The invention relates to a drum which has a wall, wherein at least the inside of the wall is provided with a surface of insulating material, an opening, defined by wall segments of the wall, radially spaced from one another with respect to a central rotational axis of the drum, and a drive mechanism for rotating the drum in a first or in a second direction, wherein at least one first electrode is arranged on the inside of the wall, and wherein at least one counter electrode is arranged on or between a central axis of the drum and the wall, and a method for coating workpieces.
DRUM AND METHOD FOR COATING WORKPIECES WITH A NON-METALLIC COATING

[0001] The invention relates to a drum and a method for coating workpieces with a non-metallic coating, in particular, a corrosion-protective coating.

[0002] A method for coating small parts with a non-metallic coating in a continuous automated coating machine is well known. Herein small parts are transported by a screw conveyor (Archimedes screw) through the coating agent and are thereby coated by the coating agent. This method and the automated machine designed therefor are, however, only suitable for coating small workpieces, such as small screws, nuts or washers.

[0003] The use of so-called G-drum is known from the field of electroplating, i.e. from a field concerned with the application of metal coatings to workpieces, usually also of metal. Electroplated layers are deposited on the workpieces, while no drying process is required after the coating process. The G-drum is approximately half full during the coating process to achieve cost-effective processing.

[0004] It is therefore an object of the present invention to provide an apparatus and a method for coating metal workpieces, wherein larger workpieces, in particular mass production components such as larger screws, can also be coated economically.

[0005] The object is solved by an apparatus according to claim 1 and a method according to claim 12.

[0006] The drum according to the present invention comprises a wall, wherein at least the inside of the wall has a surface of insulating material, an opening, defined by sections of the wall, which are arranged radially spaced from one another with respect to the central rotational axis of the drum, and a drive mechanism for rotating the drum in a first or in a second direction. The drum according to the present invention further features at least one first electrode, arranged on or at the inside of the wall and at least one counter electrode arranged on or between a central axis of the drum and its wall.

[0007] This drum enables larger workpieces than was previously possible, in particular larger mass production components of conductive material, to be coated, in particular with an insulating coating. The insulating coating is preferably a corrosion protection coating. Larger mass production components, such as larger screws, rings, clamps and the like routinely have to be coated. An apparatus designed specifically for processing components of this type achieves particularly cost-efficient coating of larger mass production components.

[0008] According to a first preferred embodiment of the drum according to the present invention the first electrode is formed as a cathode. The arrangement of the cathode on or in the wall of the drum ensures particularly uniform and rapid coating of the workpieces in a cathophoretic coating method. According to a second preferred embodiment of the drum according to the present invention, the first electrode is formed as an anode, whereby the drum according to the present invention is also suitable for anaphoretic coating methods.

[0009] An advantageous embodiment of the drum according to the present invention provides that more than one first electrode is arranged on the inside of the drum wall. In principle, the drum can function with a single first electrode, in particular if it has a suitably large dimension. It is, however, preferable to arrange a plurality of first electrodes on or in the wall of the drum to ensure rapid and uniform coating and to enable the drum to accommodate different filling levels when batches are coated in succession. Uniform, rapid and flexible coating results can be achieved using at least five first electrodes, preferably at least seven first electrodes.

[0010] The first electrode can be arranged in various ways. Conceivably, the first electrode or first electrodes can be fixed on or into the inside of the wall using screws, snap locking, adhesion or casting. The procedure of connection selected depends, among other things, on the design of the drum, the material it is composed of, the type of electrode(s) utilized and the coating processes to be carried out in the drum.

[0011] According to an advantageous embodiment, the drum is provided with a counter electrode, formed as a curved segment. This can be either a one-part counter electrode with a comparatively large surface area, or alternatively a plurality of counter electrodes arranged on an arcuate mounting. The counter electrode can be suitably arranged and aligned in accordance with the workpieces to be coated, and the intended coating method (cathophoretic, anaphoretic). According to a simple embodiment, the at least one counter electrode can be arranged directly on the central axis of the drum according to the present invention. However, it is preferable to arrange the counter electrode or counter electrodes halfway between the central axis and the wall of the drum. The spatial arrangement of the counter electrode is thus proximal to the coating process. The filling level envisaged in the drum during the coating process is preferably less than half the distance between the axis and the wall of the drum, thereby ensuring that the preferred arrangement of the counter electrode, halfway between the axis and wall of the drum, contributes to a particularly uniform coating result. The operation of the drum is, however, still guaranteed even if the counter electrode is arranged at any other position between the central axis and the wall of the drum.

[0012] Preferably, the inner surface of the drum wall is manufactured of an insulating material. The drum wall can be either entirely of plastic material, e.g. polyethylene, or any other insulating material, such as glass or ceramic, or it can be manufactured of a material covered with an insulating coating, for example, the wall can be made of metal coated with an insulating layer of Teflon or any other insulating organic or inorganic material. An inner surface of insulating material is particularly advantageous when corrosion-protective coatings are applied in the drum, which are to be deposited on conductive surfaces, in particular. In the preferred embodiment of the drum, a loss of corrosion protection agent is avoided, because it cannot be deposited on insulated surfaces.

[0013] The drum according to claim 1 can be manufactured in various ways. The wall of the drum can be formed in one-piece, for example, of plastic material. It can also be formed in one piece from a sheet of metal, if required, sheet metal with a Teflon coating. For reasons of simple manufacture and assembly, however, it is preferable that the wall of the drum be composed of a plurality of segments. Accordingly, individual segments can be particularly easily equipped with electrode(s) before assembly, and mounting of the counter electrode can be carried out in a simple manner. If during operation of the drum, the wall or the insulating coating possibly applied is damaged, individual segments can simply be replaced. Repairing a drum manufactured in one-piece is more complex.
The drum according to the present invention has overlapping wall sections, arranged radially spaced from one another with respect to the central rotational axis of the drum. Consequently, the drum is shaped in the form of a "G". The walls overlap by at least 15°, preferably at least 30° of the entire circumference of 360°, as seen from an end of the drum. This overlapping of the wall sections ensures that the workpieces to be coated are well mixed, while at the same time, enabling the drum to be emptied simply and quickly, even when filled to a higher level.

According to a particularly preferred embodiment of the invention, the drum is aligned in such a way during the coating process that the gap formed by the overlapping sections of the wall is above the level of the coating agent. The wall sections of the drum located above the level of the coating agent, in this drum position, are perforated at least in parts. The perforation of these upper wall sections achieves the fast passage of coating agent through the wall of the drum, both during emptying and filling of the drum with workpieces to be coated and/or coated workpieces, respectively.

The drum according to claim 1 can be utilized as it is. It is, however, preferable to enclose the drum and, if required, the driving mechanism, in a housing to ensure safe and low-noise operation of the drum.

The invention further provides a method for coating workpieces of conductive material with a non-metallic coating in particular of a corrosion protection coating, in a drum, comprising:

- a wall, wherein at least the inside of the wall is provided with a surface of insulating material,
- an opening, formed by wall segments, radially spaced from one another with respect to the central rotational axis of the drum,
- a drive mechanism for rotating the drum in a first direction or a second direction,
- at least one first electrode, arranged on or in the inside of the wall, and
- at least one counter electrode, arranged on or between a central axis of the drum and its wall, comprising the steps of:
  - loading the drum with liquid coating agent and workpieces in a predefined proportion,
  - venting the workpieces,
  - halting the drum,
  - applying, maintaining, and switching-off electrical voltage, and finally
  - emptying the drum.

Unlike with prior art electroplating methods, an insulating coating is applied to the workpieces in the present method. Surprisingly it has been found that this insulating coating, usually a corrosion-protective layer, can be applied efficiently, economically, quickly and reliably by means of these relatively simple steps of, loading the workpieces and coating agent, venting and coating under the application of electrical voltage and finally by simply emptying the drum after the electric voltage has been switched off. The workpieces to be coated are conductive, and preferably of metal or metal alloys, which as a rule result in uniform coating due to their excellent conductivity.

The movement of the drum—the rotation—has the effect of venting the workpieces thus ensuring uniform and total immersion of the workpieces in the coating agent. According to a preferred further embodiment of the method according to the present invention, the drum rotates at least intermittently even during the coating process, i.e. during the application of voltage. In this way, surface defects in the coating can be avoided. The coating agent may not fully penetrate in places where workpieces are immediately adjacent to one another, so that the resulting coating is not uniformly thick. These variations in the layer thickness of the coating can be avoided if the drum rotates at least intermittently during the coating process.

According to a preferred further embodiment of the method according to the present invention, the coated workpieces are separated and, if necessary, freed of excess coating agent after discharge from the drum. This step ensures that the coating is not damaged by workpieces knocking together or lying on top of each other. The excess coating agent is collected and, if technically feasible, is reused.

The method according to the present invention is advantageously followed by a subsequent step of curing if the applied coating agent is not already permanently cured or hardened when deposited on the workpiece. Curing can either be carried out in the drum itself, advantageously after the excess coating agent has been removed. It is preferable, however, if curing is carried out after the workpieces have been removed from the drum and, if necessary, have been separated from each other. Subsequent to curing, the coating agent is still not entirely hard but is smear-resistant and not prone to damage or wear under normal transport conditions. The procedure selected for curing and/or hardening, whether using heat, for example, or by introducing energy in another form, such as by irradiation, depends primarily on the selected coating agent and on the material of the workpiece.

The method according to the present invention is characterized by procedural conditions which differ greatly from those of well known electroplating methods. A voltage of at least 20 V, maximum 500 V is applied for coating. Preferably, the electrical voltage is in the range of at least 100 V to preferably 350 V, advantageously between 150 V and 250 V. Thus, the voltage is a multiple of the voltage applied in electroplating methods.

Consequently, relatively low currents in the range of 1 A up to 500 A, preferably of 10 A up to 400 A are required for the method according to the present invention. Particularly typical are currents of 1 A up to 350 A, advantageously of 1 A up to 200 A.

Depending on the coating agent utilized, coating is carried out at temperatures of 15°C to 60°C, preferably at temperatures of 20°C to 40°C, advantageously at temperatures of 25°C to 30°C. The coating process thus does not require additional energy for tempering the coating agent.

The duration of coating varies in a wide range of between 1 second and 10 minutes. The duration of coating can be suitably adjusted to correspond with the coating agent used and the requirements on the coating to be applied and on the coating thickness. In most cases, the duration of coating ranges between 10 seconds and 120 seconds, predominantly between 30 seconds and 90 seconds.

Details of the invention and the method according to the present invention will now be explained in more detail with reference to an exemplary embodiment, wherein:

FIG. 1 is a sectional view of a G-drum according to the present invention.

Drum 2 is composed of a number of planar segments 4. Segments 4 are arranged in the form of a polygonal succession of line segments around a central rotational axis 6. Segments 4 are formed of steel plates which are coated with...
Teflon on the inside of drum 2. Segments 4a, 4b on the ends overlap one another. With respect to the entire circumference of 360º, segments 4a and 4b overlap each other by approximately 30º. Herein, segment 4a is arranged closer to axis 6 than segment 4b, whereby these two segments 4a, 4b define an opening 8. FIG. 1 shows the G-drum 2 in the operating position, i.e. for coating workpieces. The lower section of wall 4 is closed. The upper section of wall 4 is perforated to enable the rapid discharge of coating agent when filling and emptying the drum. Wall 4 is provided with seven cathers 10, which are fixed into wall 4 by screws. They are arranged on those segments of wall 4 located below axis 6, when opening 8 is at the highest position above axis 6.

[0039] The coating agent and workpieces (not shown here) lie on the segments equipped with cathers 10, of wall 4, before and during the coating process.

[0040] A mount 12 is arranged on the central rotational axis 6. This mount 12 supports anode 14, comprising a plurality of individual small anodes. Anode 14 is arranged approximately halfway between axis 6 and wall 4 below by means of mount 12.

[0041] Drum 2 is fixed into a housing 16 in an anti-twist manner. A drive mechanism 18 engages with housing 16. The drive mechanism 18 can rotate housing 16—and therefore drum 2—both in a first, clockwise direction and in a second, antitwistwise direction. As shown in FIG. 1, rotation of the drum in the first direction (clockwise) has the effect of emptying drum 2. Rotation of drum 2 in the second direction (antitwistwise) mixes and, as described above, vents the contents of drum 2, namely the coating agent and workpieces to be coated.

[0042] To carry out the method according to the present invention, the drum described and depicted in FIG. 1 is used as follows: the workpieces to be coated and the coating agent are measured, usually weighed, and loaded into drum 2 in a predetermined proportion to one another. For this purpose, drum 2 can be turned to a position at which opening 8 enables easy filling of the drum.

[0043] The drum is filled to level “F” as depicted in FIG. 1. Level F is well below that known from electroplating methods, as this is the only way of ensuring uniform depositing of coating agent on the workpieces. The drum is then rotated by drive mechanism 18 at least once, preferably about five times in the second direction, i.e. antitwistwise. This has the effect of venting the workpieces and immersing them entirely in coating agent. The coating agent is a liquid, corrosion protection agent with an electrically insulating effect, such as “Delta®- Protekt” retailed by the applicant. The coating is applied at 30º C. The duration of the coating process is approximately 60 seconds.

[0044] After venting, the drive mechanism 18 is switched off and drum 2 comes to rest at the position depicted in FIG. 1. The workpieces and coating agent are now in contact with cathers 10, screwed into wall 4 of drum 2. Current is then applied at a voltage of 300 V and at a current of 300 A. Under the application of voltage the drive mechanism 18 rotates drum 2 once in an antitwistwise direction, causing the workpieces to be uniformly coated with coating agent. Once the coating has been deposited on the workpieces, the current is switched-off.

[0045] Drive mechanism 18 rotates drum 2 in a clockwise direction thus discharging the coating agent and the coated workpieces from drum 2. The workpieces are discharged onto an endless conveyer belt moving at a speed selected to achieve that the workpieces are separated from one another. The conveyer belt is provided with outlets for the coating agent which accumulates in a basin under the conveyer belt and is collected for the next coating cycle. The endless conveyer belt transports the coated workpieces, on which the coating adheres but is not permanently cured, to a continuous furnace, wherein the coating is cured at elevated temperatures.

1. A drum, comprising a wall (4), wherein at least the inside of the wall is provided with a surface of insulating material, an opening (8), defined by wall segments (4a, 4b) of the wall (4), radially spaced from one another with respect to a central rotational axis (6) of the drum (2), and a drive mechanism (18) for rotating the drum (2) in a first or in a second direction, wherein at least one first electrode (10) is arranged on the inside of the wall, and wherein at least one counter electrode (14) is arranged on or between a central axis of the drum (2) and the wall (4).

2. The drum according to claim 1, wherein the first electrode (10) is a cathode or an anode.

3. The drum according to claim 1, wherein at least two first electrodes (10) are arranged on the inside of the wall (4) of the drum (2).

4. The drum according to claim 1, wherein the at least one first electrode (10) is fixed on or into the inside of wall (4) using screws, snap locking, adhesion or casting.

5. The drum according to claim 1, wherein the counter electrode (14) is formed as an arcuate segment.

6. The drum according to claim 1, wherein the at least one counter electrode (14) is arranged halfway between the central axis and the wall (4) of the drum (2).

7. The drum according to claim 1, wherein at least the inner surface of the drum wall (4) is of plastic material.

8. The drum according to claim 1, wherein the wall (4) is either manufactured in one piece or is composed of a plurality of segments (4a, 4b).

9. The drum according to claim 1, wherein the segments (4a, 4b) of the wall (4), arranged radially spaced from one another, overlap by at least 15º of 360º.

10. The drum according to claim 1, wherein, in an operating state, the drum (2) comprises above the level of the coating agent a wall (4) being perforated at least in parts.

11. The drum according to claim 1, wherein the drum (2) is arranged in a housing (16).

12. A method for coating workpieces of conductive material with a non-metallic coating, in particular a corrosion protective coating, in a drum (2), comprising a wall (4), wherein at least the inside of the wall (4) is provided with a surface of insulating material, an opening (8), formed by wall segments (4a, 4b) of the wall (4), radially spaced from one another, a drive mechanism (18) for rotating the drum (2) in a first or in a second direction, at least one first electrode (10), arranged on the inside of the wall (4), and at least one counter electrode (14), arranged on or between a central axis of the drum (2) and its the wall (4), comprising the steps of:

- loading the drum with liquid coating agent and workpieces in a predefined proportion,
- coating the workpieces, venting the workpieces, halting the drum (2),
applying, maintaining and switching off electrical voltage, and subsequently
emptying the drum (2).
13. The method according to claim 12, wherein the work-
   pieces to be coated are made of metal.
14. The method according to claim 12, wherein venting the
   workpieces in the coating agent is achieved by rotating the
   drum (2).
15. The method according to claim 12, wherein the drum
   (2) rotates at least intermittently during the application of
   voltage to avoid uncoated places in the coating to be applied
   to the workpieces.
16. The method according to claim 12, wherein the coated
   workpieces are separated and, if necessary, freed of excess
   coating agent after discharge from the drum (2).
17. The method according to claim 12, wherein the applied
   coating is cured after discharge from the drum (2).
18. The method according to claim 12, wherein the coating
   process is carried out under application of a voltage in the
   range of 20 V to 500 V.
19. The method according to claim 12, wherein the coating
   process is carried out using current in the range of 1 A to 500
   A.
20. The method according to claim 12, wherein the coating
   process is carried out at temperatures of 15°C to 60°C.
21. The method according to claim 12, wherein the coating
   process is carried out over a time period of 1 second to 10
   minutes.
22. The drum according to claim 3, wherein at least five
   electrodes (10) are arranged on the inside of the wall (4) of
   the drum (2).
23. The drum according to claim 3, wherein at least seven
   electrodes (10) are arranged on the inside of the wall (4) of
   the drum (2).
24. The drum according to claim 7, wherein the plastic
   material is selected from the group consisting of polyethyl-
   ene, ceramic, a material covered with an insulating material
   and combinations thereof.
25. The drum according to claim 9, wherein the segments
   (4a, 4b) of the wall (4) overlap by at least 30° of 360°.
26. The method according to claim 12, wherein the coating
   process is carried out under application of a voltage in the
   range of 100 V to 350 V.
27. The method according to claim 12, wherein the coating
   process is carried out under application of a voltage in the
   range of 150 V to 250 V.
28. The method according to claim 12, wherein the coating
   process is carried out using current in the range of 1 A to 400
   A.
29. The method according to claim 12, wherein the coating
   process is carried out using current in the range of 1 A to 350
   A.
30. The method according to claim 12, wherein the coating
   process is carried out using current in the range of 1 A to 200
   A.
31. The method according to claim 12, wherein the coating
   process is carried out at temperatures of 20°C to 40°C.
32. The method according to claim 12, wherein the coating
   process is carried out at temperatures of 25°C to 30°C.
33. The method according to claim 12, wherein the coating
   process is carried out over a time period of 10 seconds to 120
   seconds.
34. The method according to claim 12, wherein the coating
   process is carried out over a time period of 30 seconds to 90
   seconds.