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(54) **Method and apparatus for moisturizing dusting material**

(57) Arrangement for mixing a liquid with a flowing solid substance, comprising a reaction chamber (1), a connection (2) for feeding the flowing solid substance to the reaction chamber (1), a connection (3) for removing the mixed substance from the reaction chamber (1), and a connection (13) for feeding the liquid to the reaction chamber (1). For mixing the liquid there are elements (10) for feeding the liquid to the reaction chamber (1) in

the form of droplets and elements (11,12,15) for feeding a compressed gas to the reaction chamber (1). On the central axis of the reaction chamber (1) is preferably arranged a mixer shaft (6), which comprises elements (9-12) for feeding the liquid and the gas to the reaction chamber from the outer surface of the shaft (6).

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## Description

**[0001]** The present invention relates to a method, according to the preamble of Claim 1, for moisturizing a dusting, flowing solid material. The scope of the application includes, for example, the moisturizing and cooling of power-plant ash, the moisturizing of the constituent components of concrete, the moisturizing of dry substances in the paper industry, and even the pre-moisturizing of dry substances in bakeries. In general, the method is intended for the moisturizing of dry substances in process industries.

**[0002]** The invention also relates to an arrangement for implementing the method.

**[0003]** In process industries, it is necessary to moisturize various dusting substances for many reasons. For example, when handling hot ash, moisturizing is intended to reduce the temperature, in order to avoid the risk of combustion, as well as to facilitate handling and to prevent dusting. On the other hand, moisturizing can be intended to form mixtures from dusting substances and substances requiring to be moisturized. Such processes exist, for example, in the bakery industry and the paper industry, in which mixtures for use elsewhere in the process are formed from fine-particle solids together with water or some other liquid.

**[0004]** Dusting substances are fine-particle, flowing substances already due to their nature. They are quite difficult to moisturize effectively. When dusting substances come into contact with a liquid, the substance certainly moisturizes easily, after which it easily forms a sticky mass, through which water penetrates poorly. Thus a fine-particle, dry substance easily collects into lumps, the centre of which is dry while the surface layer prevents the material in the centre from moisturizing. The sludge forming the surface layer is often quite adhesive, so that the material to be moisturized sticks easily and firmly to any surface that it touches. A great deal of energy is required to disperse the sludge and lumps and detach the mass that has adhered to the walls of the equipment. On the other hand, there is a great danger of blockage while the reliable operation of the moisturizing devices demands much cleaning and maintenance work.

**[0005]** One apparatus that is used for ash moisturizing in power-plant processes is a moisturizing screw, in which a screw thread is used to move a mixture of ash and water. A problem with this apparatus is that it becomes blocked easily and is quite laborious to clean after blockage. Thus this apparatus cannot be regarded as operating with satisfactory reliability in industrial processes. Attempts have been made to reduce blockage by coating the internal parts of the apparatus with rubber, but this leads to high costs, both in manufacture and when renewing the coating.

**[0006]** The present invention is intended to create a moisturizing apparatus, in which a better contact is created between the water used for moisturizing and the substance to be moisturized and which gives a better

moisturizing result.

**[0007]** The invention is based on feeding the substance to be moisturized into a reaction chamber, into which a compressed gas is blown and liquid in the form of drops is fed as a spray. The compressed air and water are fed, through a shaft arranged on the central axis of the reaction chamber, radially towards the edges of the chamber, while the shaft is simultaneously rotated. The direction of flow is from top to bottom while the substance to be moisturized is fed under pressure over the shaft.

**[0008]** In particular, compressed air and water are fed into the substance to be moisturized.

**[0009]** According to one preferred embodiment of the invention, the feed connection for the substance to be moisturized has a smaller feed cross-sectional surface than the exit connection for the moisturized substance.

**[0010]** According to one preferred embodiment of the invention, the liquid is fed to the apparatus in the longitudinal direction of the shaft, along a channel formed in its centre and into the reaction chamber through transverse, preferably radial drill holes. The air is correspondingly fed through channels running parallel to the shaft and preferably from radial, transverse drill holes.

**[0011]** More specifically, the method according to the invention is characterized by what is stated in the characterizing portion of Claim 1.

**[0012]** The arrangement according to the invention is, for its part, characterized by what is stated in the characterizing portion of Claims 7.

**[0013]** Considerable advantages are gained with the aid of the invention.

**[0014]** The most important advantage of the invention is that reliable moisturizing is ensured and blockage is avoided. The need for maintenance is reduced and, the reliable operation means that breaks in the operation of the moisturizer will not interfere with the processes depending on it. The method is suitable for many different processes, in which there is a need to moisturizing a particulate material. The apparatus is especially intended for the processing of fine-particle dusting substances, but it can also be used to similarly process materials, or mixtures of materials consisting of shavings, chips, or other reasonably light and small pieces. The essential feature is that the solid parts of the material are made to move by the effect of air blown into the reaction chamber. The intention is thus to process a flowing, solid substance. In the apparatus, the substance to be moisturized travels by gravity from the top to the bottom, so that by the movement of the substance consumes no energy. At the same time, the mixing result is good, because the material to be mixed is fed onto the top of the mixer element.

**[0015]** The construction of the apparatus is simple and the apparatus is easy to open and service. There are few moving parts and they are simple and can be economically changed when necessary.

**[0016]** In the following, the invention is examined in greater detail with the aid of the accompanying drawings.

**[0017]** Figure 1 shows a side cross-section of one embodiment of the invention.

**[0018]** Figure 2 shows an end view of the apparatus of Figure 1.

**[0019]** The body of the apparatus forms a tubular reaction chamber 1, with a feed connection 2 formed above it and an exit connector 3 below it. The feed connection 2 is narrower than the diameter of the reaction chamber 1, in order to permit efficient mixing. The feed connection 2 being narrower than the diameter of the reaction chamber ensures that the substance to be mixed will reach the mixer shaft 6. The exit connection 3 is, in turn, preferably at least the size of the diameter of the reaction chamber 1, in order to ensure the smooth exit of the moisturized substance. However, the minimum requirement is for the feed connection to be above the mixer element and the exit connection 3 to be on the opposite side of the mixer element 6 to the feed connection, so that the openings of the exit connection 3 and the feed connection 2 will be at least partly on top of each other.

**[0020]** The body of the apparatus is divided along a dividing line 5 at the central axis 4 of the reaction chamber 1. The apparatus can be opened at the dividing line 5 for cleaning and maintenance.

**[0021]** The actual mixing component consists of a mixer shaft 6 arranged on the central axis of the reaction chamber 1. The mixer shaft 6 runs through the end wall 7 of the reaction chamber and the feed-throughs of the shaft 6 are sealed with a seal 8 and the shaft is arranged to be rotated in the reaction chamber 1. In the centre of the mixer shaft 6 is a liquid-feed channel 9, from which run radial drill holes 10, which end at the outer surface of the mixer shaft and are set opposite to each other. The drill holes are arranged at an angle of 180° opposite to each other. At the first end of the liquid-feed channel 9 and the mixer element 6 is a liquid feed connection 13. The opposite end of the liquid-feed channel 6 is closed. For feeding compressed gas, there are two gas-feed channels 11 in the mixer shaft, from which transverse gas-feed drill holes 12 run to the outer surface of the mixer shaft. Compressed gas is fed to the shaft over the gas-feed connections 15. Further, rod-like dispersion pieces 14 are fitted to the outer surface of the mixer element. These dispersion pieces 14 run in a spiral around the mixer shaft 6 and at least some of them extend to close to the internal wall of the reaction chamber.

**[0022]** The method and apparatus according to the invention operate in the following manner.

**[0023]** The material to be moisturized, for example still hot dusting ash from a power plant, is fed from above through the feed connection 2 to the reaction chamber 1. The direction of flow is thus according to gravity from top to bottom and the substance should flow from the feed connection over the mixer element to the exit connection. In the chamber, the ash is moisturized, in order to finally extinguish and cool it and to prevent it releasing dust in the next processing stage. The mixer shaft is rotated at a speed of about 500 - 600 l/min while com-

pressed air obtained from a normal compressed-air network at a pressure of 3 - 8 bar is fed through the gas holes 12. Water at the factory's raw-water pressure of 2 - 4 bar is fed in turn from the liquid drill holes 10. The water-feed drill holes 10 are dimensioned in such a way that the water being fed forms droplets when it leaves the drill holes 10. The water in the form of drops is distributed evenly over the substance being moisturized, so that the result of the moisturizing is more even and lumping cannot easily occur. Another factor that substantially affects the evenness of the moisturizing is the effect of the large volume of compressed air fed through the compressed-air feed drill holes. The volume of compressed air bulks material being moisturized and being fed through the rotating shaft creates a flow with powerful vortices, which prevents the dusting substance from adhering together and forming lumps due to the effect of water. Thus the compressed air homogenizes the flow of substance and bulks the substance being fed, in order to facilitate its mixing with water. The amount of compressed air must be reasonable, in order to ensure bulk-

**[0024]** The dispersion pieces 14 rotate at high speed in the reaction chamber and further mix the flows in the chamber and break up lumps. Their most important function is, however, to keep the walls of the reaction chamber clean by preventing the moisturized substance from sticking to the walls of the reaction chamber.

**[0025]** An adjustable amount of water is fed to the reaction chamber. The amount can be adjusted using a simple setting valve. The water pressure must be sufficient to be able to adjust it to form droplets in the water-feed drill holes. For example, the adjustment of the amount in the moisturizing of ash is adjusted in such a way as to stop the release of dust, but liquid water must not come from the moisturizer nor may the ash form sludge. If dust comes from the apparatus, the amount of water is naturally increased while if the ash forms sludge the amount of water is decreased. If it is necessary to adjust the ratio of the liquid to the dusting substance more precisely, measurement and automatic adjustment can be used.

**[0026]** The apparatus according to the invention can be manufactured from conventional construction materials, such as carbon steel, stainless or acid-resistant steel, composite materials, or polyethylene. If necessary, its components can be surfaced with rubber, in order to increase wear resistance. The materials selected will of course depend on the materials and operating conditions for which the apparatus is intended.

**[0027]** In addition to the above, the present invention has other embodiments as well.

**[0028]** In place of the mixer shaft, the compressed air and water can be fed from the internal walls of the chamber from nozzles directed upwards against the feed direction of the dusting material. However, in that case it will probably become quite difficult to adjust the apparatus for the operating conditions and it may be difficult to

obtain a mixing result with the same certainty as with the apparatus described above. Even though the apparatus is primarily a moisturizer, it can be used as a mixer, particularly for one or more dusting substances and some liquid. Instead of air, an inert gas, for instance, can be used as the mixing gas, if the substances being processed demand this. The water-feed channels and air channels in the shaft can be arranged in other ways too and particularly there can be several air channels placed around the water-feed channels. However, there is at least one of each, as there are liquid and air feed drill holes too. The drill holes 10, 12 can be arranged directly radially, or at an angle, or some at an angle and some directly radially, in which case flows travelling across each other will be obtained. The dispersion pieces 14 are preferably pin-like, for instance round, but even wing-like pieces can be envisaged in applications, in which there is less danger of adhesion from the substance being moisturized.

**[0029]** The cross-sections of the reaction chamber 1 and the feed and exit connections are preferably rotationally symmetrical. Mixing will then function well in the reaction chamber while the connections will be easy to manufacture and attach to the reaction chamber. If these are of some other shape, the feed cross-section of the feed connection should be smaller than that of the reaction chamber and the exist connection.

## Claims

1. Method for mixing a liquid with a flowing solid substance, in which method:

- the flowing solid substance is fed to a reaction chamber (1),
- in the reaction chamber (1), compressed gas is fed into the flowing substance and liquid in the form of droplets is fed as sprays, and
- the flowing substance is mixed using mixer elements (6, 14),

**characterized in that** the substance to be mixed is fed to the mixer elements (6, 14) from a feed connection (2) above them and the flowing substance is removed from beneath the mixer elements (6, 14) from an exit connection (3), which is at least partly in alignment with the feed connection (2) in the vertical direction.

2. Method according to Claim 1, **characterized in that** the compressed gas is air and the liquid is water.

3. Method according to Claim 1 of 2, **characterized in that** the liquid and gas are fed through a mixer shaft (6) fitted to the central axis (4) of the reaction chamber (1), from the outer surface of the mixer shaft (6) towards the edges of the chamber (1), while the shaft

(6) is simultaneously rotated.

4. Method according to any of the above Claims, **characterized in that** the liquid is fed to the apparatus along the mixer shaft (6) in the longitudinal direction of the shaft (6) through a channel (9) formed in its centre and at least partly through transverse, preferably radial drill holes (10) and the gas is fed correspondingly through channels (11) in the longitudinal direction of the mixer shaft (6) and from preferably radial, at least partly transverse drill holes (12).

5. Method according to any of Claims 1 - 4, **characterized in that** the flowing substance is fed to the reaction chamber from a connection (2), the diameter of which is smaller than the diameter of the reaction chamber (1).

6. Method according to any of Claims 1 - 5, **characterized in that** the flowing substance is removed from the reaction chamber (1) from a connection (3), the diameter of which is larger than the diameter of the reaction chamber (1).

7. Arrangement for mixing a liquid with a flowing solid substance, which comprises

- a reaction chamber (1),
- a connection (2) for feeding the flowing solid substance to the reaction chamber (1),
- a connection (3) for removing the mixed substance from the reaction chamber (1),
- a connection (13) for feed the liquid to the reaction chamber (1),
- elements (6, 14) fitted to the mixing chamber (1) for mixing the flowing substance,
- elements (10) for feeding the liquid to the reaction chamber (1) in the form of droplets, and
- elements (11, 12, 15) for feeding a compressed gas to the reaction chamber (1),

**characterized in that** the connections (2, 3) for feeding the flowing substance to the reaction chamber (1) and for removing the mixed substance are arranged on opposite sides of the elements (6,14) for mixing the flowing substance, in such a way that the connections (2, 3) are at least partly aligned with each other in the vertical direction.

8. Arrangement according to Claim 7, **characterized by** a mixer shaft (6) arranged on the central axis (4) of the reaction chamber (1), which comprise elements (9 - 12) for feeding the liquid and the gas to the reaction chamber from the outer surface of the shaft (6).

9. Arrangement according to Claim 8, **characterized in that** the elements for feeding the liquid and the

gas are arranged to feed the liquid and correspondingly the gas radially relative to the shaft.

- 10.** Arrangement according to any of Claims 7 - 9, **characterized in that** the feed cross-section of the feed connection (2) for the flowing solid substance is smaller than the reaction chamber (1) and the exit connection (3). 5
- 11.** Arrangement according to any of Claims 7 - 10, **characterized in that** radial dispersion elements (14) are fitted to the mixer shaft (6). 10
- 12.** Arrangement according to any of Claims 7 - 11, **characterized in that** the reaction chamber (1) is rotationally symmetrical and is arranged to be divided along a dividing line (5) running horizontally through its central axis (4). 15

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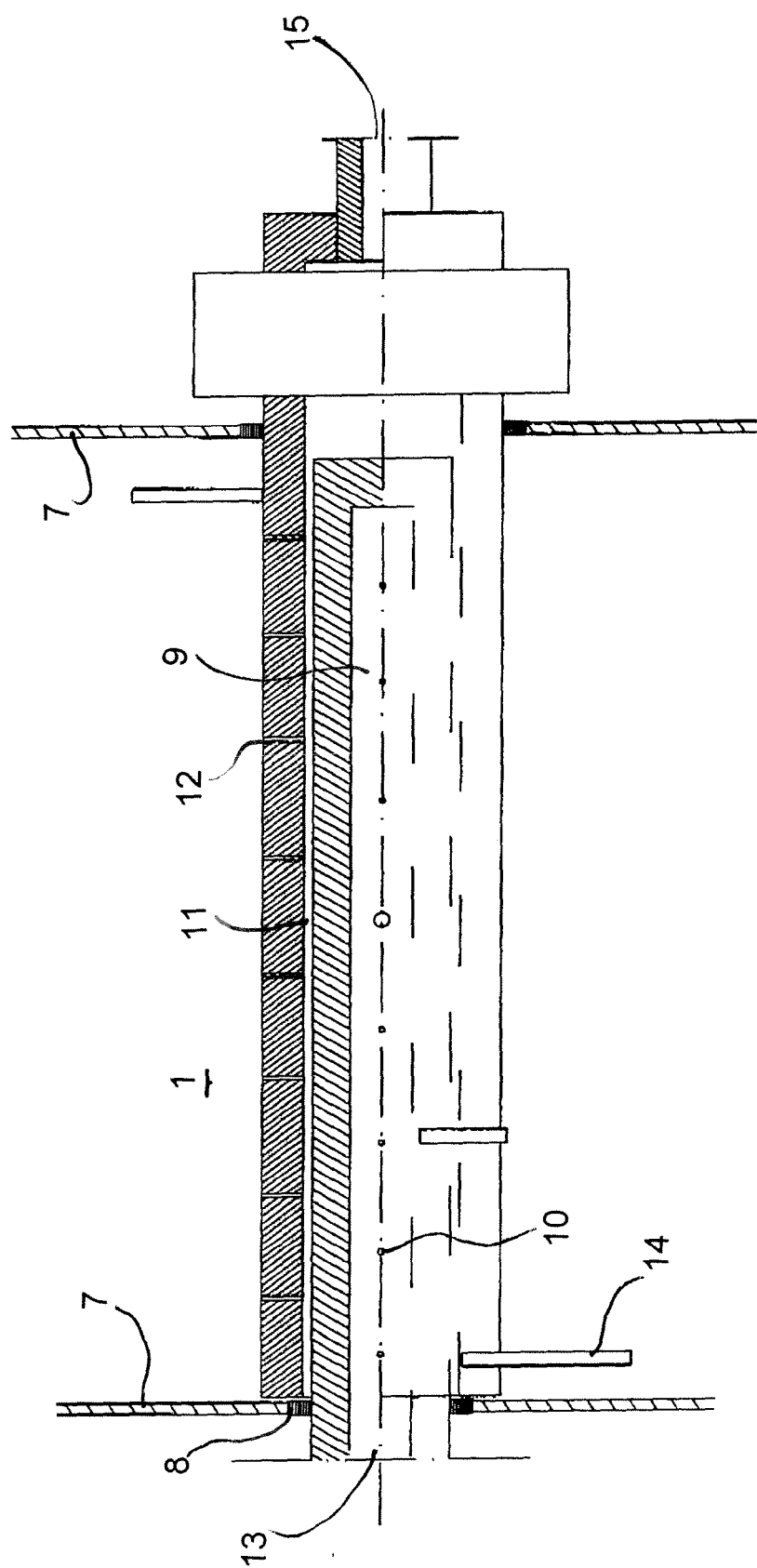


FIG. 1

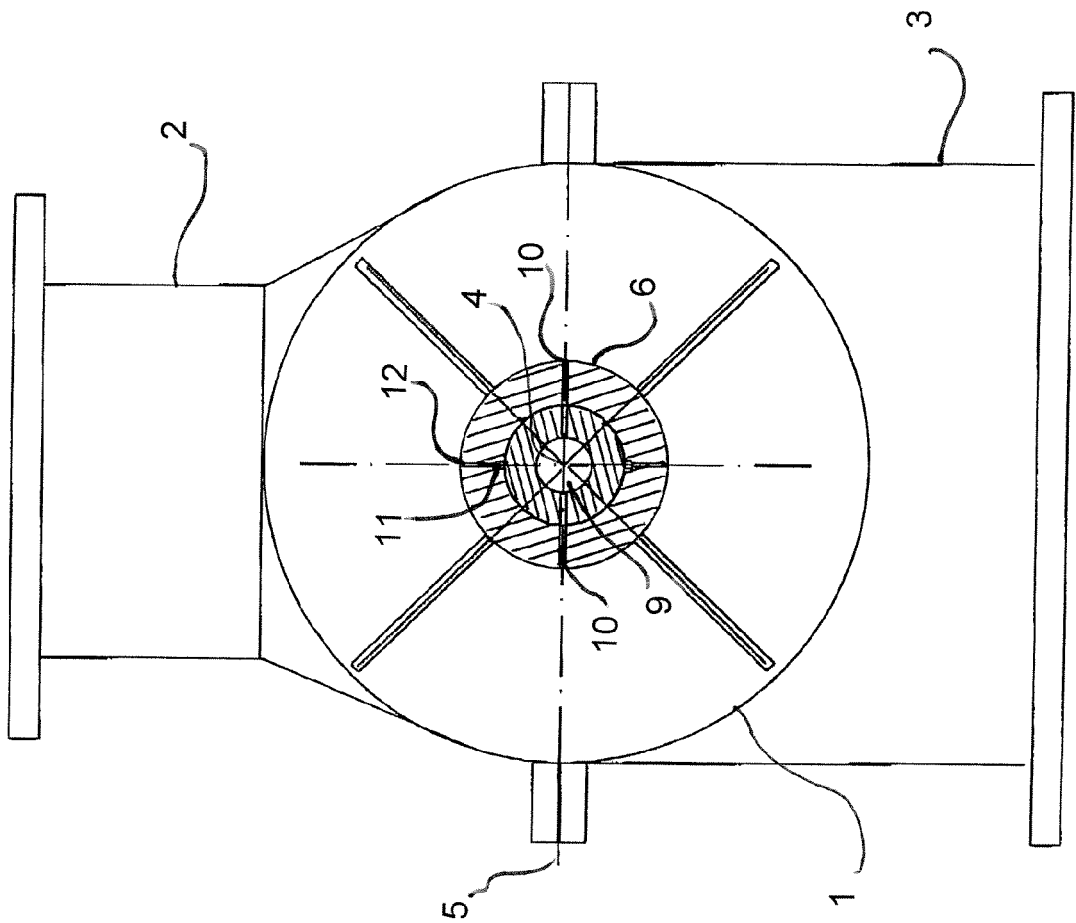


FIG. 2