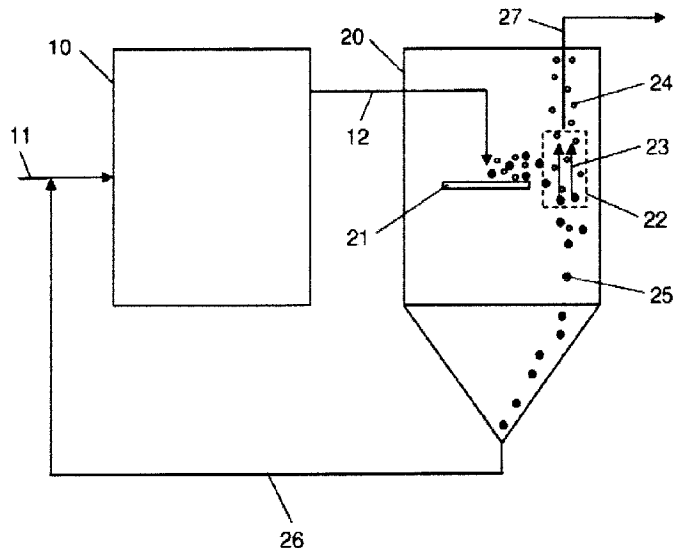




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(54) **Titre : AUGMENTATION DE L'EFFICACITE DE DISPOSITIFS DE SEPARATION DE PARTICULES SOLIDES PAR TAILLE**
(54) **Title: EFFICIENCY INCREASE IN DEVICES FOR SEPARATING SOLID PARTICLES ACCORDING TO SIZE**



(57) **Abrégé/Abstract:**

The present invention relates to the use of a flow aid for increasing the efficiency of a device for separating solid particles according to size.

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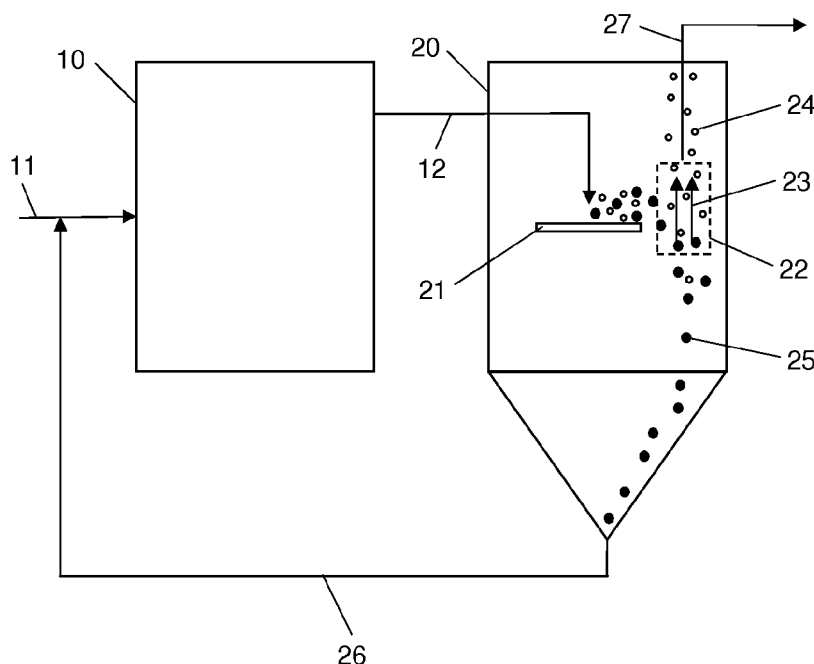
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(54) Title: EFFICIENCY INCREASE IN DEVICES FOR SEPARATING SOLID PARTICLES ACCORDING TO SIZE

(54) Bezeichnung : EFFIZIENZSTEIGERUNG BEI VORRICHTUNGEN ZUR GRÖSSENSEPARIERUNG VON FESTSTOFFPARTIKELN



(57) Abstract: The present invention relates to the use of a flow aid for increasing the efficiency of a device for separating solid particles according to size.

(57) Zusammenfassung: Die vorliegende Erfindung betrifft die Verwendung eines Fließmittels zur Steigerung der Effizienz einer Vorrichtung zur Grössenseparierung von Feststoffpartikeln.

Fig. 1

WO 2013/092763 A1



SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG). **Veröffentlicht:**

— *mit internationalem Recherchenbericht (Artikel 21 Absatz 3)*

Efficiency Increase in Devices for Separating Solid Particles According to Size

Technical field

The invention relates to the use of a substance for increasing the efficiency of a device for separating solid particles according to size.

Prior art

A central step and a considerable cost factor in the manufacture of mineral binders, particularly cement, is the grinding of coarse-grained mineral solids to a fine powder. Thus, in cement manufacturing, clinker, for example, and depending on the cement type to be manufactured, optionally additives, such as, slag sand or limestone, for example, are also ground to a fine powder. In principle, cements and additives can here be ground together or also separately. After grinding, the particle sizes of mineral binders are typically in the range of $< 50 \mu\text{m}$.

The fineness of the mineral binder is an important quality criterion here. For example, cured mortar or concrete mixtures with fine ground mineral binders in general have higher compressive strengths than corresponding mixtures based on coarser ground mineral binders.

In order to facilitate the crushing of solids in grinding devices, so-called grinding aids can be used. They bring about a strong reduction of the grinding duration and of the energy expenditure required for the grinding. Since the 1960s, organic liquids have proven themselves as grinding aids, particularly glycols and amino alcohols, as well as mixtures thereof. They are

added in quantities of up to approximately 0.2%, relative to the material to be ground, together with said material into the cement mill.

The use of dispersants as grinding aids, for example, is also known. In this regard, WO 2005/123624 A1 (Sika) describes the use of polycarboxylate ethers for improving the grinding efficiency.

In larger installations, for example, in cement plants, so-called devices for separating solid particles according to size are usually located downstream of the grinding devices. Such devices are also referred to as separators. The purpose of the separators is to classify or to separate the solids ground in the grinding device according to size. Those solid particles that are sufficiently fine are removed as product from the grinding process, while excessively coarse particles are fed back to the mill to crush them further. This can occur in continuous operation and it ensures in particular a narrow particle size distribution of the ground solids at a high productive capacity.

However, as before, it is in principle desirable to increase the production capacity of such installations at the lowest possible expense.

Representation of the invention

The problem of the invention therefore is to improve the manufacture of finely ground solids, particularly of mineral binders, or to design it more efficiently. Here, the production capacity in particular should be increased. This should take place as economically as possible, and, if possible, the properties of the ground solids should not be affected to a noteworthy extent. The improvement should in particular be possible using existing installations with as minor adaptations as possible. In particular in the case of binders, the improvement of the production

capacity should not entail any significant negative influences on the properties of the binders, such as, for example, the setting or solidification behavior or the workability.

Surprisingly, it has been found that the problem of the invention can be solved. Accordingly, the core of the invention is the use of a water reducing admixture for increasing the efficiency of a device for separating solid particles according to size.

It has been found surprisingly in tests that the use of a water reducing admixture can significantly improve the efficiency of the device for separating solid particles according to size. The water reducing admixtures here are even more effective than conventional grinding additives, such as alkanolamines or glycol compounds, for example. This is unexpected for the person skilled in the art, since, in principle, water reducing admixtures are designed for liquefying water-based liquid systems and not for dry or powdery solid particles as they result from grinding processes.

In particular, the use of a water reducing admixture allows an improvement of the selectivity of the device for separating solid particles according to size or separator. In particular, this means that the proportion of solid particles classified erroneously as excessively coarse can be reduced. Loose agglomeration of multiple solid particles that have already been ground sufficiently finely, for example, can lead to such erroneous classifications. Another source of error is an agglomerate formation due to the accretion of sufficiently finely ground solid particles to coarse particles. Such agglomerates break down in any case, for example, due to mechanical actions applied on them during transferring, transport and later processing of the ground solids, and, insofar as the final product is concerned, they do not represent a noteworthy problem. However, if they are discarded erroneously or fed back into the grinding device, where they are ground again unnecessarily, the production capacity is appreciably reduced.

Therefore, the use according to the invention of a water reducing admixture can increase in particular the production capacity of a grinding device with a downstream device for separating solid particles according to size. In particular, the proportion of solid particles unnecessarily fed back into the grinding device (also referred to as "return material" or "grit") can be reduced.

In addition, the solution according to the invention requires no adaptations or modifications of existing installations, since the water reducing admixture can be admixed in a simple manner with the material to be ground or the solid particles. As a result, a flexible and economic solution is made available, which can be implemented in a simple manner in existing installations.

Additional aspects of the invention are the subject matter of additional independent claims. Particularly preferred embodiments of the invention are the subject matter of the dependent claims.

Ways to carry out the invention

A first aspect of the present invention relates to the use of a water reducing admixture for increasing the efficiency of a device for separating solid particles according to size.

The expression "device for separating according to size" denotes in particular a device for separating solid particles on the basis of their particle size. Such devices are also referred to as separators. Accordingly, the purpose of such devices or separators is to classify or separate on the basis of their size solid particles that have been ground, for example, in a grinding device.

The term "water reducing admixture" in the present context denotes in particular a substance that is capable of improving the flowability of mortar compositions and/or concrete

compositions prepared with water and/or of reducing the water demand of such a composition. Such substances are also referred to as "plasticizer." For example, the water reducing admixture can comprise a lignin sulfonate, a gluconate, a naphthaline sulfonate, a melamine sulfonate, a vinyl copolymer, a polycarboxylate, in particular a polycarboxylate ether, or mixtures thereof.

In the present context, "solid particles" are in particular inorganic and/or mineral solid particles. They are in particular in dry and/or powdery form. In particular, the solid particles consist of inorganic substances used for construction, which can be used, for example, as components for compositions of cement, mortar and/or concrete. It is preferable for the solid particles to be mineral binders and/or additives for mineral binders. Typically, the solid particles have particle sizes in the range of 0.01-1000 μm , and in particular 0.1-100 μm .

Here, a "mineral binder" is a binder, in particular, an inorganic binder, which, in the presence of water, optionally with appropriate excitation, reacts in a hydration reaction to form solid hydrates or hydrate phases. It can be, for example, a hydraulic binder (for example, cement or hydraulic lime), a latent hydraulic binder (for example, slag or slag sand), a pozzolanic binder (for example, fly ash, trass or rice husk ash) and/or a binder with combined properties, such as, for example, fired clay or slate. The binders can be separate or in any combinations.

An "additive for a mineral binder" is, for example, an inert mineral substance, such as limestone, quartz powder and/or pigments, for example.

Preferably at least one portion of the solid particles contains of a mineral binder and/or an additive for a mineral binder or the at least one portion of the solid particles consists thereof. A content of the at least one portion of the solid particles relative to all the solid particles is in particular at least 50 wt%, in particular at least 75 wt%, especially at least 90 wt%.

In particular, the at least one portion of the solid particles contains at least 5 wt%, preferably at least 25 wt%, in particular ≥ 50 wt%, of a hydraulic binder, preferably cement and/or cement clinker.

In an additional advantageous embodiment, the at least one portion of the solid particles contains 5-100 wt%, in particular 5-65 wt%, of a latent hydraulic and/or pozzolanic binder, in particular slag and/or fly ash.

It is also possible that the at least one portion of the solid particles contains or consists of an additive for mineral binders, and/or an inert component.

In particular, at least one portion of the solid particles can represent a mixture of a hydraulic binder, in particular cement clinker, and a latent hydraulic and/or pozzolanic binder and/or an additive for a mineral binder. Mixtures of a cement clinker, slag and/or fly ash and/or limestone are preferable, for example. The content of the latent hydraulic and/or of the pozzolanic binder here is in particular 5-95 wt%, particularly preferably 5-65 wt%, particularly preferably 15-35 wt%, while there is at least 35 wt%, especially at least 65 wt%, of the hydraulic binder. Moreover, the mixture can in addition contain an inert substance, for example, limestone. After the grinding, such mixtures can be used, for example, as binder components in mortar mixtures and in concrete mixtures.

The device for separating solid particles according to size or separator is designed in particular so that the solid particles can be separated in the dry state.

In particular, the device is designed for separating solid particles according to size and/or it is operated in particular in such a manner that there is a separation limit of approximately 10-40 μm . This means that solid particles having a particle size above the separation limit are to be separated from solid particles having a particle size below the separation limit.

It is particularly preferable for the device for separating solid particles according to the size to be an air separator. In an air separator, the solid particles are separated in particular on the basis of the ratio of flow resistance, force of gravity and/or centrifugal force in a gas stream.

In practice, different types of air separators are used. A distinction is made in particular between static air separators and dynamic air separators. The dynamic air separators here are usually assigned based on their design to three different generations (1st, 2nd and 3rd generation).

In the case of dynamic 1st and 2nd generation air separators, the solid particles to be separated are generally directed from above onto a rotating distributor plate, as a result of which the particles are projected in a horizontal direction into a separation zone which is arranged around the distributor plate. In the separation zone, air flows in a vertical direction upward. Owing to the ratio of flow resistance, force of gravity and centrifugal force, particles having a size or a weight above the separation limit sink downward, while particles having a size or a weight below the separation limit are carried off by the air stream. As a result, the desired separation according to size is achieved. The difference between 1st generation and 2nd generation air separators lies in particular in that, in the case of 2nd generation air separators, no internally circulating air streams are used, instead air streams supplied from outside are used. As a result the efficiency can be improved.

In the case of dynamic 3rd generation air separators, the solid particles to be separated are usually directed from a rotating plate into an air stream flowing in a vertical direction around a rotating cage structure. The solid particles to be separated, depending on the ratio of flow resistance and centrifugal force, either reach the interior of the cage structure (particles having a size or a weight below the separation limit) or they move in a radial direction away from the cage

structure (particles having a size or a weight above the separation limit). Such air separators are particularly compact and they have a high selectivity and efficiency.

In practice, air separators have proven themselves in particular for separating solid particles as are present in ground mineral binders and/or in additives for such binders. In principle, the present invention works with all the air separators, regardless of the type and/or the construction.

The air separator is designed here in particular as a high efficiency separator with a noncirculating air stream. In comparison to air separators with circulating air stream, such high efficiency separators are particularly efficient in regard to the problems of returned material or grit. It is particularly preferable for the air separator to be a 3rd generation air separator.

However, in principle, the device for separating solid particles according to size can also be designed differently, for example, as a centrifugal separator, a gravity separator, a measurement cyclone, a jet deflection separator, an impactor or a plansifter.

The device for separating solid particles according to size is located downstream of, in particular, a grinding device, preferably a cement mill. The grinding device can be, for example, a ball mill, a bowl mill (also referred to as a vertical roller mill in English), a material bed roller mill (also referred to as a roller press mill in English), or a HORO mill (also referred to as a horizontal roller mill in English). In principle, the type of mill plays no role.

Here, it is advantageous to feed solid particles that exceed a predetermined size or the separation limit from the device for separating according to size back to the grinding device. This can occur particularly during operation and in a continuous manner. The interaction between the grinding device and the device for separating solid particles according to size thus allows a

particularly efficient production of ground solid particles having a defined particle size distribution.

In principle, the grinding device and the device for separating solid particles according to size can also be separate. The grinding process and the sifting of the solid particles can accordingly also be carried out independently of one another. Solid particles that have been classified as excessively large in the device for separating solid particles according to size in this case can be fed, for example, in a separate step to the grinding device for regrinding. However, this is generally less efficient.

The term "grinding" or "grinding process" here denotes in particular a method in which a mean grain or particle size of a solid or of a mixture of different solids is reduced. This occurs in a grinding device, particularly in a mill, especially in a cement mill.

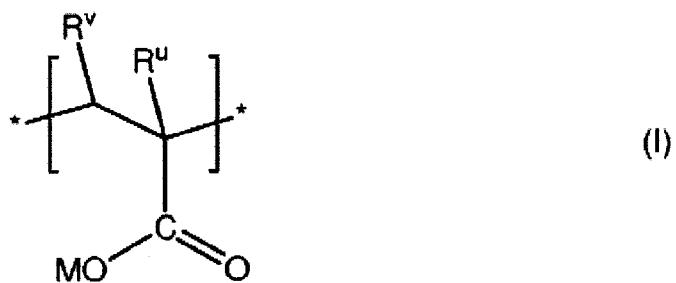
The grinding process can comprise, for example, the grinding of clinker, optionally together with inert and/or active additives, such as, for example, gypsum, anhydrite, α -semihydrate, β -semihydrate, latent hydraulic binders, pozzolanic binders and/or inert fillers.

Typically, the solid or the mixture of different solids, in particular a mineral binder, is ground during the grinding to a Blaine value of at least $500 \text{ cm}^2/\text{g}$, in particular at least $1000 \text{ cm}^2/\text{g}$, preferably at least $2000 \text{ cm}^2/\text{g}$, and even more preferably at least $2500 \text{ cm}^2/\text{g}$.

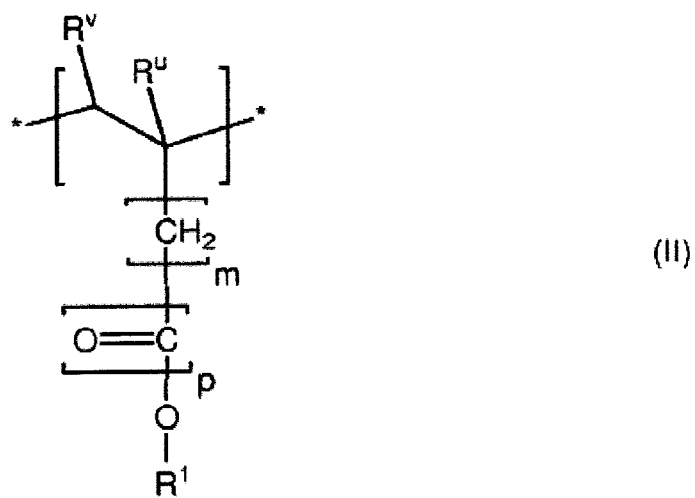
The water reducing admixture is preferably a polycarboxylate. Moreover, it is preferable for the polycarboxylate to be a comb polymer, which has a polycarboxylate backbone and polyether side chains, wherein the polyether side chains are bound via ester, ether and/or amide groups to the polycarboxylate backbone. Such water reducing admixtures have been found to be exceedingly advantageous in the present context. In addition, it is known that such water reducing admixtures are highly compatible with binders, and in part can even have advantages.

The water reducing admixture is in particular a polycarboxylate or comb polymer, which comprises or consists of the following partial structure units:

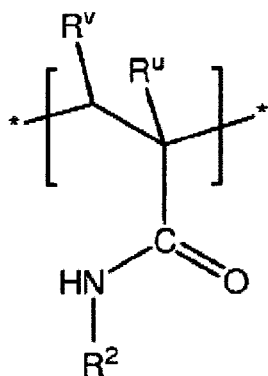
a) a mole fractions of a partial structural unit S1 of formula (I)



b) b mole fractions of a partial structural unit S2 of formula (II)

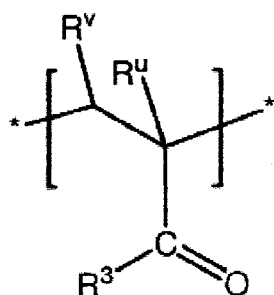


c) c mole fractions of a partial structural unit S3 of formula (III)



(III)

d) d mole fractions of a partial structural unit S4 of formula (IV)



(IV)

where

M independently of one another represents H^+ , an alkali metal ion, an alkaline earth metal ion, a bivalent or trivalent metal ion, an ammonium ion or an organic ammonium group,

each R^u independently of the others stands for hydrogen or a methyl group,

each R^v independently one another stands for hydrogen or $COOM$,

$m = 0, 1$ or 2 ,

$p = 0$ or 1 ,

R^1 and R^2 independently of one another stand for a C_1 to C_{20} alkyl group, cycloalkyl group, alkylaryl group or for $-[AO]_n-R^4$,

where $A = C_2$ to C_4 alkylene, R^4 stands for H, a C_1 to C_{20} alkyl group, cyclohexyl group or alkylaryl group,

and $n = 2-250$,

R^3 independently of one another stand for NH_2 , $-NR^5R^6$, $-OR^7NR^8R^9$, where R^5 and R^6 independently of one another stand for

a C_1 to C_{20} alkyl group, cycloalkyl group, alkylaryl group or aryl group,

or they stand for a hydroxyalkyl group or for an acetoxyethyl ($CH_3-CO-O-CH_2-CH_2-$) or a hydroxy-isopropyl ($HO-CH(CH_3)-CH_2-$) or an acetoxyisopropyl group ($CH_3-CO-O-CH(CH_3)-CH_2-$);

or R^5 and R^6 together form a ring of which the nitrogen is a part, in order to construct a morpholine or imidazoline ring;

R^7 is a C_2-C_4 alkylene group,

R^8 and R^9 each represent independently of one another a C_1 to C_{20} alkyl group, cycloalkyl group, alkylaryl group, aryl group or a hydroxyalkyl group,

and where a , b , c and d represent mole fractions of the respective partial structural units S1, S2, S3 and S4, with

$$a/b/c/d = (0.1 - 0.9) / (0.1 - 0.9) / (0 - 0.8) / (0 - 0.8),$$

$$\text{in particular } a/b/c/d = (0.3 - 0.9) / (0.1 - 0.7) / (0 - 0.6) / (0 - 0.4),$$

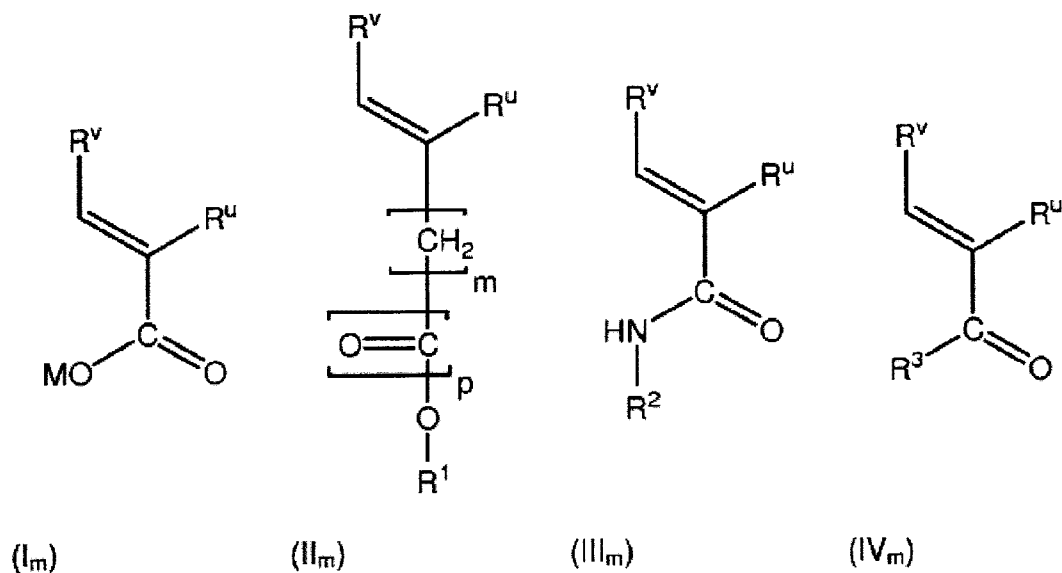
$$\text{preferably } a/b/c/d = (0.5 - 0.8) / (0.2 - 0.4) / (0.001 - 0.005) / 0$$

and under the condition that $a + b + c + d = 1$.

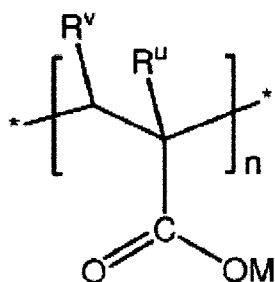
The sequence of the partial structural units S1, S2, S3 and S4 can alternately be, block-like or random. In principle, it is also possible for additional structural units to be present in addition to the partial structural units S1, S2, S3 and S4.

It is preferable for the partial structural units S1, S2, S3 and S4 together to constitute a content by weight of at least 50 wt%, in particular at least 90 wt%, and most particularly preferably at least 95 wt%, with respect to the total weight of the comb polymer.

The manufacture of comb polymers itself is known to the person skilled in the art and it can be carried out, for example, by radical polymerization of the corresponding monomers of formula (I_m), (II_m), (III_m) and (IV_m), respectively, which leads to a comb polymer KP with the partial structural units S1, S2, S3 and S4. The residues R^u, R^v, R¹, R², R³, M, m and p here are as defined.



It is also possible to prepare the copolymers by polymer-analogue reaction of a polycarboxylic acid of formula (V).



(V).

In the polymer-analogue reaction, the polycarboxylic acid of formula (V) is esterified or amidated with the corresponding alcohols or amines (for example, HO-R^1 , $\text{H}_2\text{N-R}^2$, H-R^3) and then, if necessary, neutralized or partially neutralized (depending on the type of the residue M, for example, with metal hydroxides or ammonia). Details regarding the polymer-analogue reaction are disclosed, for example, in EP 1 138 697 B1 on page 7, line 20 to page 8, line 50, as well as in its examples, or in EP 1 061 089 B1 on page 4, line 54 to page 5, line 38 as well as in its examples. In a deviation therefrom, as described in EP 1 348 729 A1 on page 3 to page 5 as well as in its examples, the comb polymer can be produced in the solid aggregate state. The disclosure of these mentioned patents is hereby included in particular by reference. The preparation by a polymer-analogue reaction is preferred.

Corresponding comb polymers are also commercially marketed by Sika Schweiz AG under the commercial name series ViscoCrete®.

R^v represents in particular hydrogen and R^u stands preferably for hydrogen and/or a methyl group.

$m = 0$ and $p = 1$ preferably.

$m = 1-2$ and $p = 0$ are also advantageous.

In particular R^v is equal to hydrogen, R^u stands for a methyl group, $m = 1-2$ and $p = 0$.

R^1 and/or R^2 stand, in each case independently of one another, advantageously for $-[AO]_n-R^4$ where $n = 8-200$, in particular 20-70, and A stands for C_2 to C_4 alkylene.

R^4 is, in each case independently of one another, preferably hydrogen or a methyl group.

It is particularly preferable to use polycarboxylates or comb polymers where

a) the residues R^u and R^v stand for hydrogen,

b) $m = 0$,

c) $p = 1$,

d) R^1 and R^2 , in each case independently of one another, stand for $-[AO]_n-R^4$ where $n = 20-70$ and $A = C_2$ alkylene,

e) R^4 represents a methyl group and/or

f) $a/b/c/d = (0.5 - 0.8) / (0.2 - 0.4) / (0.001 - 0.005) / 0$

It is also advantageous to use comb polymers or polycarboxylates where

a) $p = 0$ and $m = 1-2$,

b) R^1 , in each case independently of one another, stands for $-[AO]_n-R^4$ where $n = 8-200$, in particular 20-70,

c) R^4 stands for hydrogen or a methyl group, in particular hydrogen,

d) and/or A stands for C_2 to C_4 alkylene, in particular a C_2 alkylene.

A weight average molecular weight (M_w) of the comb polymer or polycarboxylate is in particular 5000-150,000 g/mol, preferably 10,000-100,000 g/mol, especially 20,000-90,000

g/mol. The weight average molecular weight (M_w) is determined by gel permeation chromatography (GPC), wherein polyethylene glycol (PEG) is used as standard.

The water reducing admixture can be used, in particular, as the sole additive and without additional components.

Furthermore, it can be advantageous if the water reducing admixture is used in the form of a composition with at least one additive, for example, a grinding additive, a concrete additive and/or a mortar additive.

The at least one additive comprises in particular an additional water reducing admixture, a grinding aid, a chromium reducing agent, a defoaming agent, a dye, a preservative, a water reducing admixture, a delaying agent, accelerator, an air entraining agent, a shrinkage reducing agent, a corrosion inhibitor or mixtures thereof.

Concretely, the following can be used, for example:

- a) one or more alkanolamines and/or salts thereof
- b) one or more alkali and/or alkaline earth nitrates
- c) one or more alkali and/or alkaline earth nitrites
- d) one or more alkali and/or alkaline earth thiocyanates
- e) one or more α -hydroxycarboxylic acids
- f) one or more alkali and/or alkaline earth halides
- g) glycerol and/or glycerol derivatives
- h) one or more glycols and/or glycol derivatives
- i) one or more aluminum salts
- j) one or more alkali and/or alkaline earth hydroxides
- k) one or more gluconates

l) one or more lignin compounds

m) molasses

n) one or more sucroses

o) one or more monocarboxylic acids, for example, acetic acid.

Here, mixtures of the substances mentioned under a)-o) can also be present.

According to an additional advantageous embodiment, the water reducing admixture is used in the form of a composition with at least one grinding aid. In particular, if the device for separating according to size or separator is located downstream of a grinding device, then a satisfactory grinding efficiency can be achieved as a result. In addition, it has been found that the grinding aid is suitably compatible with regard to improving the separator efficiency.

The at least one grinding aid is selected in particular from the group comprising glycols, organic amines and ammonium salts of organic amines with carboxylic acids.

According to an advantageous embodiment, the at least one grinding aid comprises an alkanolamine, which in particular is a triethanolamine and/or triisopropylamine.

According to another advantageous embodiment, the at least one grinding aid comprises a glycol, in particular diethylene glycol.

Such compositions are especially advantageous in view of the grinding efficiency and the binder properties.

A particularly preferred composition contains or consists of:

a) 5-99 wt%, preferably 5-50 wt%, more preferably 5-30 wt%, of the water reducing admixture;

b) 1-80 wt%, preferably 5-60 wt%, more preferably 5-30 wt%, of the at least one grinding aid;

c) 0-90 wt%, in particular 1-20 wt%, of at least one additional component;

d) 0-90 wt%, in particular 10-60 wt%, water.

The water reducing admixture here is in particular a polycarboxylate or comb polymer as defined above. A particularly preferred grinding aid is an amino alcohol and/or a glycol, in particular as described above.

As at least one additional component, a monocarboxylic acid, for example, acetic acid, is particularly advantageous.

The water reducing admixture is used preferably in a quantity of 0.001-1 wt%, in particular 0.003-0.2 wt%, more preferably 0.003-0.1 wt%, even more preferably, 0.005-0.07 wt%, with respect to the weight of the solid particles. As a result, an optimal effect is achieved. The indications here relate to the content of the pure water reducing admixture without possible additional components, which can be present, for example, in the case of the use of the water reducing admixture in the form of a composition.

The water reducing admixture or the composition is used advantageously in the liquid aggregate state. As a result, an improved distribution and wetting of the solid particles can be achieved. For example, the water reducing admixture or the composition can be in the form of a solution or dispersion. In particular, as an aqueous solution or dispersion.

However, in principle, it is also possible to use the water reducing admixture or the composition as a melt or in a solid aggregate state, for example, in the form of powders, pellets or scales.

The water reducing admixture or the composition is added, in particular before and/or during a grinding process for solid particles, to these particles. Optimal mixing is achieved as a result.

However, in principle, the addition can also occur after the grinding process, wherein, however, a sufficient distribution of the water reducing admixture or of the compound has to be ensured. This can occur by spraying, for example.

Additional advantageous embodiment examples of the invention are evident to the person skilled in the art based on the following embodiment examples.

Brief description of the drawings

The drawing used to explain the embodiment examples shows:

Figure 1 A diagrammatic representation of an arrangement of a continuous ball mill with downstream air separator.

Embodiment examples

1. Grinding device with air separator

Fig. 1 shows a diagrammatic representation of an arrangement that is used consisting of continuous ball mill 10 and air separator 20. Solids 11 to be ground, for example, a cement clinker, are here fed to the continuous ball mill 10 and ground therein in a manner which in itself is known. The ground solid particles 12, for example, ground cement clinker, are subsequently fed to the downstream air separator 20. In the air separator 20, the ground solid particles 12 are directed onto a rotating distributor plate 21, as a result of which the particles are projected in a horizontal direction into a separation zone 22 arranged next to the distributor plate 21. In the separation zone 22, air 23 flows in vertical direction upward. Coarse particles 25 having a size or a weight above the separation limit here sink downward, while fine particles 24 having a size or a weight below the separation limit are carried off by the air stream 23 and discharged as product

27 from the air separator 20. The coarse particles 25, which have been classified as excessively coarse in the air separator 20, are continuously fed back to the ball mill 10 via the conveyor device 26 and ground again. As a result, a continuous operation becomes possible.

2. Materials used

2.1 Water reducing admixture

For the following tests, a water reducing admixture in the form of a comb polymer KP1 was prepared in a manner which in itself is known by a polymer-analogue reaction of polyacrylic acid ($M_w = 4500 \text{ g/mol}$) with alcohols of the HO-R^1 type and amines of the $\text{H}_2\text{N-R}^2$ type (conversion rate greater than 97%). The raw materials used for this purpose are commercially available from various suppliers. The structure of the comb polymer KP1 produced in this manner here corresponds to the above described comb polymer with the partial structural units S1, S2 and S3, where:

- R^u and R^v stand for hydrogen;
- $m = 0$ and $p = 1$;
- R^1 stands for a mixture of a methoxy-terminated polyethylene glycol having a weight $M_n = 1000 \text{ g/mol}$ (PEG1000- OCH_3) and a methoxy-terminated polyethylene glycol having a weight $M_n = 3000 \text{ g/mol}$ (PEG3000- OCH_3). The molar ratio of PEG1000- OCH_3 to PEG3000- OCH_3 here is 0.205/0.153.
- R^2 is a methoxy-terminated ethylene oxide/propylene oxide copolymer having a weight $M_n = 2000 \text{ g/mol}$, wherein the ethylene and propylene oxide units are in a molar ratio of 50:50;
- $a/b/c/d = 0.640/0.205/0.153/0.002/0$, and
- the molecular weight of the comb polymer (M_w) is approximately 60,000 g/mol.

A solution containing 40 wt% of the comb polymer in water was obtained.

Such comb polymers are also available commercially from Sika Schweiz under the name Viscocrete.

2.1 Composition Z1

A first composition Z1 was prepared by mixing 10 wt% (solid matter content) of the comb polymer KP1, 30 wt% diethylene glycol, and 5 wt% acetic acid (60 wt% in water) in 55 wt% water.

2.2 Composition Z2

A second composition Z2 was prepared by mixing 10 wt% of the comb polymer KP1, 20 wt% triisopropanolamine (85 wt% in water), 10 wt% triethanolamine (80 wt% in water), 5 wt% acetic acid (60 wt% in water) in 55 wt% water.

2.3 Composition Z3

A third composition Z3 was prepared substantially like composition Z1, wherein, however, no comb polymer was admixed and instead the quantity of diethylene glycol was increased accordingly.

2.4 Composition Z4

A fourth composition Z4 was prepared substantially like composition Z2, wherein, however, no comb polymer was admixed and instead the quantity of triethanolamine and triisopropylamine was increased proportionally.

3. Grinding tests without separator (batch process)

For comparison purposes, the compositions Z1 and Z3 were used as additives in grinding tests (M1 and M2). Here, in each case, equal quantities of a cement clinker were ground under identical conditions in laboratory ball mills. The grinding tests were here carried out as a batch process. Test R1 is a reference test without additive. The compositions Z1 and Z3 were added to the cement clinker before the grinding process at a dosage of in each case 0.025 wt% relative to the cement clinker. The grinding duration and grinding parameters were kept constant in all the grinding tests.

After the grinding process was completed, the fineness according to Blaine was determined. Table 1 gives an overview of the grinding tests performed and the corresponding results.

Test	R1	M1	M2
Additive	-	Z1	Z3
Fineness [cm ² /g]	2200	2760	2880

Table 1

From Table 1 it is apparent in particular that both the composition Z1 with water reducing admixture and also the composition Z3 without water reducing admixture significantly improve the grinding fineness compared to grinding without additive (R1). However, with the composition Z3 (without water reducing admixture) an approximately 6% higher grinding fineness was achievable than with composition Z1 (with water reducing admixture). Purely with

regard to the grinding efficiency, the use of a water reducing admixture thus brings no advantages.

4. Grinding tests without separator (continuous process)

Also for comparison purposes, the compositions Z2 and Z4 were used in grinding tests in a continuous ball mill without connected separator (open circuit). The cement clinker was fed to the continuous ball mill together with the respective additive or the respective composition Z2 or Z4, wherein the dosage of the compositions Z2 and Z4 in each case was 0.07 wt% relative to the cement clinker.

The cement clinker was in each case ground to a constant Blaine fineness of approximately 4000 cm²/g.

Subsequently, the production capacity per unit of time as well as the content of particles having a size larger than 45 µm was measured. The determination of the particles larger than 45 µm occurred in a manner which in itself is known by measuring the sieve residue with an air jet sieve.

Table 2 gives an overview of the tests (M3 and M4) performed and the corresponding results.

Test	M3	M4
Additive	Z2	Z4
Production capacity [tons/hour]	55	55
Content particles > 45 µm	14.0%	13.8%

Table 2

From Table 2 it is apparent in particular that, in regard to the production capacity of a grinding device without downstream separator, the use of a water reducing admixture compared to amino alcohols does not bring any advantages. In addition, in this case, the proportion of the coarse particles $> 45 \mu\text{m}$ cannot be further reduced by the water reducing admixture.

5. Grinding tests with separator

In the grinding tests with separator, cement clinker was ground with a continuous ball mill and a downstream air separator in the closed circuit as diagrammatically represented in Fig. 1. The cement clinker was fed to the continuous ball mill together with the optionally used additive or the respective composition Z1 or Z3, wherein the dosage of the compositions Z1 or Z3 in each case was 0.025 wt% relative to the cement clinker.

The cement clinker was ground in each case to a constant Blaine fineness of approximately $3500 \text{ cm}^2/\text{g}$.

Subsequently, the production capacity per unit of time was measured.

Table 3 gives an overview of the tests performed (S1 and S2) and the corresponding results. R2 is a reference test without additive.

Test	R2	S1	S2
Additive	-	Z1	Z3
Production capacity [tons/hour]	100	116	108
Increase relative to R2	0	16%	8%

Table 3

Similar tests with a continuous ball mill and a downstream air separator in the closed circuit were also carried out on another installation with the compositions Z2 and Z4 at different concentrations. Table 4 gives an overview of the tests performed (S3-S5) and the associated results.

Test	S3	S4	S5
Additive	Z4	Z2	Z2
Concentration additive [wt%]	0.03	0.03	0.045
Production capacity [tons/hour]	70	75	78
Increase relative to S3	0%	7%	11%

Table 4

It is also apparent from Table 4 that by using a water reducing admixture (tests S4 and S5), a clear increase in the production capacity is possible.

In summary, it can be said that the use of a water reducing admixture in comparison to conventional grinding aids has no significant influence on the grinding efficiency or on the grinding process itself (see results in Tables 1 and 2). However, due to the use of a water reducing admixture, the production capacity can be greatly increased in comparison to conventional grinding aids in the case of the use of a downstream separator (see Tables 3 and 4). From this it can be concluded immediately that the use of a water reducing admixture results in

an increase of the efficiency of a device for separating solid particles according to size or separator.

However, it should be understood that the above-described embodiments are merely illustrative examples that can be modified as desired in the context of the invention.

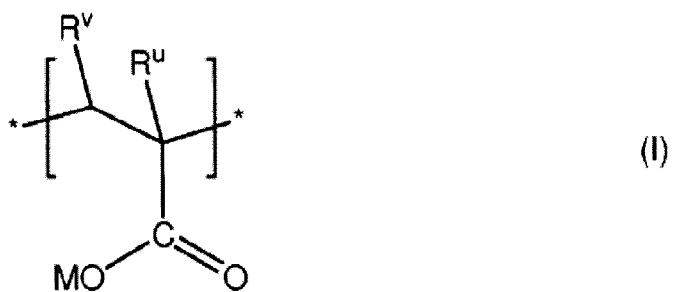
In particular, the air separator shown in Fig. 1 can also be designed differently, for example, as a dynamic 3rd generation air separator as described above.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

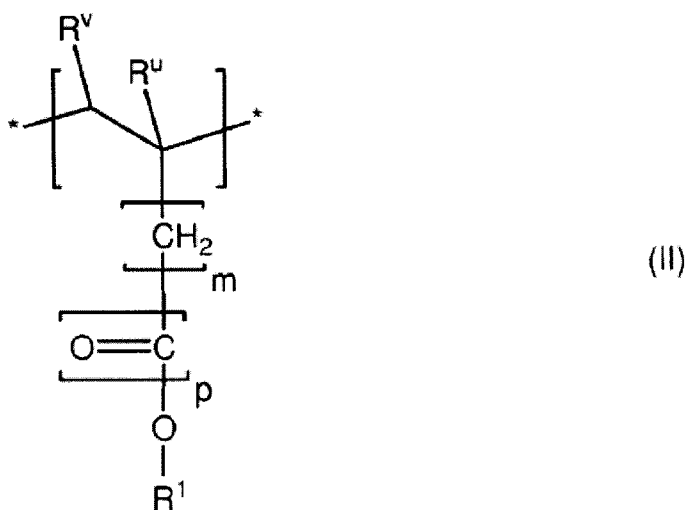
1. Use of a water reducing admixture for increasing the efficiency of a device for separating solid particles according to size, wherein
the solid particles are particles of inorganic and/or mineral solids,
the device for separating solid particles according to size being located downstream of a grinding device is an air separator,
the water reducing admixture is a polycarboxylate which is a comb polymer, which has a polycarboxylate backbone and polyether side chains, wherein the polyether side chains are bound via ester, ether and/or amide groups to the polycarboxylate backbone, and
whereby the solid particles contain at least 5wt% cement and/or cement clinker.
2. A use according to claim 1, wherein the grinding device is a cement mill.
3. A use according to claim 1 or 2, wherein solid particles that exceed a predetermined size are fed back to the grinding device during operation from the device for separating according to size.
4. A use according to any one of claims 1 to 3, wherein at least a portion of the solid particles contains or consists thereof a mineral binder and/or an additive for a mineral binder.

5. A use according to any one of claims 1 to 4, wherein the comb polymer comprises of the following partial structural units:

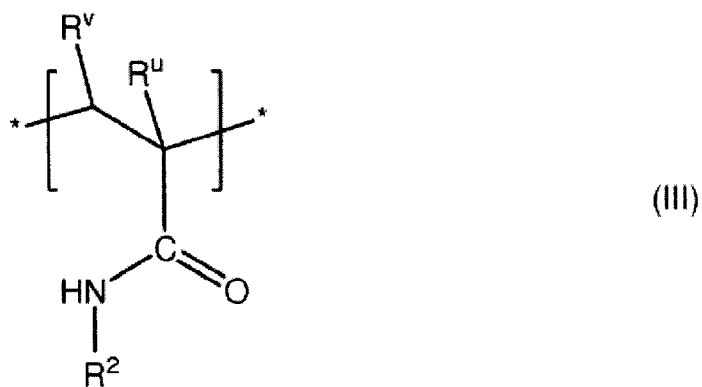
a) a mole fractions of a partial structural unit S1 of formula (I)



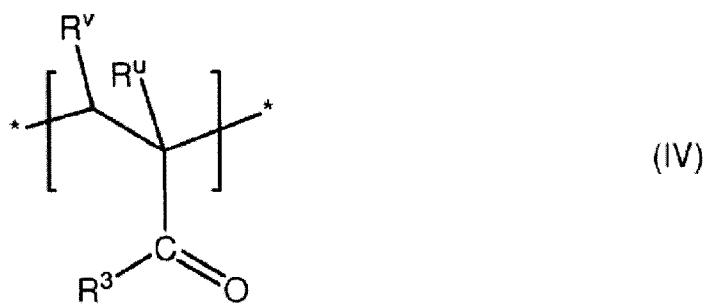
b) b mole fractions of a partial structural unit S2 of formula (II)



c) c mole fractions of a partial structural unit S3 of formula (III)



d) d mole fractions of a partial structural unit S4 of formula (IV)



wherein

M independently represents H^+ , an alkali metal ion, an alkaline earth metal ion, a bivalent or trivalent metal ion, an ammonium ion or an organic ammonium group,

each R^u independently represents hydrogen or a methyl group,

each R^v independently represents hydrogen or COOM,

m = 0, 1 or 2,

p = 0 or 1,

R¹ and R² independently represents a C₁ to C₂₀ alkyl group, cycloalkyl group, alkylaryl group or for -[AO]_n-R⁴,

where A = C₂ to C₄ alkylene, R⁴ represents H, a C₁ to C₂₀ alkyl group, cyclohexyl group or alkylaryl group,

and n = 2-250,

R³ independently represents NH₂, -NR⁵R⁶, -OR⁷NR⁸R⁹, wherein R⁵ and R⁶ independently represents a C₁ to C₂₀ alkyl group, cycloalkyl group, alkylaryl group or aryl group; or

a hydroxyalkyl group or for an acetoxyethyl (CH₃-CO-O-CH₂-CH₂-) or a hydroxy-isopropyl (HO-CH(CH₃)-CH₂-) or an acetoxyisopropyl group (CH₃-CO-O-CH(CH₃)-CH₂-);

or R⁵ and R⁶ together form a ring of which the nitrogen is a part, in order to construct a morpholine or imidazoline ring;

R⁷ is a C₂-C₄ alkylene group,

R⁸ and R⁹ each independently represent a C₁ to C₂₀ alkyl group, cycloalkyl group, alkylaryl group, aryl group or a hydroxyalkyl group,

and wherein a, b, c and d represent mole fractions of the respective partial structural units S1, S2, S3 and S4, with

$$a/b/c/d = (0.1 - 0.9) / (0.1 - 0.9) / (0 - 0.8) / (0 - 0.8),$$

and under the condition that $a + b + c + d = 1$.

6. A use according to claim 5, wherein $a/b/c/d = (0.3 - 0.9) / (0.1 - 0.7) / (0 - 0.6) / (0 - 0.4)$.

7. A use according to claim 5, wherein $a/b/c/d = (0.5 - 0.8) / (0.2 - 0.4) / (0.001 - 0.005) / 0$.

8. A use according to any one of claims 5 to 7, wherein in the polycarboxylate

a) the residues R^u and R^v stand for hydrogen,

b) $m = 0$,

c) $p = 1$,

d) R^1 and R^2 , in each case independently represent $-[AO]_n-R^4$ where $n = 20-70$ and $A = C_2$ alkylene,

e) R^4 represents a methyl group and/or

f) $a/b/c/d = (0.5 - 0.8) / (0.2 - 0.4) / (0.001 - 0.005) / 0$.

9. A use according to any one of claims 1 to 8, wherein the water reducing admixture is used in the form of a composition with at least one grinding aid.

10. A use according to claim 9, wherein the grinding aid is a glycol, organic amine or an ammonium salt of an organic amine with a carboxylic acid.

11. A use according to claim 9 or 10, wherein the at least one grinding aid comprises an alkanolamine.

12. A use according to claim 9 or 10, wherein the at least one grinding aid comprises triethanolamine and/or triisopropylamine.

13. A use according to any one of claims 9 to 12, wherein the at least one grinding aid comprises a glycol.

14. A use according to any one of claims 9 to 12, wherein the at least one grinding aid comprises diethylene glycol.

15. A use according to any one of claims 9 to 14, wherein the composition comprises:

- a) 5-99 wt% of the water reducing admixture;
- b) 1-80 wt% of the at least one grinding aid;
- c) 0-90 wt% of at least one additional component;
- d) 0-90 wt% water.

16. A use according to any one of claims 9 to 14, wherein the composition comprises:

- a) 5-50 wt% of the water reducing admixture;
- b) 5-60 wt% of the at least one grinding aid;

- c) 1-20 wt% of at least one additional component;
- d) 10-60 wt% water.

17. A use according to any one of claims 9 to 14, wherein the composition comprises:

- a) 5-30 wt% of the water reducing admixture;
- b) 5-30 wt% of the at least one grinding aid;
- c) 1-20 wt% of at least one additional component;
- d) 10-60 wt% water.

18. A use according to any one of claims 1 to 17, wherein the water reducing admixture is used in a quantity of 0.001-1 wt% relative to the weight of the solid particles.

19. A use according to any one of claims 1 to 17, wherein the water reducing admixture is used in a quantity of 0.003-0.2 wt% relative to the weight of the solid particles.

20. A use according to any one of claims 1 to 17, wherein the water reducing admixture is used in a quantity of 0.003-0.1 wt% relative to the weight of the solid particles.

21. A use according to any one of claims 1 to 17, wherein the water reducing admixture is used in a quantity of 0.005-0.07 wt% relative to the weight of the solid particles.

22. A use according to any one of claims 1 to 21, wherein the water reducing admixture or the composition is used in the liquid aggregate state.

23. A use according to any one of claims 1 to 22, wherein the water reducing admixture or the composition is added, before and/or during a grinding process for solid particles, to these particles.

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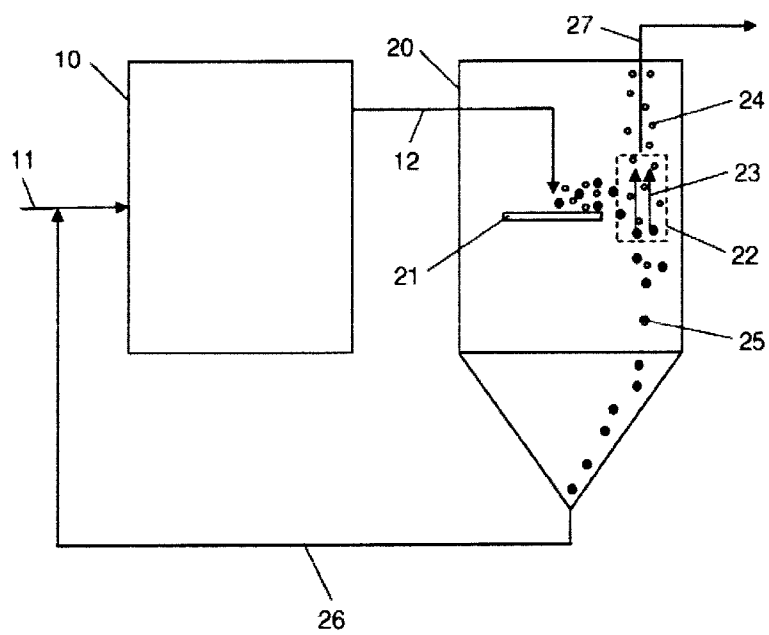


Fig. 1

