), several monolayers can be superposed on the surface of the rotating cylindrical dewatering sieve, each monolayer corresponding to the discharge of the fiber cement slurry by a device with a slot shaped outlet.

Several rotating cylindrical dewatering sieves can be aligned consecutively, each of them continuously fed by at least one device with a slot shaped outlet.

Steps b) and c) of the process according to the present invention are typical steps of a Hatschek process. In step b), the monolayer(s) which is (are) formed on the rotating

dewatering sieve(s) is (are) transferred to a dewatering felt belt, generally provided with vacuum boxes. The fiber reinforced cement layer(s) is (are) further dewatered by press rollers and vacuum boxes, and conveyed by means of the felt belt to the forming cylinder.

The production steps a) to c) are continued until the desired thickness on the forming cylinder has been reached.

The green uncured fiber cement sheet on the forming cylinder is then cut and unfolded to obtain a flat sheet. This operation can be done manually with a knife following a groove in the forming drum or automatically with a steel blade incorporated in the forming cylinder or with a wire.

The cementitious slurry which is discharged on the surface of the rotating cylindrical dewatering sieve has a concentration preferably of not higher than 150 g of solids per litre of cementitious slurry, more preferably of not higher than 100 g of solids per litre of cementitious slurry. Concentrations of not higher than 70 g of solids per litre of cementitious slurry are particularly preferred. Concentrations higher than 150 g/litre lead to a bad dispersion of the fibers, and consequently unsatisfactory reinforcing and mechanical properties.

The fiber reinforced cement sheet manufactured according to the process of the present invention comprises several layers each of which is formed by continuous discharge of the cementitious slurry comprising fibers onto the surface of a rotating cylindrical dewatering sieve such that the weight of each monolayer expressed in g of solids per m^2 of layer is preferably in the range from 250 to 750. Each monolayer is characterized by a thickness preferably ranging from 0.25 to 0.4 mm as measured after the forming cylinder. This avoids the orientation of part of the reinforcing fibres in the z direction and provides a

homogeneous distribution of the fibers; it also facilitates dewatering because of the low amount of solids per surface unit. The number of monolayers is generally between 20 and 25.

It has been observed that the dewatering rate of the fiber cement slurry can be too slow when discharged onto the surface of a rotating dewatering sieve by means of any of the devices shown in figures 1 and 2. In order to increase the dewatering rate, the device is preferably provided with an upper fixed or pivotable and adjustable lip (6)as shown in figure 2 to keep the slurry in closer contact with the dewatering sieve and to avoid spoiling of the cementitious slurry due to overflow. In a preferred embodiment, the end-part of the device preferably has straight left and right edges (7) as depicted in figure 1, to confine the slurry on the rotating cylindrical dewatering sieve.

With the aim to further increase the dewatering rate in order to avoid slurry overflow, the rotating dewatering sieve is preferably equipped with a vacuum box located inside the dewatering sieve. The preferable use of a vacuum box within the sieve implies a flat internal surface of the sieve, which allows the preferable installation of sliding contact sealings located at the edges of the vacuum box.

In order to further optimize the dewatering rate, the sieve is provided with holes; the holed curved plate is then covered with a coarse metal grid and a fine sieve superposed on the latter, as usually performed with Hatschek machines.

The fiber cement manufacturing process according to the invention enables to control and vary the fiber orientation by adjusting the geometric parameters of the feeding device and the speed difference between Vj and Vs. The fiber cement manufacturing process according to the present invention allows to vary the fiber orientation factor in a more flexible and

easier way compared to a Hatschek process (where fiber orientation can only be slightly modified in a narrow range by changing the setup of the orientation screws located in the vats) and allows to achieve higher orientation factors than commonly obtained with the conventional Hatschek process.

The fiber reinforced cement sheets manufactured according to process of the present invention have improved mechanical properties in the cross direction without impairing the mechanical properties in the machine direction. Fiber reinforced cement sheets manufactured according to the process of the present invention are characterized by an orientation factor expressed as the ratio of the cross direction maximum bending strength to the machine direction maximum bending strength measured on air-dry samples which is preferably in the range of from 0.65 to 1.4. The average mechanical properties of the fiber reinforced cement sheets manufactured according to the invention are hence improved compared to fiber cement sheets produced on a conventional Hatschek line.

Detailed description of particular embodiments

The invention is described hereafter in a detailed way using particular examples of embodiment.

Preparation of the blends and pilot production of fiber reinforced cement samples

Cementitious products were manufactured on a pilot line reproducing the main characteristics of the products obtained by industrial methods. The following composition has been used after strong dilution with water to obtain a consistency below

70 g/l : Poly(vinylalcohol) fibres (6 mm length, 2 dtex) :1.9wt%, cellulose Kraft fibers refined to 46 °SR :3wt%, limestone :12wt%, amorphous silica : 6.4wt%, Portland cement 52.5N : 76.7wt% (concentrations of solids expressed in weight % with respect to the total dry matter).
The sheets were hardened during one night at 50 °C, and afterwards under plastic cover sheet during 14 days at room temperature.

Trials at various Vj/Vs ratios were run on the pilot line according to the invention. Four different devices with a slot shaped outlet were used and selected from the types depicted in the figures 1 and 2.
Device 1 is shown in figure 4, i.e. with two inlet pipes. The channel is composed of three sections: a first diverging section with a length of 275 mm, having parallel upper and lower walls and moving away side walls forming angle of 15° with respect to the machine direction; then a converging section with a length of 100 mm, characterized by approaching upper and lower walls forming an angle of 11° until the distance between upper and lower walls reaches 9 mm and parallel side walls, and a third section having a length of 200 mm and with parallel side walls and parallel upper and lower walls The sum of the width of the inlets is 3 cm, the width of the outlet is 32 cm.
Device 2 is not depicted as it is similar to device 1, but has its third section with upper and lower walls separated by a distance of 9 mm at its junction with section 2 and moving away in the z direction (i.e. the direction perpendicular to the plane formed by the cross and the machine direction) at an angle of 2° over a length of 250 mm.

Device 3 is shown in figure 2 i.e. a triangle-shaped front view with moving away side walls with an angle of 25° with respect to the machine direction and a length of 250 mm; and upper and lower walls which are approaching at an angle of 7.5°until the distance between the upper and lower walls reaches 9 mm. Device 4 is not depicted as it is similar to device 3, but has parallel upper and lower walls separated by a distance of 9 mm. The rotating sieve has a width of about 400 mm, and the width of the sheets is between 300 and 320 mm.

Comparative trials were also run on a conventional Hatschek pilot line (VF (Vat Feeding)) equipped with a screw,; the rotation speed of the disorientation screws was adjusted in order to obtain a peripheral sieve speed (which is equal to the speed of the felt) matching the rotation speed of the disorientation screw multiplied by its thread lead (i.e. the distance along the screw's axis which is covered by one complete revolution of the screw).

Measurement of flexural strength

The bending strength is determined by a flexural test on three points using a span of 146 mm and a test speed of 20 mm/minute on samples of 50 mm*160 mm which have been dried in a ventilated oven at 40°C for 2 days ("air dry" samples) or saturated with water through immersion in water for 3 days ("water saturated" samples). The bending strength of ten samples is determined in each of the two directions (machine direction (MD) and (cross direction (CD)), 2 weeks after the production. The test equipment records the stress/strain curve, and the maximum bending strength (called "MOR", Modulus Of Rupture, expressed

in MPa) and the work of fracture up to maximum bending strength("iMOR", integral at the Modulus Of Rupture, expressed in J/m^2) are calculated. The orientation factors $OF_{(MOR)}$ and $OF_{(iMOR)}$ are defined as the ratio of $MOR_{(CD)}$ resp. $iMOR_{(CD)}$ to $MOR_{(MD)}$ resp. $iMOR_{(MD)}$.

Example 1 and comparative example 1

Trials were run on a conventional Hatschek pilot line (VF (Vat Feeding)) provided with an orientation screw (Comparative example 1), and on the pilot line according to the invention (SF (Sieve Feeding)) equipped with device 1 and a vacuum box in the sieve (Example 1). The sieve feeding trials have been run with Vj/Vs ratios varying between 0.86 and 1.42. A felt speed of 40 m/min was used for all trials. The MOR and iMOR of air-dry samples(AD) and water-saturated samples (WS) are given in table I. They are expressed in % of the respective mechanical property of Comparative Example 1.

Table I

Condition	Property		Example 1	Comparative Example 1
WS	MOR	CD (%)	138	100
		MD (%)	101	100
	iMOR	CD (%)	183	100
		MD (%)	106	100
AD	MOR	CD (%)	139	100
		MD (%)	106	100
	iMOR	CD (%)	199	100
		MD (%)	112	100

The results in table I show that the average strengths (i.e. the average of the strength in the MD and CD direction) for the example according to the invention are significantly higher with respect to the comparative example; the higher average strengths for the trials according to the invention are primarily due to an improvement of the cross direction strengths. In other words, the improvement of the cross direction strength (CD) does not impair the machine direction strength (MD), and hence the average strength of the sheets is increased using the process according to the invention compared to the strength obtained on a conventional Hatschek machine equipped with a vat containing the cementitious slurry from which a layer is formed on a rotating sieve located in the vat.

The OF values for these trials are summarized in Table II below, and show that higher OF values can be obtained with the process according to the present invention (example 1) compared to a typical Hatschek process (comparative example 1).

Table II

Condition	OF based on	Example 1	Comparative Example 1
WS	MOR	0.88	0.64
	iMOR	0.78	0.45
AD	MOR	0.81	0.61
	iMOR	0.62	0.30

Examples 2 to 5

Table III shows the $OF_{(iMOR)}$ and $OF_{(MOR)}$ values which have been obtained with several devices used in the process according to the invention.

Table III

Ex.	Device	Line speed (m/min)	Vj/Vs	$OF_{(iMOR)}$ (Air dry)	$OF_{(MOR)}$ (Air dry)
2a	2	40	0.6	0.47	0.66
2b			0.7	0.51	0.65
2c			0.9	0.66	0.75
2d			1.1	0.75	0.83
2e			1.3	0.60	0.71
2f		20	0.3	0.65	0.78
2g			0.7	0.77	0.90
2h			1.0	1.0	0.94
3a	3	40	0.9	0.74	0.85
3b			1.0	0.82	0.95
3c			1.1	0.65	0.85
4a	4	40	0.5	0.28	0.78
4b			0.6	0.47	0.85
4c			0.8	0.53	0.75
4d			0.9	0.6	0.75
4e			1.0	0.97	0.96
4f			1.2	1.12	1.1
4g			1.5	0.88	0.91
5a	1	30	0.8	0.61	0.76
5b			1.0	0.8	0.81
5c			1.2	0.6	0.75
5d			1.3	0.51	0.70

The results in table III show that OF can be controlled to a large extent using the process according to the invention and

that most OF values are higher than the OF of the comparative example 1 in table II. Moreover, OF values higher than 1 can be obtained, which means that the majority of the fibers are oriented in the cross direction.

The results in table III indicate that the difference between Vj and Vs plays an important role in fiber orientation control. The OF usually reaches the maximum at a Vj/Vs ratio in the range of 1 to 1.2 although the optimum ratio depends on the geometry of the device.

CLAIMS

1. Process for the manufacture of a layered fiber reinforced cement sheet comprising the following steps:
a) formation of at least one fiber cement monolayer by continuous discharge of a cementitious slurry comprising reinforcing fibers onto the surface of at least one rotating cylindrical dewatering sieve through at least one device with a slot shaped outlet,
b) transfer of the at least one fiber cement monolayer formed in step a) to a dewatering conveyer felt,
c) transfer of the at least one dewatered monolayer obtained in step b) on a forming cylinder, until the desired thickness of the layered fiber reinforced cement sheet on said forming cylinder is obtained.

2. Process according to claim 1 wherein the forward speed of the outlet jet is in the range of 0.2 to 1.8 times the peripheral speed of the rotating cylindrical dewatering sieve.

3. Process according to claim 1 or claim 2 wherein said cementitious slurry has a concentration of not higher than 150 g of solids per litre of cementitious slurry.

4. Process according to any of the preceding claims wherein the weight of the monolayer in step a) is in the range from 250 to 750 expressed in g of solids per m^2.

5. Process according to any of the preceding claims characterized by an impingement angle of the cementitious slurry on the rotating dewatering sieve in the range of 0° to 75°.

6. Process according to any of the preceding claims wherein the device comprises one or more inlets.

7. Process according to any of the preceding claims wherein the width of the slot outlet is at least 2.5 times the total width of the inlets.

8. Process according to any of the preceding claims wherein the length of the device for the discharge of the cementitious slurry is preferably at least 2.5 times the total width of the inlets.

9. Process according to any of the preceding claims wherein the device comprises at least one part with continuously moving away sidewalls.

10. Process according to any of the preceding claims wherein the device is internally partially or totally partitioned by internal walls.

11. Process according to any of the preceding claims wherein the device for the discharge is equipped with an upper fixed or pivotable and adjustable lip to keep the cementitious slurry in close contact with the rotating cylindrical dewatering sieve.

12. Process according to any of the preceding claims wherein the device is coupled to a tapered cross direction manifold or radial fiber cement slurry feeding system.

13. Fiber reinforced cement sheet manufactured according to the process of any of the preceding claims.

14. Fiber reinforced cement sheet according to claim 13 characterized by an orientation factor expressed as the ratio of the cross direction maximum bending strength to the machine direction maximum bending strength measured on air-dry samples which is in the range from 0.65 to 1.4.

AMENDED CLAIMS
received by the International Bureau on 29 March 2012 (29.03.2012)

CLAIMS

1. Process for the manufacture of a layered fiber reinforced cement sheet comprising the following steps:

a) formation of at least one fiber cement monolayer by continuous discharge of a cementitious slurry comprising reinforcing fibers onto the surface of at least one rotating cylindrical dewatering sieve through at least one device with a slot shaped outlet which replaces the vat feeding of a Hatschek line,

b) transfer of the at least one fiber cement monolayer formed in step a) to a dewatering conveyer felt,

c) transfer of the at least one dewatered monolayer obtained in step b) on a forming cylinder, until the layered fiber reinforced cement sheet comprising monolayers each of which is obtained by continuous discharge of a cementitious slurry on the surface of a rotating cylindrical dewatering sieve has reached the desired thickness on said forming cylinder

and wherein said process is implemented on an existing Hatschek line.

2. Process according to claim 1 wherein the forward speed of the outlet jet is in the range of 0.2 to 1.8 times the peripheral speed of the rotating cylindrical dewatering sieve.

3. Process according to claim 1 or claim 2 wherein said cementitious slurry has a concentration of not higher than 150 g of solids per litre of cementitious slurry.

4. Process according to any of the preceding claims wherein the weight of the monolayer in step a) is in the range from 250 to 750 expressed in g of solids per m^2.

5. Process according to any of the preceding claims characterized by an impingement angle of the cementitious slurry on the rotating dewatering sieve in the range of 0° to 75°.

6. Process according to any of the preceding claims wherein the device comprises one or more inlets.

7. Process according to any of the preceding claims wherein the width of the slot outlet is at least 2.5 times the total width of the inlets.

8. Process according to any of the preceding claims wherein the length of the device for the discharge of the cementitious slurry is preferably at least 2.5 times the total width of the inlets.

9. Process according to any of the preceding claims wherein the device comprises at least one part with continuously moving away sidewalls.

10. Process according to any of the preceding claims wherein the device is internally partially or totally partitioned by internal walls.

11. Process according to any of the preceding claims wherein the device for the discharge is equipped with an upper fixed or

pivotable and adjustable lip to keep the cementitious slurry in close contact with the rotating cylindrical dewatering sieve.

12. Process according to any of the preceding claims wherein the device is coupled to a tapered cross direction manifold or radial fiber cement slurry feeding system.

13. Fiber reinforced cement sheet manufactured according to the process of any of the preceding claims.

14. Fiber reinforced cement sheet according to claim 13 characterized by an orientation factor expressed as the ratio of the cross direction maximum bending strength to the machine direction maximum bending strength measured on air-dry samples which is in the range from 0.65 to 1.4.

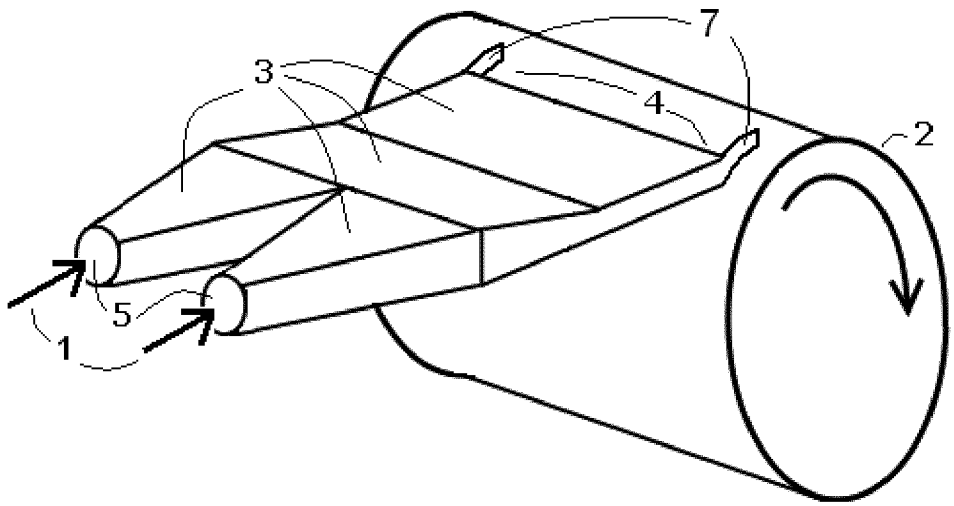


Figure 1

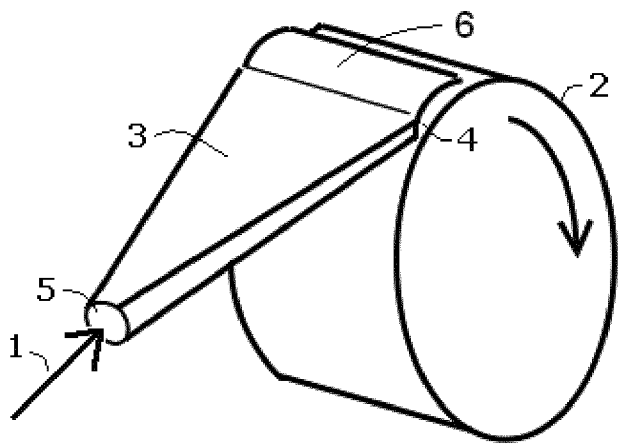


Figure 2

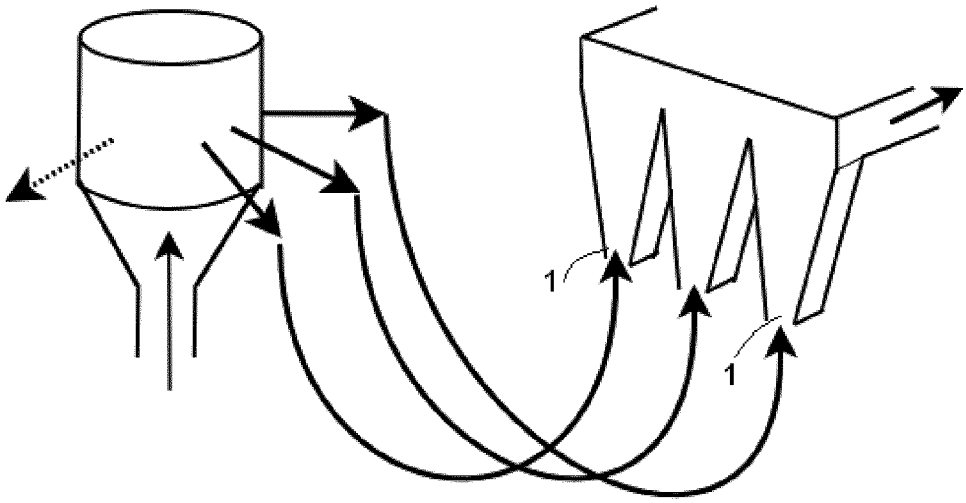


Figure 3

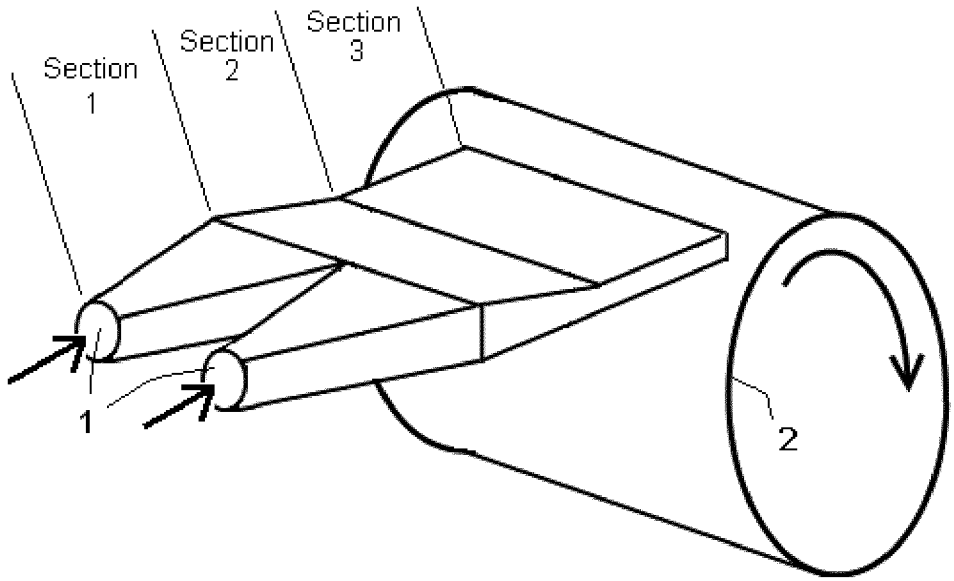


Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/071920

A. CLASSIFICATION OF SUBJECT MATTER
INV. B28B1/52 B28B13/02 B28B1/30
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B28B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	FR 2 250 314 A1 (EVERITUBE [FR]) 30 May 1975 (1975-05-30) pages 3-7; figures -----	1-6, 11-14 7-10
X	BR 8 205 639 A (EVERITUBE [FR]) 2 May 1984 (1984-05-02) abstract; figures -----	1,13
Y	JP 7 052138 A (KUBOTA KK) 28 February 1995 (1995-02-28) abstract; figures -----	7-10
A	DE 198 24 604 C1 (ETERNIT AG [DE] REINTJES FRANK [DE]; BEERMANN MARIO BERNHARD [DE]; HER) 16 December 1999 (1999-12-16) columns 4-6; figures ----- -/--	1,6-9

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 January 2012	01/02/2012

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/071920

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 2 051 226 U (KUNMING LIGHT BUILDING MATERIA [CN]) 17 January 1990 (1990-01-17) abstract; figures -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/071920

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2250314 A1	30-05-1975	NONE	
BR 8205639 A	02-05-1984	NONE	
JP 7052138 A	28-02-1995	JP 2874146 B2	24-03-1999
		JP 7052138 A	28-02-1995
DE 19824604 C1	16-12-1999	AU 4370599 A	20-12-1999
		DE 19824604 C1	16-12-1999
		EP 1084015 A1	21-03-2001
		WO 9962681 A1	09-12-1999
CN 2051226 U	17-01-1990	NONE	