

Method and device for preparing and separating a material comprising a composite multi-substance system

The invention relates to a method for preparing and separating a material comprising a composite multi-substance system and also to a vertical roller mill for carrying out this method.

Approximately 80 million tonnes of building waste are produced annually in Germany. A large proportion of this is crushed concrete. Concrete and thus also crushed concrete consist essentially of grit, sand and cement stone. The cement stone serves, amongst other things, to bind the other two components.

It is desirable, especially in areas in which no natural grit and sand deposits are present, to prepare the crushed concrete in such a way that it can be separated into its individual constituent parts. In particular, it is hereby of interest to recover the grit and / or sand used. It is essential here, however, that the grit and the sand should be purified as completely as possible with respect to cement stone, as otherwise, when using the said recovered grit or sand for producing concrete, the concrete produced in such manner possibly has lower strengths.

WO 2011/142663 A1 discloses for example a separating device for comminuting crushed concrete and, if possible, also being able to recover the individual components of the concrete. However, the desired levels of purity of the individual recycled components such as grit and sand cannot be achieved, or can only be achieved under particularly favourable conditions, with this device.

An essential feature of concrete recycling is that in particular the grit is not to be comminuted during preparation of the crushed concrete, since otherwise it can only be further used for the concrete production in an inferior quality.

In recent times, roller mills, which are actually pure comminuting units, have also been used to prepare and separate materials.

Such a method is known for example from WO 2011/107124 A1. In the method described therein, stainless steel slags consisting of a silicate portion and a metal portion are comminuted in a targeted way and these portions are thereby separated from each

other. Significant hardness differences between the individual portions and density differences are exploited during the comminution in order to achieve a separation. Essential features of this method are to continue to use the mill primarily as a comminuting unit and to clearly comminute the raw materials supplied, and to also achieve a separation only as a secondary, downstream property. Through the required pressure-based comminution, this method only allows separation to be achieved if one of the components to be separated is ductile, so that it is not comminuted during the grinding process. In other words, the separation takes place in that one component is ground by the roller pressure while another component is not comminuted. This is possible because the component not to be comminuted has ductile properties. In case the pressure during grinding is slightly too high, this component indeed deforms, which is not desired, however it continues not being comminuted.

Such a method cannot be used, however, for the preparation and separation of crushed concrete, as crushed concrete does not have any ductile constituent parts, and all constituent parts or components of the crushed concrete would thus be comminuted by the mill. The desired result, in particular purification and recovery of the grit, cannot therefore be achieved.

It is an object of the invention to indicate a method and a device, with which a preparation and separation of a material comprising a composite multi-substance system, wherein the components of the multi-substance system do not have any ductile properties, is possible.

This object is achieved according to the invention through a method for preparing and separating a material comprising a composite multi-substance system having the features of claim 1 and a vertical roller mill having the features of claim 13.

Advantageous embodiments of the invention are indicated in the sub-claims and in the description.

According to the inventive method for preparing and separating a composite multi-substance system comprising at least a first component and a second component which is connected to the first component, and wherein the two components do not have any

ductile properties, the material is fed as a feed material to a roller mill which has a grinding pan and grinding rollers for in-bed attrition.

A grinding bed of processed material and material to be processed is formed on the grinding pan during operation, on which grinding bed the grinding rollers roll. During the in-bed attrition the material is separated into the first and the second component by means of grinding rollers in the grinding bed through shear stress and abrasion of the particles of the components between themselves, wherein the particles of the first component, the particles of the second component and particles of the same component are reciprocally attrited.

In order to facilitate the in-bed attrition in the roller mill, the latter is operated with an extremely low pressing force of the rollers so that a contact pressure merely in the range of from 15 kN/m^2 up to a maximum of 140 kN/m^2 is reached with respect to the vertically projected area of the average roller diameter. The pressing force is hereby selected so that essentially no pressure-based comminution of the first and / or second component is carried out directly through the contact pressure. In other words, the preparation of the material takes place essentially only through the attrition of the material and the particles of the first and / or second component reciprocally. A pressure-based comminution is not provided. Insofar as a comminution is carried out, this is realised mainly through the reciprocal abrasion of the material.

Furthermore, the roller mill is operated in such a way that the grinding bed has a minimum height which is greater than the diameter of the particles of one of the two components. Subsequent to the in-bed attrition and the processing in the grinding bed, at least the first and the second component are removed from the processing circuit of the roller mill and sorted.

A core idea of the method according to the invention can be seen in that a roller mill, in particular a vertical roller mill, is no longer used as a comminution unit, wherein the material to be comminuted is "pressed" through the pressure of the rollers, but instead the roller mill, in particular the grinding bed formed on the roller mill, is used for the separation and preparation of the feed material into its constituent parts, in particular into the first and second component. This separation and preparation of the feed material takes

place within the grinding bed through reciprocal frictional stress, i.e. attrition of the material.

Corresponding to the invention it was recognised that through the formation according to the invention of the grinding bed with only an extremely low compressive stress through the rollers in the grinding bed, an attrition process takes place or is facilitated between the individual components of the material which consists of the composite multi-substance system.

Using the in-bed attrition according to the invention it is thus also possible with a roller mill to separate multi-substance systems, of which the components do not have any ductile properties. It is even possible to carry out such a separation with multi-substance systems, of which the components are brittle. In other words, grinding essentially no longer takes place in the mill, as the pressing force of the rollers is dimensioned so that essentially comminution is no longer possible through the rollers or their direct influence on the grinding bed. The separation and the associated partial comminution of the components of the multi-substance system are achieved mainly through the attrition process taking place in the grinding bed.

Within the scope of the invention attrition or attriting can be understood to be the purification of a plurality of components from adhesions between themselves through reciprocal rubbing against each other. The separation of the components hereby takes place in particular through the shear forces, produced by the components rubbing against each other, on the surfaces which lead to purification of the individual components.

A further core idea forming the basis for the invention is to form the grinding bed in such a way that it has a minimum height that is greater than the diameter of the particles of one of the two components. In particular the harder or the tougher of the two components of the composite multi-substance system is selected. It is ensured through this design of the grinding bed that the harder component is not comminuted through the roller pressure. In this connection it must not necessarily be the hardest of the components. It is also advantageous for example if the grinding bed height is at least as high as the average size of one of the components. In this way it is ensured with sufficient probability that during the preparation process there is not a pressure-based comminu-

tion but essentially the preparation and comminution due to attrition processes in the grinding bed, thus an abrasion-based comminution.

According to the meaning of the invention the composite multi-substance system can also consist of more than the two components indicated here by way of example. The more cohesive component can also be understood to be the harder component according to the meaning of the invention.

The preferably selected pressing force of the rollers, which can also alternatively be described as grinding rollers, is selected so that a contact pressure arises in the range of from 15 kN/m^2 up to a maximum of 140 kN/m^2 . The pressing force is dependent, inter alia, upon the size of the rollers, the size of the vertical mill and / or the weight of the rollers. The contact pressure is hereby used as a reference value, so that a guide variable is present irrespective of the dimensions of the rollers or the mill. The preferred range of the contact pressure is dependent upon the materials to be processed, wherein the contact pressure is selected so that there is essentially no pressure-based comminution of the grinding material. Since many different hardnesses are present over the whole breadth of the multi-substance system when processing a natural multi-substance system, a small part being subjected to an undesirable pressure comminution or being unsuccessfully processed cannot be completely excluded.

The invention is further based on the surprising finding that, in spite of the contact pressure that is actually much too low for the operation of a roller mill, processing of the feed material is possible. This lies essentially in that, in contrast with the operating mode of the mill to date, actual grinding no longer takes place but instead the materials process one another essentially reciprocally and are not processed by the rollers. This even leads to a preparation and separation of materials also being possible with the method according to the invention, of which the components essentially do not have any density differences.

The pressing force is advantageously selected in such a way that shear forces between the particles, produced during the in-bed attrition, lie in the range of from 5 kN/m^2 to 70 kN/m^2 , in particular between 7 kN/m^2 and 20 kN/m^2 . The indicated ranges for the shear forces between the particles of the different components of the composite multi-substance system facilitate a good attrition in the grinding bed, so that the preparation

and separation of the composite multi-substance system can be carried out in the mill. Here, the shear forces present also allow a sufficiently great purity of the individual components between themselves to be achieved without risking too great comminution.

A component which is essential in the adjustment of the shear forces is the pressing force of the rollers. This should ideally be set so that by rotating the grinding plate in combination with the rollers and the rotation of the rollers the desired shear forces arise in the grinding bed. In other words, different shear or friction forces act on the material to be processed. On the one hand the shear and friction forces of the individual material particles between themselves, on the other hand the shear forces applied to the material via the rollers.

Normally, when using a roller mill as a comminution unit the rollers are set in rotation by the grinding bed. In the standard state it can therefore be assumed that the peripheral speed of the rollers is of similar magnitude to the relative speed of the grinding bed which is located on the rotating grinding plate. If, however, the rollers rotate more slowly than the grinding plate or the grinding bed, the different speeds at the contact points lead to the production of shear forces which can be used for in-bed attrition according to the invention.

More specifically, the production of the shear forces is based essentially upon the speed of the particles which are guided along below the mill in comparison with the peripheral speed of the roller which sweeps by the particles or by which the particles sweep.

In contrast with the standard operating mode when grinding with a roller mill, it is necessary with the method according to the invention to clearly increase the grinding bed height. For the method according to the invention the grinding bed preferably has a maximum height of 8% of the grinding pan diameter, but preferably approximately 4% of the grinding pan diameter. In the conventional operating mode of a roller mill the grinding material is actively comminuted or crushed by the rollers. It is hereby desirable for the grinding gap, i.e. the distance between the grinding rollers and the grinding plate or the grinding pan, not to be too large, in order that the forces incorporated by the grinding rollers into the grinding bed can be actively used to comminute the grinding material. If the grinding gap is too large it can on the one hand arise that the grinding material is in part merely compressed and that thus adequate pressure is not applied to the grind-

ing material, and on the other hand that the grinding material flows out of the grinding gap so that it is displaced but not comminuted.

In contrast with this, it is desirable corresponding to the operating mode according to the invention for movements of the particles or components of the multi-substance system to be attrited to arise in the grinding bed. It is thus preferable if the grinding bed height is clearly higher than in the case of roller mills exclusively used for grinding. The greater grinding bed height leads to more relative movements of the particles or components in the grinding bed between themselves so that the in-bed attrition is hereby achieved.

In principle, the grinding bed height can be adjusted by means of the pressing force of the rollers, a feed mass flow, a grinding pan speed, a height of a retention rim of the grinding pan and / or an inner circulating flow.

An increase in the pressing force of the grinding rollers reduces, through an associated increase in the contact pressure, the grinding bed height. An increase in the feed mass flow, i.e. if more grinding material per time unit is fed as feed material to the roller mill, increases the grinding bed height. In contrast, a higher grinding pan speed in turn reduces the height of the grinding bed, as the existing grinding material is removed more quickly again from the grinding pan. The retention rim of the grinding pan is located at the edge of the grinding pan and is used to reduce or prevent the grinding material running over the edge of the pan. If the height of the retention rim is raised, the height of the grinding bed also increases.

A further parameter which can be used to adjust the grinding bed height is the inner circulating flow. It is hereby a question, in particular in the case of roller mills with integrated classifier, of the quantity of the particles that are rejected during classification and recirculated back to the grinding pan for further processing. If the inner circulating flow is increased, the grinding bed height also increases. The inner circulating flow can be influenced for example by means of the classifier settings as well as also by means of the volume of the process air stream.

It has proved advantageous for example, if the material bonding of the multi-substance system is increased, to increase the pressing force in order to achieve the necessary forces for the in-bed attrition in spite of the increased material bonding. Since, however,

the grinding bed height should ideally be kept constant, other parameters must be adapted, as the grinding bed height is initially reduced through the increased pressing force. It is hereby preferable to increase the feed mass flow and / or the inner circulating flow. Alternatively or additionally, the grinding pan speed can also be reduced. The setting of these parameters is also possible during ongoing operation so that, if it is ascertained for example during tests that the material bonding of the multi-substance system is greater than to date, it is possible to react thereto through the parameters indicated here.

A further possibility is to increase the height of the retention rim. However, this is impossible, or only possible with difficulties, during ongoing operation. This variation is mainly used therefore if the roller mill used is to be switched to a different multi-substance system or is to be designed for this.

If the material bonding of the multi-substance system is reduced, the pressing force is correspondingly reduced, whereby in principle the grinding bed would increase. In order to counteract this, the previously mentioned parameters can now be adjusted in the respective opposite direction.

During operation of a roller mill it is in principle desirable to process a throughput that is as high as possible, i.e. as much feed material as possible per time unit. If the mass flow is increased in order to increase the throughput, it is advantageous if in particular the grinding pan speed is increased in order to maintain the grinding bed height. An increase in the pressing force of the rollers would indeed also reduce the grinding bed height but this would lead to a change in the in-bed attrition variables. In particular, through the higher pressing force of the rollers, the grinding pressure, i.e. the force incorporated into the grinding bed by means of the rollers, would be increased, whereby the contact pressure is also increased. This can lead to a poorer preparation and separation of the multi-substance system. It is thus preferable that, if the feed mass flow is increased, this should be compensated merely through an increase in the grinding pan speed. The same can also be carried out if the inner recirculation is compulsorily increased. This is the case for example if a higher degree of breakdown of the materials is required and less material is therefore removed as fines through the classifier. This leads - as already indicated previously - to more material being fed back to the grinding

plate and, in a similar way to the case of an increase in the feed mass flow, to the grinding bed height increasing. It is also preferable here to control this essentially only through an adaptation, in particular an increase, in the grinding pan speed, so that the grinding bed height remains constant.

Different roller mill types are known. In some roller mills, the rollers are directly driven. In others, in particular of the LOESCHE type, the rollers themselves are not driven, but instead set in rotation through the friction forces produced between the rollers and the grinding bed. This is relatively unproblematic in the normal operating mode of a roller mill, wherein the roller mill is used for grinding. When using a roller mill for in-bed attrition, however, it has been ascertained that increased attention is to be paid to the rotation of the grinding rollers due to the extremely low pressing forces of these grinding rollers.

In this connection it is preferable if the roller mill is operated during start-up with a higher pressing force of the rollers than the pressing force selected during operation. This is necessary in order to initially set in rotation the rollers which have a starting torque to be overcome. Subsequently, during the in-bed attrition operation, the friction between the grinding bed and the grinding rollers is sufficient in most cases to maintain the rotation of the rollers.

In this connection it is preferable for the rotation of the rollers to be monitored during operation and for the pressing force of the rollers to be increased at least over time if it is ascertained that the rotation of the rollers is too low. An insufficient rotation of the rollers leads to the shear forces introduced by the rollers into the grinding bed changing and the quality of the in-bed attrition thus also changing. Through the short-term increase in the pressing force of the rollers it is ensured that they have a sufficient rotation or a sufficient angular momentum. According to the meaning of the invention, an insufficient rotation of the rollers is understood to mean that the peripheral speed of the roller is lower than 50% of the speed of the material flow under the roller. By approximation it can be assumed that the material flow under the roller corresponds to the rotation speed of the grinding pan or the grinding plate below the rollers. In dependence upon the material, adaptations of a few per cent can be provided in order to facilitate better estimation of the speed.

In order to facilitate start-up of the roller mill, in particular setting in rotation of the grinding rollers, with the only low admissible pressing forces for the in-bed attrition, the roller bearings are advantageously designed with a greater play than conventionally. This reduces on the one hand the starting torque and reduces on the other hand in addition also the risk of stopping or the grinding rollers having a rotation speed that is too low.

According to a preferred embodiment the roller mill is operated in an over-running and / or air stream mode. In the operating mode as a pure over-running mill, the grinding material prepared is conveyed inter alia through the rotation of the grinding pan over a possibly present retention rim and falls into an area below the grinding pan. It can be transported away from here. In the air stream operating mode, the grinding material dropping down over the grinding plate is taken up by means of a process air stream and is blown away in particular upwards. Above the grinding pan there is in most cases a classifier, to which the prepared grinding material is transported by means of the process air stream. Classification takes place in the classifier so that sufficiently finely prepared grinding material is discharged from the preparation process, whereas grinding material to be further processed is fed as so-called reject back to the preparation process.

In connection with the invention, in particular the in-bed attrition is also described as a grinding process, as this can be regarded as distantly related to standard grinding processes, but differs therefrom through a different comminution technique. However, the in-bed attrition is carried out by means of a roller mill and the terminology for mills is thus applied for easier understanding, although in the actual sense no further grinding takes place. In a combined over-running and air stream mode, not all the over-running grinding material is taken up by the process air stream sweeping around the grinding pan, but instead only a proportion thereof. A further proportion falls downwards and is transported away from below the grinding pan by conveying means.

According to a preferred embodiment the material comprising the composite multi-substance system to be prepared and separated is crushed concrete. Crushed concrete itself consists mostly of grit, sand and cement stone. The method according to the invention allows grit and sand to be separated from each other and from the cement stone and purified by means of the in-bed attrition. Through the in-bed attrition, in par-

particular the grit and sand are rubbed away from the cement stone so that after the method according to the invention grit and sand are once again present essentially in a pure form and can thus be re-used for concrete production.

In a further advantageous embodiment of the method, a vertical roller mill with a classifier, which can also be integrated, is used. In addition a process air stream is set in such a way that a component, for example cement stone, and at least in part compounds from the first and the second component, such as cement stone and sand, are transported from the over-running grinding material to the classifier by means of the process air stream, whereas the first purified component, such as grit and sand, is removed as coarse material from the grinding process.

It is further provided that at least a proportion of the comminuted second component, such as for example comminuted cement stone, is removed at the classifier as fines from the grinding process, and insufficiently comminuted particles of the second component as well as adhesions of the first and the second component, such as for example cement stones and compounds of cement stones and sand, are rejected by the classifier and fed back to the grinding pan. In addition, sand can be separated from the coarse material removed by means of screens in order to thus facilitate a further separation in the case of multi-substance systems comprising more than two components.

According to an advantageous embodiment, a vertical roller mill is operated in the combined over-running and air stream mode. The process air stream, which sweeps from below around the grinding pan, is set so that it transports only light or small materials, in particular comminuted cement stone and adhesions of cement stone and sand, in the upward direction of the classifier. Purified heavy components such as sand and grit can fall downwards counter to the process stream and be discharged from the grinding process as coarse material. In addition, adhesions of the components such as grit, sand and cement stone can be discharged from the grinding process as coarse material. This still insufficiently prepared material can be detected by means of sorting processes and be fed back to the in-bed attrition process according to the invention.

In order to separate grit and sand, a subsequent separation by means of screening is suitable. The material brought to the classifier with the process air stream is classified there. Depending upon the setting of the classifier, for example only comminuted ce-

ment stone is discharged as fines, whereas the remaining material is fed back to the grinding pan. The comminution of the cement stone takes place corresponding to the method according to the invention essentially not through a compressive stress but instead through the in-bed attrition. In other words, the cement stone is triturated by the other particles and other cement stones. Through this trituration it is also possible to remove the cement stone from sand and grit without comminuting sand and grit themselves.

The method according to the invention can preferably be carried out with a roller mill with a rotatable grinding pan, on which a grinding bed of grinding material is formed during operation, and with at least two stationary, rotatable grinding rollers which roll during operation on the grinding material. In this case a classifier is preferably arranged above the grinding rollers and in addition a means for defining and maintaining a minimum grinding gap between the grinding pan and the grinding rollers is provided.

The vertical roller mill according to the invention is based upon the recognition that a clearly lower compression of the grinding material on the grinding bed is necessary, or may arise, in the in-bed attrition than with a conventional grinding bed which is present for example for coal grinding. Through this low compression or force effect through the grinding rollers, however, there is a problem in connection with locally differing hardnesses and further properties of the grinding bed which can be of clearly differing levels. For example, more air inclusions may be present at some points than at others as a result of the low compression and relatively great height of the grinding bed. If the grinding rollers are operated with a constant pressing force, there is the risk that at the points where more air inclusions are present the grinding rollers compress the grinding bed significantly more greatly than at other points. It can even arise that the grinding rollers impact through as far as the grinding pan. All these variants and phenomena arising lead to non-smooth running of the grinding rollers. This in turn leads to vibrations in the whole operation of the vertical mill which may be undesirable and in part even harmful. For example the preparation process with the vertical roller mill must be stopped if too great vibrations arise.

In this connection it was recognised in the invention that it is necessary for the first time in vertical mills to provide a means for defining and maintaining a minimum grinding gap

between the grinding pan and the grinding rollers. This means ensures that the grinding rollers are prevented through the different properties of the grinding bed from impacting through onto the grinding pan.

Different possibilities are conceivable in order to implement this means. For example corresponding stops or stop buffers for the grinding rollers can be provided in an advantageous embodiment. Another possibility is to design the hydraulic system of the grinding rollers correspondingly.

According to a preferred embodiment, a hydraulic system is provided to adjust the pressing force of the grinding rollers during operation. This hydraulic system counteracts the weight force of the grinding rollers in order to facilitate a contact pressure in the range of from 15 kN/m^2 to 140 kN/m^2 with respect to the vertically projected area of the average roller diameter. The hydraulic system in vertical roller mills, in particular of the LOESCHE type, is conventionally designed so that the pressing force of the grinding rollers acts in the same direction as the weight force. Normally, by means of the hydraulic system, a contact pressure of from 600 kN/m^2 up to 1000 kN/m^2 or more is to be achieved. This is not desirable, however, in the in-bed attrition.

Due to the size of the grinding rollers in different mill systems and the weight thereof of up to 45 t, it is necessary to provide an inverse hydraulic system in order to reduce the weight force of the grinding rollers which presses on the grinding bed. The already known hydraulic system, which is used in part to pivot out the grinding rollers, cannot be used here, as it does indeed reduce the pressure of the grinding rollers on the grinding bed but is not suited to maintain this pressure, thus the pressing force, at a constant level. Instead, it is only designed for a swift pivoting-out of the grinding rollers for example for maintenance purposes.

According to an advantageous embodiment a monitoring system is provided on each grinding roller and monitors the rotation of the grinding rollers during operation. This is necessary when using a vertical roller mill for the in-bed attrition, since – as already stated – work takes place with a very low pressing force, meaning that it can arise that the grinding rollers no longer sufficiently rotate. By means of the provision of monitoring systems this status can be detected and suitable counter measures initiated, for example temporarily increasing the pressing force.

The invention will be explained in greater detail below using schematic example embodiments by reference to the drawings, in which:

Fig. 1 shows a flow diagram for concrete preparation according to the invention;

Fig. 2 shows a cross-section through a vertical roller mill; and

Fig. 3 shows a cut-out of the vertical roller mill of Fig. 2.

Fig. 1 shows, by way of example for the inventive method for preparing and separating a material comprising a composite multi-substance system, a flow diagram 10 for preparing crushed concrete. The method for crushed concrete preparation described in greater detail below can be used in the same or a similar way also for other material systems, in which the individual components have no ductile properties. The following design is to be regarded merely as an example in order to illustrate the exact execution of the method according to the invention and its advantages by way of examples. The individual method steps which are described in correlation in this example can also each be carried out individually and are thus each to be considered separately as part of the invention.

Conventionally, concrete granulate is produced in portions of 0 mm to 63 mm from crushed concrete through breaking and separation of reinforced steel. Subsequently, a classification into grit and sand portions normally takes place. These portions have, however, not yet negligible adhesions of cement stone. The use of recycled grit and sand of only up to a maximum of 15% as aggregate in concrete production as a replacement for primary grit and sand is thus regarded as technically justifiable.

This threshold of maximum 15% of recycled material as grit and sand replacement can clearly be upwardly displaced by means of the method according to the invention.

For this, concrete granulate with a size of for example up to 80 mm grain size is used as a starting material or feed product 11. This concrete granulate, which is also described as crushed concrete, is fed to a roller mill 12 according to the invention as feed material. The roller mill 12 is operated in the method according to Fig. 1 in the combined over-running and air stream mode and is also described as a vertical roller mill. The process-

es taking place in the roller mill 12 and the operating mode of the roller mill 12 will be described in more detail below by reference to Fig. 2.

The roller mill 12 is operated corresponding to the invention as an in-bed attrition unit and not as a comminution unit. Prepared and comminuted cement stone 16 can thus be removed from the preparation circuit at a classifier provided in the roller mill 12 which can in principle also be arranged downstream of the roller mill 12.

By way of over-running, coarse material 13 is removed from the preparation in the roller mill 12, which coarse material 13 essentially consists of prepared grit, sand and still adhering material, but of which the proportion is clearly smaller than in the feed material 11. The material with adhesions can be in particular grit and / or sand with adhesions of cement stone. Subsequently the coarse material 13 is subjected to a screen 14, with which the sand 17 can be removed as a portion of 0 mm to 2 mm. This sand 17 is purified through the method 10 according to the invention so well that it can be used similarly to primary sand in the concrete production.

The coarse material 13 which has a size of over 2 mm is subsequently subjected to a density sorting means 15. This serves to allow purified grit 18 with higher density to be discharged from the processing circuit. Material that does not have a sufficiently high density – this is in particular grit and / or sand, on which adhesions of cement stone are still present – is in turn fed to the in-bed attrition in the roller mill 12.

Further, a method is conceivable which, however, is not described herein, wherein the sand is also fed to a density sorting means to separate any adhesions of cement stone or other impurities which might still be present there and to feed them again to the grinding mill.

It is thus possible with the method 10 according to the invention to be able to extract from crushed concrete, in particular concrete granulate 11, grit 18 and sand 17 in such a high purity that these components can be used analogously to primary grit and sand in concrete production. A far higher recycling rate than the rate of 15% possible to date is thus achieved.

The density sorting can be realised as dry density sorting for example by means of wind classifiers, air jigs and / or air-fluidised bed sorting. Alternatively, a wet density sorting

can also be carried out. However, the materials fed back to the roller mill 12 must then be dried again. Possible example wet sorting methods are: sink-or-swim separation, both statically and dynamically, setting sorting, spiral separator or hearth sorting as well as fluidised bed sorting methods.

The roller mill 12 and the operation thereof for in-bed attrition will be explained in greater detail below by reference to the detailed Fig. 2.

Fig. 2 shows a schematic cross-sectional view through a vertical roller mill 30 of the LOESCHE type. An essential component of the roller mill 30 is constituted by truncated cone shaped grinding rollers 31 which roll on a grinding bed 41. In the partially cross-sectional view shown here, only two grinding rollers 31 are shown. However, vertical roller mills 30 with three, four, six or more grinding rollers can also be used.

The grinding bed 41 is formed on a grinding pan 32. The grinding rollers 31 themselves, which can alternatively also be described as rollers, are provided in fixed position but can be rotated about the axis shown in the drawing. The grinding pan 32 in turn is – as indicated – rotatable about its central axis. If the grinding pan 32 is rotated, the grinding material 42 present on the grinding bed rotates too. The grinding rollers 31 are hereby set in rotation through friction between the grinding material 42 and the outer contour of the grinding rollers 31.

A classifier 34 is provided above the grinding pan 32 and can be both dynamically and statically designed. The in-bed attrition process according to the invention is described in more detail below.

The feed or grinding material 42, for example crushed concrete, is fed via a material feed 35 to the preparation process. The material feed 35 is hereby formed so that the feed material 42 is fed in the central region of the grinding pan 32.

Through the rotation of the grinding pan 32, the grinding material is accelerated on the one hand and transported spirally outwards on the other hand, so that the grinding rollers 31 roll over it. Corresponding to the in-bed attrition method according to the invention, the grinding rollers 31 are, however, operated in a different way from that normally known in roller mills 30. They are not hereby essentially used for pressure comminution of the grinding material.

Corresponding to the method according to the invention, merely an extremely low contact pressure is applied to the grinding bed 41 by the grinding rollers 31. This lies in the range of from 15 kN/m^2 to a maximum of 140 kN/m^2 . It preferably lies in particular in the range of between 30 kN/m^2 and 80 kN/m^2 . This contact pressure serves essentially to incorporate sufficiently great shear forces into the grinding bed 41 so that the particles present there attrite each other reciprocally.

Grinding rollers normally have an average diameter of up to 2.8 m and have a weight of up to 45 t. With this great weight, a much higher contact pressure would be achieved than the maximum possible with the in-bed attrition. For this reason, an inverse hydraulic system (not shown in Fig. 2) is provided which is used to counteract the weight force of the rollers 31. This hydraulic system can engage as a negative force on a rocker arm 33 of the grinding rollers 31. In other words, the inverse hydraulic system presses onto the rocker arm 33 in such a way that the roller 31 is slightly raised and a force counter to its weight force acts on the roller.

Through the further feeding of new grinding material 42 and the rotation of the grinding pan 32, which can also be described as the grinding plate, the material located on the grinding pan 32 which is already prepared in part is displaced and runs over a retention rim 36 into a gap between the grinding pan 32 and mill housing.

Through the operation of the mill both in the over-running and air stream mode, a first classification takes place at this point. A proportion of the over-run processed material is transported by the process air 37 flowing in from below in the direction of the classifier 34, whereby another proportion can be removed as over-run coarse material from the processing circuit.

An essential feature for the first classification is the quantity of the process air 37 supplied. In addition the classification can also be influenced by a blade ring 38. The process air 37 is hereby adjusted in combination with the blade ring 38 in such a way that essentially grit and sand can be removed from the processing circuit as overrunning coarse material 51. This is then subjected to screening, as described by reference to Fig. 1.

Adhesion materials of grit and / or sand with cement stone which has not yet been sufficiently attrited can also be removed from the processing circuit as over-running coarse material 51. The adhesion materials are, as already set out in relation to Fig. 1, subsequently fed back to the processing circuit with new crushed concrete.

Through the process air and the optionally provided blade ring a first classification is carried out which can be regarded as density sorting.

The blown-in process air 37 carries in particular comminuted cement stone and also particles of sand with adhering cement stone to the classifier 34. A second classification takes place here. This is in turn also a density sorting.

Here, using the classifier 34, in particular sufficiently comminuted cement stone is discharged from the processing circuit. This comminuted cement stone is removed from the processing circuit with the outgoing process air at the process air outlet.

Insufficiently comminuted cement stone or adhesion material comprising cement stone and sand is fed back to the grinding pan 32 via a grit cone 40 and fed there to a further in-bed attrition.

In addition roller speed sensors 46 are provided on the rollers 31 which detect the speed of the rollers 31 during the operation. This is necessary as it can arise through the low pressing force, with which the rollers 31 are pressed onto the grinding bed in the in-bed attrition, that the rollers rotate too slowly. If this is detected by means of the roller speed sensors 46, the pressing force can be temporarily increased in order to thus increase the rotation of the rollers.

An essential feature of the method according to the invention and the successful in-bed attrition is to design the grinding bed to be sufficiently high so that sufficient particles of the feed material are present to allow reciprocal attrition. Possible influencing values for the grinding bed will be explained in more detail below in Fig. 3.

Fig. 3 shows a cut-out of the roller mill 30 of Fig. 2. The same reference numerals as in Fig. 2 are further used here.

In order to influence the grinding bed height s , essentially the feed mass flow $m_{m,in}$, the pressing force F_W of the grinding rollers 31, the grinding pan speed n_s , the height h of the retention rim 36 and the inner circulating flow are available. The inner circulating flow is not shown here in Fig. 3. It is essentially material rejected by the classifier which accounts for a part of the feed mass flow $m_{m,in}$.

The influence of the individual setting parameters will be explained in more detail below, in each case under the assumption that the other parameters in this connection remain constant. The aim here is to vary the grinding bed height s , in particular under the rollers 31, i.e. between the rollers 31 and the grinding pan 32. This area is also known as the grinding gap.

In a simple manner, the grinding bed height s can be varied through a variation in the pressing force F_W of the rollers 31 which influences the contact pressure. The contact pressure is the force which acts directly below the rollers on the grinding bed. If the pressing force F_W of the rollers is increased, the grinding material is more greatly compressed or comminuted so that the grinding bed height s reduces. Vice versa, the grinding bed height s increases if the rollers 31 are pressed with a lower pressing force F_W onto the grinding bed 41.

An increase in the feed mass flow $m_{m,in}$ increases the grinding bed height s . If more material per time unit is fed to the grinding pan 32, more grinding material is located on the grinding pan 32 with an assumed equal dwell time thereof on the grinding pan. It compulsorily follows from this that the mass flow on the mill $m_{m,on}$ is also increased. Since there is consequently more material on the grinding pan 32, the grinding bed height s is also higher.

The influencing of the feed mass flow $m_{m,in}$ can take place in two ways. On the one hand more feed material can be fed to the roller mill 30 per time unit. On the other hand the classifier can be set differently so that a higher rejection rate is present at the classifier, meaning that more material is fed back to the grinding pan 32. The rejection rate can also be increased by increasing the process air stream, since in this case less grinding material is removed from the processing circuit downwards as coarse material, but is instead transported to the classifier as potential fines. The feed mass flow $m_{m,in}$ and the inner circulating flow influence essentially the discharge mass flow $m_{m,out}$. If the

inner circulating flow is increased, reference is made to the circulating load being increased. In other words, more material is located in the preparation circuit within the mill. This means, in a different mode of expression, that the discharge mass flow $m_{m,out}$ is reduced at least over time. If the feed mass flow $m_{m,in}$ is increased, thus more feed material is fed to the mill, the discharge mass flow $m_{m,out}$ also compulsorily increases.

A different possibility for varying the grinding bed height is to increase the pan speed n_s . If this is increased the grinding bed height s is reduced. A higher grinding pan speed n_s reduces the dwell time of the material to be processed on the grinding pan 32. Accordingly, the mass flow $m_{m,on}$ on the grinding pan also becomes lower. The grinding bed height s also hereby compulsorily decreases.

A further possibility for influencing the grinding bed height s is the retention rim 36. If its height h is increased, more material builds up on the grinding plate. This means that in principle more material must be present on the grinding pan 32 in order that it can flow with the discharge mass flow $m_{m,out}$ from the grinding pan 32.

An essential feature of all the parameters set out here is that these reciprocally influence each other. A higher retention rim 36 does indeed lead on the one hand to a higher grinding bed, on the other hand also to a longer dwell time of the feed material on the grinding pan 32. This leads, depending upon the pressing force F_W of the rollers 31, to a better attrition between them, but also under certain circumstances to an undesirable long stress period and thus all in all under certain circumstances to a lower throughput.

By way of example, individual features of the method according to the invention and the vertical roller mill according to the invention have been shown here in combination. It is, however, obvious that each of these features can also be used individually.

Likewise, the example, in particular in Figs. 1 and 2, is related to the preparation of crushed concrete. The method according to the invention can, however, also be used to prepare and separate many different composite multi-substance systems. For example, the in-bed attrition in the roller mill, which in other words facilitates a merely frictional stress of the material to be processed and does not constitute any actual comminution, can also be used for the preparation of natural slate which consists of argillaceous shale and impurities such as lime, ores or other organic components. It is hereby essential to

ensure a frictional stress of the natural slate in order to produce ground slate, in which, in spite of the fineness thereof, the individual particles continue to have a plate-shaped form.

Similarly, the method is suited for processing mica which consists of sheet silicates and possible impurities. Up to now, mainly pure deposits have been utilised. However, this is only the case since up to now no suitable preparation methods for dry attrition and separation were known.

The method according to the invention can also be used to prepare kaolin containing industrial sands which consist of kaolin, feldspar and quartz sand. The use and preparation of graphite ore, which is composed of graphite and ore matrices, and of clay or bentonite, contaminated by sand or non-sheet-silicates as well as the breakdown through attrition of heavy mineral sands for separating cohesive components and hereinafter the density separation of rutile, zircon, ilmenite, etc. from an encasing sandy fraction are possible with the method according to the invention. Even FeCr slags, which consist of slaking slag, corresponding metal and under certain circumstances stabilised slags, can be prepared. An essential feature here, however, is that the metal component must be a non-ductile component, as otherwise an attrition according to the method according to the invention is not possible, as otherwise no frictional stress according to the meaning of the invention can be realised.

With the method according to the invention and the roller mill according to the invention, it is thus possible to prepare and separate composite multi-substance systems simply and efficiently.

Claims

1. Method for preparing and separating a material comprising a composite multi-substance system,
wherein the composite multi-substance system consists of at least a first component and a second component which is connected to the first component, and wherein neither of the two components has any ductile properties,
wherein the material is fed as feed material (42) to a roller mill (30) with a grinding pan (32) and with grinding rollers (31) for in-bed attrition,
wherein a grinding bed (41) comprising material to be processed and material that has been processed is formed on the grinding pan (32) during operation,
wherein the grinding rollers (31) roll on the grinding bed (41) during operation,
wherein the material is separated during the in-bed attrition by means of the grinding rollers (31) in the grinding bed (41) into the first and the second component through shear stress and abrasion of the particles of the components between themselves, wherein the particles of the first component, the particles of the second component and particles of the same component are reciprocally attrited,
wherein for the in-bed attrition the roller mill (30) is operated only with a pressing force (F_W) of the grinding rollers (31) in order to achieve a contact pressure in the range of from 15 kN/m^2 to 140 kN/m^2 with respect to the vertically projected area of the average roller diameter, which is selected so that essentially no pressure-based comminution of the first and / or the second component is carried out directly through the contact pressure,
wherein the roller mill (30) is operated in such a way that the grinding bed (41) has a minimum height that is greater than the diameter of the particles of one of the two components, and
wherein at least the first and the second component are removed from a processing circuit of the roller mill (30) and sorted.
2. Method according to claim 1,
characterised in that
the pressing force is selected in such a way that the shear forces between the parti-

cles produced during the in-bed attrition lie in the range of from 5 kN/m² to 70 kN/m², in particular 7 kN/m² to 20 kN/m².

3. Method according to claim 1 or 2,
characterised in that
the grinding bed height (s) is controlled to a maximum of 8% of the grinding pan diameter.
4. Method according to one of claims 1 to 3,
characterised in that
the grinding bed height (s) is controlled to approximately 4% of the grinding pan diameter.
5. Method according to one of claims 1 to 4,
characterised in that
with a required pressing force (F_w) the grinding bed height (s) is adjusted by means of a feed mass flow ($m_{m,in}$), a grinding pan speed (n_s), a height (h) of a retention rim of the grinding pan (31) and / or an inner circulating flow.
6. Method according to one of claims 1 to 4,
characterised in that
if the material bonding of the multi-substance system is increased the pressing force (F_w) is increased in order to achieve the in-bed attrition, wherein a feed mass flow ($m_{m,in}$) is increased, a height (h) of the retention rim is increased, an inner circulating flow is increased and / or a grinding pan speed (n_s) is reduced in order to maintain a grinding bed height (s).
7. Method according to one of claims 1 to 6,
characterised in that
a feed mass flow ($m_{m,in}$) is increased in order to increase a throughput, wherein a grinding pan speed (n_s) is increased in order to maintain a grinding bed height (s).
8. Method according to one of claims 1 to 7,
characterised in that

the roller mill (30) is operated during start-up with a higher pressing force (F_W) of the grinding rollers (31) than the pressing force (F_W) selected during operation.

9. Method according to one of claims 1 to 8,

characterised in that

the rotation of the grinding rollers (31) is monitored during operation, and

the pressing force (F_W) of the grinding rollers (31) is increased at least over time if a peripheral speed of the roller is lower than 50% of the speed of the material flow under the roller is ascertained.

10. Method according to one of claims 1 to 9,

characterised in that

the roller mill (30) is operated in an over-running and / or air stream mode.

11. Method according to one of claims 1 to 10,

characterised in that

crushed concrete comprising grit, sand and cement stone is fed as material, and grit and sand are separated from each other and from cement stone by means of the in-bed attrition.

12. Method according to claim 11,

characterised in that

a vertical roller mill with a classifier (34) is used,

a process air stream is adjusted in such a way that cement stone and at least in part compounds of cement stone and sand from the over-running grinding material are transported by means of the process air stream to the classifier (34), and grit and sand are removed from the grinding process as coarse material, comminuted cement stone is removed from the grinding process as fines at the classifier (34), and cement stone as well as compounds of cement stone and sand are rejected by the classifier (34) and fed back to the grinding pan (32), and sand is separated from the discharged coarse material by means of screening.

13. Vertical roller mill,

with a rotatable grinding pan (32), on which a grinding bed (41) of grinding material (42) is formed during operation,

with at least two stationary, rotatable grinding rollers (31) which roll on the grinding

bed (41) during operation,
with a classifier (34) arranged above the grinding rollers (31), and
with a means for defining and maintaining a minimum grinding gap between the grinding pan (32) and grinding rollers (31),
wherein a hydraulic system for adjusting the pressing force (F_w) of the grinding rollers (31) during operation is provided, which counteracts the weight force of the grinding rollers in order to facilitate a contact pressure in the range of from 15 kN/m² to 140 kN/m² with respect to the vertically projected area of the average roller diameter.

14. Vertical roller mill according to claim 13,
characterised in that
a monitoring system (46) is provided on each grinding roller (31) in order to monitor the rotation of the grinding roller (31) during operation.