

A method of compaction of a powder and a roller compaction device

The present invention pertains to a method of compaction of a powder by means of nip rollers, wherein the powder is transported at a supply speed to a nip area between the nip rollers.

5 Compaction of a powder is well known in the field of powder coatings in order to re-use particles which have undesired sizes. Powder coatings are solvent-free paints comprising a mixture of polymer and optionally one or more cross linkers and/or pigments, that are applied as dry powders. Once
10 applied to an object the powder is molten and forms a liquid film. Upon curing the film, the polymer is cross-linked and the paint film solidifies. In order to obtain a steady powder spray the particle size of the powder must be within a desired range. Relatively small or large particles may be undesired in a powder
15 coating process.

 In general, powder coatings are produced by milling which results in a relatively broad particle size range. Undesired particles at both ends of the size range may be removed and collected by means of a classifier and a cyclone.
20 Preferably, the collected powder waste is re-used for the powder coating process. A suitable option to re-use the powder waste is compaction or dry bonding using nip rollers in order to form a hard solid that can directly be re-milled or re-ground to form a powder coating. This means that the compacted powder can be
25 returned to the milling device during the same production batch. In order to form a hard solid from a compacted fine powder significant pressure is required. However, a too high pressure may cause premature melting due to a temperature increase of the compacted powder, hence requiring additional cooling, and a too
30 low pressure may generate too small particles during re-milling.

 The physical properties of fine particles that are generated during production of powder coatings vary significantly, for example in respect of their size distribution, average size, fluidity, bulk density, polymer

content, etc. There are several ambient conditions which affect their properties, such as temperature and humidity, but their properties may also vary over time due to settling.

Due to the pressure at the nip rollers the particles
5 undergo plastic deformation and fracture at the inter-particle contact points and particles bond to each other. The strength of the bond depends on the inter particle area that deforms. In general the strength of the compacted product depends on the particle size distribution, shape and the elasticity modulus of
10 the material. In practice, a pressure of 15-20 kN per cm roller width appears to yield a hard compacted product.

US 6,500,385 is related to a compaction process for working up powder coating waste to yield reusable powder coatings by compaction of the powder coating waste without
15 complete melting to yield a sintered product. In the known process powder coating residues arising during powder coating production are continuously separated, continuously compacted and the compacted product is continuously ground together with fresh material to be ground of the same batch of powder coating
20 without extrusion to yield a powder coating.

It is an object of the present invention to provide a method for optimal compaction of powder waste.

This is achieved by the method according to the invention, wherein friction between at least one of the nip
25 rollers and the powder at said nip roller is determined, and wherein depending on the friction the rotational speed of at least one of the nip rollers is adjusted whereas the supply speed of the powder to the nip rollers as well as the distance between the nip rollers are maintained substantially constant.

30 An advantage of the method according to the invention is that it can be automated easily in a closed loop control which requires minimum operator intervention. Determining the friction basically means that the variation in powder quality fed to the nip rollers is monitored. Maintaining the supply
35 speed of the powder to the nip rollers as well as the distance between the nip rollers substantially constant is advantageous in that varying the supply speed can change the fluidity of the powder which may lead to a method which is more difficult to

control automatically, whereas variation of the distance between the nip rollers requires a relatively complex compaction device.

In principle, the friction can be determined by determining the reaction force by the nip roller exerted on the powder. The force can be derived by means of a force sensor or a strain gauge, for example.

In an advantageous embodiment the nip roller is driven by an electric motor and the friction is derived by determining the electrical power consumption of the electric motor. This is a rather simple method of deriving the friction at a certain speed of the nip roller.

The rotational speed of the nip roller may be adjusted on the basis of the friction at the nip roller. This means that determining the friction as well as controlling the speed is performed at the same nip roller.

It is advantageous to drive the nip rollers independently from each other since this provides a great freedom of process control. For example, it may be desired to operate the nip rollers at different speeds.

In a specific embodiment the friction levels between the powder and both nip rollers are determined and the rotational speeds of both nip rollers are adjusted independently from each other. For example, it provides the opportunity to take into account wear of each of the nip rollers which may require a different speed control of the respective nip rollers.

In general, the rotational speeds of the nip rollers will be increased if the friction at the nip rollers increases. Due to the higher speed the compaction pressure will reduce. When the compaction pressure becomes too low the friction will decrease below a certain value and the rotational speed of the nip rollers may be reduced to compensate this effect.

The invention is also related to a roller compaction device for compaction of a powder, which comprises nip rollers and a feeder for transporting a powder to a nip area between the nip rollers, a sensing apparatus for determining friction between at least one of the nip rollers and the powder at the nip roller, and a controller for adjusting the rotational speed of at least one of the nip rollers, depending on the friction

level, whereas the speed of the feeder as well as the distance between the nip rollers is substantially constant.

The nip roller may be driven by an electric motor, wherein measurement devices for determining the electrical power consumption and speed of the electric motor are connected to the controller. The signals from the measurement devices, for example an electrical current detector, volt meter and a speed sensor, are used as input signals for a control program in the controller.

The circumferential surfaces of the nip rollers may be smooth, which means that the surfaces lack a macroscopic embossing or texture. This is advantageous for obtaining a consistent hard solid product which is particularly suitable for re-grinding.

In a particular embodiment one of the nip rollers has a diabolo-shape, whereas the other nip roller has frustoconical opposite axial end portions which are shaped complementarily. This reduces loss of powder at the axial ends of the nip rollers compared to entirely cylindrical nip rollers. It is noted that these shapes of the nip rollers may be applied to any other roller compaction device including nip rollers, independent from the presence of the sensing apparatus and the controller.

JP H05 293357 is related to a device in which powder in a hopper is pushed between a pair of rolls mutually rotated in the reverse direction by a rotated screw, compressed and molded. The discharge density of moldings is calculated from the discharge volume and the discharge weight of the moldings in keeping with rotation of the rolls. Quality of the moldings is controlled while keeping the discharge density as an index. Further pressurization force of the rolls is controlled in order to maintain the discharge density of the moldings constant. Furthermore the number of revolutions of the screw is controlled in order to maintain thickness of the moldings constant. As a result, such function is second that the moldings having specified quality are continuously obtained at the specified capacity. The method according to the present invention does not determine the properties of the resulting product, but it determines a process parameter during manufacturing, i.e. friction between a roller and the powder. An advantage of

controlling the process on the basis of a parameter further upstream in the process such as in the method according to the present invention provides a faster system control.

US 3,734,659 is related to a material compacting apparatus including opposed compacting rolls mounted for lateral displacement to vary the spacing between the rolls depending upon the pressure exerted during compacting. A hopper is positioned above the rolls for holding the material, and a feed screw is located within the hopper for feeding the material to the rolls. Control means are provided for varying the driving action of the feed screw with the variations depending upon any tendency of the pressure applied by the rolls to vary. The feed screw is hydraulically or electrically driven and signals are applied to the drive means for varying the feed screw pressure. Variations in the driving force of the feed screw are designed to offset the forces tending to vary the spacing between the rolls whereby a constant roll spacing, and therefore a product of constant thickness can be achieved. The method according to the invention, however, does control the nip roller speed, whereas the supply speed of the powder to the nip rollers as well as the distance between the nip rollers are maintained substantially constant.

JP 2009 149960 is related to a powder-rolling apparatus for manufacturing a clad material by compression-bonding a powder to the surfaces of a base material. It comprises a pair of rolling rolls which are provided rotatably around axis lines that extend toward a horizontal direction in parallel, and are arranged so as to face each other while sandwiching the base material so that the outer peripheral surfaces respectively press one surface and the other surface of the surfaces of the base material. The pair of the rolling rolls are arranged such that one rolling roll is provided in the upper part with respect to the other rolling roll which transports the powder that has been supplied onto the outer peripheral surface along with the rotation and compression-bonds the powder to the base material. JP 2009 149960 is related to a coating device rather than a compaction device. Only a limited amount of the powder is transported to the area between the plate to be coated and the roller. In fact, there is no nip area between the rollers

because of the presence of the plate to be coated. In a compaction device the nip area between the nip is entirely filled by powder and it is only powder that passes through the nip area and between the nip rollers.

5 The invention will hereafter be elucidated with reference to drawings illustrating an embodiment of the invention schematically.

Fig. 1 is an illustrative side view of an embodiment of a compaction device according to the invention.

10 Fig. 2 is an enlarged view of a part of the embodiment as shown in Fig. 1.

Fig. 3 is a bottom view of the embodiment of Fig. 1.

Fig. 4 is a block diagram, illustrating an embodiment of the method of compaction of the powder by means of the compaction device as shown in Fig. 1.

15 Powder coatings which are produced by milling result in a relatively broad size range. Particles at both ends of the size range that are undesired for the powder coating process are removed and collected. The collected powder waste can be re-used for the powder coating process by compaction or dry bonding in order to form a hard solid that can be directly re-milled or re-ground to form a powder coating. This means that the compacted powder can be returned to the milling device during the same production batch.

25 Fig. 1 shows an embodiment of a roller compaction device 1 according to the invention. The roller compaction device 1 comprises two counter-rotating nip rollers 2, 3 as indicated by arrows in Fig. 1. A powder P, for example fine polymeric particles that may be smaller than 10 μm , is fed to a storage device, in this case a hopper 4. The nip rollers 2, 3 are driven separately by electric motors (not shown). This means that the nip rollers 2, 3 can be driven independently from each other.

35 The powder P is transported from the hopper 4 to a nip area between the nip rollers 2, 3 by means of a feed screw 5. In this embodiment the feed screw 5 runs at a fixed speed such that the powder P is transported at a constant supply speed to the nip rollers 2, 3. In an alternative embodiment the feed screw 5 may be operated at a variable speed, if desired. When the powder

P is transported by the feed screw 5 air can be removed and the bulk density may be increased without deforming the particles. Additionally, vibration and/or vacuum filtration may be applied to increase the bulk density at the feed screw 5.

Fig. 2 shows a transport region of the powder P between the feed screw 5 and a narrowest gap between the nip rollers 2, 3 in more detail. The powder P passes a slip region S and subsequently a nip region N. In the nip region N the powder moves at substantially the same speed as the circumferential speeds of the nip rollers 2, 3. In the nip region N the fine particles are compressed such that they form a hard sheet when leaving the narrowest gap between the nip rollers 2, 3. In practice the sheet may have a thickness of 5-10 mm, but a thinner or thicker sheet is conceivable. In the embodiment as shown in Figs. 1 and 2 the narrowest gap is constant since the relative positions of the nip rollers 2, 3 are fixed, but in an alternative embodiment the distance between the nip rollers 2, 3 may be adjustable.

The process of compaction of the powder P can be controlled in order to maintain an appropriate quality of the resulting sheet of compacted powder. In the embodiment as shown in Figs. 1 and 2 the quality is maintained by determining friction between the powder P and the nip rollers 2, 3 and controlling the rotational speed of the respective nip rollers 2, 3. The friction level is determined by measuring the electrical power consumption of the respective electric motors at their respective speeds. The friction level between the powder P and a nip roller at a certain rotational speed thereof is higher when the measured electrical power consumption is higher. The force by the corresponding nip roller exerted on the powder P at the corresponding speed of the nip roller is indirectly measured in this way. In an alternative embodiment the force can be derived by measuring the reaction force in said nip roller, for example by means of a strain gauge.

Fig. 3 shows the nip rollers 2, 3 separately as seen from below in Fig. 1. It can be seen that the nip rollers 2, 3 have cylindrical centre portions whereas the respective axial end portions are shaped differently. One of their nip rollers 2 has a diabolo-shape, whereas the other nip roller 3 has

frustoconical opposite axial end portions which are shaped complementarily. In other words, each of the nip rollers 2, 3 has opposite tapered axial end portions, converging in outward direction at one of the nip rollers 3 and diverging in outward direction at the other nip roller 2. It appears that the end portions shaped in this way minimize loss of the powder P at the axial ends of the nip rollers 2, 3. The nip rollers 2, 3 have smooth circumferential surfaces, but in an alternative embodiment the nip rollers 2, 3 may be provided with embossed surfaces.

The roller compaction device 1 is also provided with a controller 6 for adjusting the rotational speeds of the nip rollers 2, 3. Fig. 4 shows a block diagram that illustrates how the controller 6 works in a schematic way. In this embodiment the controller 6 comprises a PLC (Programmable Logic Controller) or PAC (Programmable Automation Controller) which controls a first drive control 7 for setting the speed of the feed screw 5, a second drive control 8 for setting the rotational speed of the electric motor of one of the nip rollers 2 and a third drive control 9 for setting the rotational speed of the electric motor of the other nip roller 3. The electric motors may be controlled by means of a variable frequency inverter drive in order to be able to adjust their rotational speeds. The controller is also provided with a user interface 10 which provides an operator information in respect of several process parameters.

Fig. 4 shows six relevant input signals to the PLC 6: two actual speed levels of the respective electric motors, and two actual voltage and electrical current levels to the respective electric motors. The actual input signal values are compared with desired values, possibly after converting the values to physical parameters. If the controller detects a difference between the actual level and the desired level of a certain parameter the rotational speed of one or both nip rollers 2, 3 is adjusted. For example, if at a certain rotational speed of both nip rollers 2, 3 the electrical current to both electric motors is higher than a desired value at that speed, the friction between the nip rollers 2, 3 and the powder P has become too high and the controller 6 increases the speeds of the nip rollers 2, 3.

The invention is not limited to the embodiment as shown in the drawings and described hereinbefore, which may be varied in different manners within the scope of the claims. For example, the friction between the nip rollers and the powder may
5 be determined in an alternative manner.

CLAIMS

1. A method of compaction of a powder (P) by means of nip rollers (2, 3), wherein the powder (P) is transported at a supply speed to a nip area between the nip rollers (2, 3) and friction between at least one of the nip rollers (2, 3) and the powder (P) at said nip roller (2, 3) is determined, wherein
5 depending on the friction the rotational speed of at least one of the nip rollers (2, 3) is adjusted, whereas the supply speed of the powder (P) to the nip rollers (2, 3) as well as the distance between the nip rollers (2, 3) are maintained
10 substantially constant.

2. A method according to claim 1, wherein the friction is determined by means of determining the force by said nip roller (2, 3) exerted on the powder (P) at a certain speed of the nip roller (2, 3).

15 3. A method according to claim 2, wherein the force is derived by measuring a reaction force in said nip roller (2, 3).

4. A method according to claim 2, wherein said nip roller (2, 30) is driven by an electric motor and the force is
20 derived by determining the electrical power consumption of the electric motor at a certain speed thereof.

5. A method according to one of the preceding claims, wherein the rotational speed of said nip roller (2, 3) is adjusted on the basis of the friction at said nip roller (2, 3).

25 6. A method according to one of the preceding claims, wherein the nip rollers (2, 3) are driven independently from each other.

7. A method according to claim 6, wherein the friction levels between the powder (P) and both nip rollers (2, 3) are determined and the rotational speeds of both nip rollers (2, 3) are adjusted independently from each other.
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8. A roller compaction device (1) for compaction of a powder (P), comprising nip rollers (2, 3) and a feeder (5) for transporting a powder (P) to a nip area between the nip rollers (2, 3), a sensing apparatus for determining the friction between
35 at least one of the nip rollers (2, 3) and the powder (P) at said nip roller (2, 3), and a controller for adjusting the

rotational speed of at least one of the nip rollers (2, 3), depending on the friction, whereas the speed of the feeder (5) as well as the distance between the nip rollers (2, 3) is substantially constant.

5 9. A roller compaction device (1) according to claim 8, wherein said nip roller is driven by an electric motor, and wherein measurement devices for determining the electrical power consumption and speed of the electric motor are connected to the controller.

10 10. A roller compaction device (1) according to claim 8 or 9, wherein the circumferential surfaces of the nip rollers (2, 3) are smooth.

15 11. A roller compaction device (1) according to one of the claims 8-10, wherein one of the nip rollers (2, 3) has a diabolo-shape, whereas the other nip roller (2, 3) has frustoconical opposite axial end portions which are shaped complementarily.

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