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(54) Title: AN ELECTROSTATICALLY ATOMIZING EQUIPMENT AND A METHOD FOR CHARACTERIZING ATOMIZATION OF AN INDIRECT CHARGING ATOMIZER

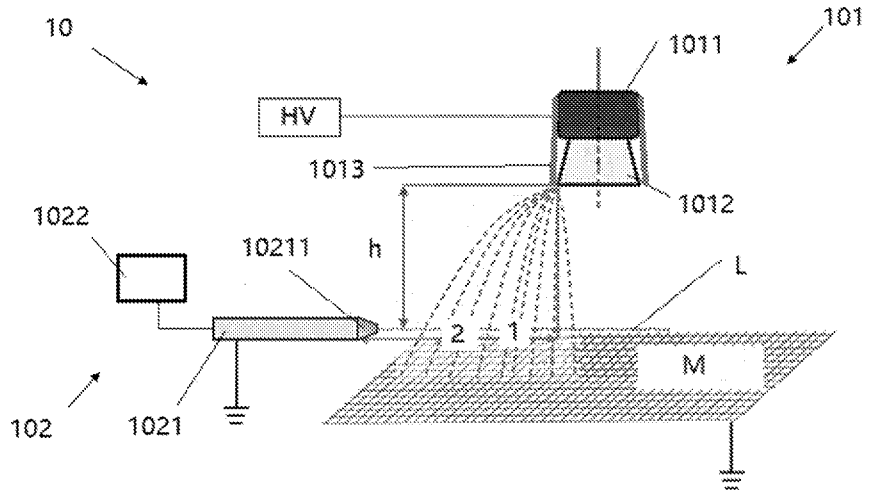

Figure 1

(57) Abstract: This invention provides an electrostatically atomizing equipment, comprising parts of: (A) an indirect charging atomizer comprising a rotary bell cup for atomizing and dispensing an electrically non-insulative coating composition, (B) an indirect charging part having an input port for connection with a high voltage power that is fixed to the bell cup for electrostatically charging the atomized and dispensed coating composition, and (C) a device for quantitatively characterizing the atomization of the indirect charging atomizer comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition, wherein said optical measurement part is grounded and kept substantially equipotential to the bell cup of the indirect charging atomizer. And this invention also provides a method for characterizing atomization of the invented electrostatically atomizing equipment.

WO 2025/051152 A1

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AN ELECTROSTATICALLY ATOMIZING EQUIPMENT AND A METHOD FOR CHARACTERIZING ATOMIZATION OF AN INDIRECT CHARGING ATOMIZER

TECHNICAL FIELD

The invention relates to an electrostatically atomizing equipment and a method for characterizing atomization of an indirect charging atomizer.

BACKGROUND

Nowadays in automotive industry there are various coating compositions, such as coating composition for basecoat that is often applied onto substrates through atomization, for example by using electrostatically atomizing equipment. Painting in automotive OEM (original equipment manufacturer) production lines always use high voltage to atomize coating materials through charging static electricity in order to increase the efficiency of applying (i.e. increasing the amount of coating droplet that are finally deposited on the substrate) and decrease overspray which may cause contamination and surface defects such as pinholes after curing or baking of the coating composition.

Characteristic parameters of atomization, such as size and quantity of atomized coating droplets as well as droplet size distribution and homogeneity of spray formed by atomization are used to characterize and evaluate atomization of coating composition. For example, smaller droplet size and larger quantity of droplets indicate a higher degree of atomization and homogeneity of spraying.

In automotive OEM production lines, or painting laboratories, atomization is accomplished by electrostatically atomizing equipment, particularly an indirect charging atomizer with a rotary bell cup and is subject to many influencing factors such as the rotation speed of the bell cup, shaping air, flowrate of the liquid paint, and the high voltage applied to the atomizer. Thus, the atomization of the electrostatically atomizing equipment could be managed by adjusting the influencing factors.

However, there is no deep dive into the correlation between the high voltage applied to the atomizer through electrostatically charging and the characteristic parameters of the atomization for example, the droplet size distribution of the spraying. Thus, the qualities of coating layers after curing or baking could be only controlled based on empiric and repetitive experiments are required to pick out best conditions.

Therefore, it is still required to provide a method for charactering atomization through which the coating spraying could be accurately controlled and an electrostatically atomizing equipment thereof.

SUMMARY OF THE INVENTION

In one aspect, the present invention provides an electrostatically atomizing equipment, comprising parts of:

(A) an indirect charging atomizer comprising a rotary bell cup for atomizing and dispensing an electrically non-insulative coating composition,
(B) an indirect charging part having an input port for connection with a high voltage power that is fixed to the indirect charging atomizer for electrostatically charging the atomized and dispensed coating composition, and
(C) a device for quantitatively characterizing the atomization of the indirect charging atomizer comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition, wherein said optical measurement part is grounded and kept substantially equipotential to the bell cup of the indirect charging atomizer.

In another aspect, the present invention provides a method for characterizing atomization of the invented electrostatically atomizing equipment, comprising steps of:
(i) spraying a coating composition atomized by the electrostatically atomizing equipment through a rotary bell cup,
(ii) detecting the atomized coating composition by an optical measurement part, and
(iii) determining characteristic parameters of atomization based on data obtained through the optical measurement part.

DETAILED DESCRIPTION OF THE INVENTION

The undefined article “a”, “an”, “the” means one or more of the species designated by the term following said article.

In the context of the present disclosure, any specific values mentioned for a feature (comprising the specific values mentioned in a range as the end point) can be recombined to form a new range.

In the context of the present disclosure, each aspect so defined may be combined with any other aspect or aspects unless clearly indicated to the contrary. In particular, any feature indicated as being preferred or advantageous may be combined with any other feature or features indicated as being preferred or advantageous.

In the context of the present disclosure, “coating” and “paint” is used alternatively to express the same meaning, i.e. a substance composed of solid matters suspended in a liquid medium and applied as a protective or decorative coating to surfaces of various substrates.

In the automotive OEM industry, the liquid coating materials, including primer, basecoat, and clearcoat, are sprayed to car body surfaces via atomizers. To maximize transfer efficiency and minimize overspray, atomizers working electrostatically usually by application of high voltage (i.e. electrostatically atomizers), have been the majority in the paint shops of car production factories. Among the atomizers working electrostatically, indirect/external charging atomizers, for example, Duerr ecobell EXT and ABB RB1000

EXT, are widely used for electrically non-insulative coating materials, for example, water-base coating materials or water-borne liquid paint, in automotive OEM production lines worldwide, which involve high voltage up to 100,000 volts.

The present invention provides an electrostatically atomizing equipment, comprising parts of:
(A) an indirect charging atomizer comprising a rotary bell cup for atomizing and dispensing an electrically non-insulative coating composition,
(B) an indirect charging part having an input port for connection with a high voltage power that is fixed to the indirect charging atomizer for electrostatically charging the atomized and dispensed coating composition, and
(C) a device for quantitatively characterizing the atomization of the indirect charging atomizer comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition, wherein said optical measurement part is grounded and kept substantially equipotential to the bell cup of the indirect charging atomizer.

The present invention also provides a method for characterizing atomization of the invented electrostatically atomizing equipment, comprising steps of:
(i) spraying a coating composition atomized by the electrostatically atomizing equipment through a rotary bell cup,
(ii) detecting the atomized coating composition by an optical measurement part, and
(iii) determining characteristic parameters of atomization based on data obtained through the optical measurement part.

By implementing the method of the present invention, it is possible to improve properties of coating layers by electrostatically charging atomization, especially to overcome surface defects such as pinholes and clouding. Moreover, it is helpful to figure out whether the coating composition is homogeneous to avoid surface defects of coating layers such as streaks. All in all, the invented method provides a simple, efficient and cost-saving approach to screen coating formulations.

EMBODIMENT

Below embodiments further illustrate how this invention could be carried out.

Embodiment 1

An electrostatically atomizing equipment, comprising parts of:
(A) an indirect charging atomizer comprising a rotary bell cup for atomizing and dispensing an electrically non-insulative coating composition,
(B) an indirect charging part having an input port for connection with a high voltage power that is fixed to the indirect charging atomizer for electrostatically charging the atomized and dispensed coating composition, and
(C) a device for quantitatively characterizing the atomization of the indirect charging

atomizer comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition, wherein said optical measurement part is grounded and kept substantially equipotential to the bell cup of the indirect charging atomizer.

Embodiment 2

The electrostatically atomizing equipment according to embodiment 1, wherein said device for quantitatively characterizing the atomization of the indirect charging atomizer comprises a data collecting and processing unit that collects optical data from the optical measurement part and determines characteristic parameters of atomization based on collected data.

Embodiment 3

The electrostatically atomizing equipment according to embodiment 2, wherein the characteristic parameters comprise average size and size distribution of droplets of atomized coating composition after spraying and homogeneity of spraying.

Embodiment 4

The electrostatically atomizing equipment according to any one of embodiments 1 to 3, wherein it comprises a grounded metal mesh placed in a plane substantially parallel to a mouth plane of rotary bell cup.

Embodiment 5

The electrostatically atomizing equipment according to embodiment 4, wherein the shortest path between the plane of metal mesh and the bottom plane of rotary bell cup is in a range of from 15cm to 50cm and preferably from 20cm to 30cm.

Embodiment 6

The electrostatically atomizing equipment according to any one of embodiments 1 to 5, wherein the optical measurement part has a metal mask at its head portion comprising through holes for passage of light emitted by the head portion of the optical measurement part.

Embodiment 7

The electrostatically atomizing equipment according to any one of embodiments 1 to 6, wherein the light source of the optical measurement part is laser.

Embodiment 8

The electrostatically atomizing equipment according to any one of embodiments 1 to 7, wherein the indirect charging part is fixed to atomizer header that has an input port connected to a high voltage power.

Embodiment 9

A method for characterizing atomization of the electrostatically atomizing equipment according to any one of embodiments 1 to 8, comprising steps of:
(i) spraying a coating composition atomized by the electrostatically atomizing equipment through a rotary bell cup,
(ii) detecting the atomized coating composition by an optical measurement part, and
(iii) determining characteristic parameters of atomization based on data obtained through the optical measurement part.

Embodiment 10
The method according to embodiment 9, wherein in step (i) a grounded metal mesh is placed in a plane substantially parallel to a mouth plane of rotary bell cup.

Embodiment 11
The method according to embodiment 10, wherein the shortest path between the plane of metal mesh and the bottom plane of rotary bell cup is in a range of from 15cm to 50cm and preferably from 20cm to 30cm.

Embodiment 12
The method according to any one of embodiments 9 to 11, wherein in step (i) the indirect charging part is fixed to atomizer header that has an input port connected to a high voltage power.

Embodiment 13
The method according to any one of embodiments 9 to 12, wherein in step (ii) the optical measurement part has a metal mask at its head portion comprising through holes for passage of light emitted by the head portion of the optical measurement part.

Embodiment 14
The method according to any one of embodiments 9 to 13, wherein the light source of the optical measurement part is laser.

Embodiment 15
The method according to any one of embodiments 9 to 14, wherein in step (iii) the characteristic parameters comprise average size and size distribution of droplets of atomized coating composition after spraying and homogeneity of spraying.

DESCRIPTION OF FIGURES

FIG. 1 shows a schematic view of an electrostatically atomizing equipment according to the present invention.
FIG.2 shows a schematic structural diagram of an indirect charging atomizer of the electrostatically atomizing equipment according to the present invention.
FIG.3 shows comparison between characteristic parameters of the sprays formed by atomization under different voltages and rotation speeds.

EXAMPLE

The present invention will be better understood in view of the following non-limiting examples. The examples do not limit the scope of the invention as described and claimed.

FIG.1 shows an electrostatically atomizing equipment 10 according to the present invention, in which an electrostatically atomizer embodied in the form of an indirect/external charging atomizer 101, is used to atomize and dispense paint droplets towards a target, such as a substrate or a workpiece, and electrostatically charge the dispensed atomized paint droplets as they fly away from the atomizer.

Specifically, referring to FIG.2, the indirect/external charging atomizer 101, comprising an atomizer header 1011 and a grounded rotary bell cup 1012 (for example, with a rotation speed of 10-70kRPM), is supplied with liquid paint P (for example, a water base or water-borne coating composition) from a paint supply system. The atomizer atomizes the liquid paint by acting centrifugal force, forming filaments, to produce a spray in the form of droplets. The indirect/external charging atomizer 101 further comprises an indirect charging part 1013 which has an input port connected to a high voltage power supply HV and is operatively mounted with respect to the bell cup 1012.

In the atomizer shown in FIG.2, the liquid paint P is dispensed by breaking up into a large number of droplets by centrifugal force at an edge of the bell cup 1012 and then is indirectly charged by corona discharge from the indirect charging part 1013. The indirect charging part is embodied in the form of emitting electrode needles. Charging of the droplet takes place due to free ions produced from corona discharge at the electrode needles. Droplets are charged by contact with the ion flow during propagation through the electric field E created between the substrate W that is usually grounded and the droplets that are being charged. Since no continuous path exists between the indirect charging part 1013 and the paint supply system, shunting of the high voltage power supply to ground is avoided.

The atomizer can thus be referred to as an indirect charging atomizer or an external charging atomizer, in which external electrodes are used to produce free ions, interacting and thereby charging the already formed paint droplets after they leave the rotating bell cup.

For the indirect charging atomizer 101, the liquid paint is usually selected from electrically non-insulative, for example, water-borne, liquid paint, such as basecoat or primer, which has high electrical conductivity. By doing so, an insulating measure for the whole liquid supply system can be dispensed with.

The electrostatically atomizing equipment 10 in FIG.1 further comprises a device 102 for characterizing atomization of the atomizer. The device 102 comprises an optical

measurement part 1021 configured for optically capturing droplets of the spray produced by the atomizer. In the embodiment shown, the optical measurement part 1021 is grounded by a grounding cable and thus kept substantially equipotential to the bell cup 1012 of the indirect charging atomizer. Charges carried by the overspray droplets attached onto the optical measurement part can be released directly thereby. By having the optical measurement part and the atomizer spaced with each other by a proper distance, for example, of more than 150mm, the optical measurement part can be protected from being contaminated severely by flying paint droplets while avoiding high energy discharge therebetween. Hence, it is made possible to ensure that the optical measurement part can function safely and reliably.

The term "substantially equipotential" in the context means that the optical measurement part and the bell cup of the indirect charging atomizer are at substantially the same potential of zero, and the potential difference therebetween, if any, is kept so small that it can be negligible directly.

The term "high voltage" in the context used refers to a voltage having a magnitude above zero and, in most cases, lower than 100kV. It may vary according to the specific application of the electrostatically atomizers.

The optical measurement part 1021 is a laser measuring means, for example, an AOM SpraySpy sensor unit. The optical measurement part comprises a head portion from which light can be emitted and travels into the spray. In an area of the head portion, detector lenses are provided for allowing light transmission therethrough. Preferably, the optical measurement part is provided with a metal mask 10211 at the head portion or in the proximity of the head portion. The head portion (including especially the detector lenses) is covered by the metal mask and protected from contamination by the flying paint droplets. The metal mask 10211 comprises though holes for passage of light emitted from the head portion into the spray. The metal mask thus works as a Faraday cage shield, which may help to capture the flying paint droplets that will otherwise accumulate on and contaminate the detector lenses and thus to keep the detector lenses clean, protecting the laser transmission from being blocked and avoiding the optical measurement from failing.

The electrostatically atomizing equipment 10 comprises a grounded metal mesh M placed in a plane that intersects transversely with the spray. With the grounded metal mesh M, it is possible to trap the electric field and to shape the spray pattern (particularly the spray pattern between the plane where the metal mesh is located and the bell cup) and therefore to highly reduce overall overspray. In case that the bell cup 1012 is oriented downwards, the metal mesh M is placed vertically below the bell cup and is sized to have sufficient length and width so that the overall spray is shaped in a desired manner. In a preferable embodiment, the metal mesh is spaced from the edge of the bell cup of the indirect charging atomizer by a distance h of from 15cm to 50cm and preferably from 20cm to 30cm.

The device 102 for characterizing paint atomization of the atomizer comprises a data collecting and processing unit 1022 for collecting optical data obtained from the optical measurement part 1021 and determining characteristic parameters of atomization (for example, at least one characteristic parameter of droplet size distribution and/or of homogeneity of spraying) on a basis of optical data collected.

The indirect charging part 1013 of the indirect charging atomizer 101 is spaced from surrounding grounded objects (grounded objects that are placed near the atomizer, for example, optical measurement part, supporting stand for supporting the optical measurement part, panels or walls or substrates to be coated, and so on) by a predetermined distance, for example, of at least 20cm. By the distance between the indirect charging part and the optical measurement part, high voltage risks such as electric sparks caused by extremely high potential difference therebetween can be reduced to an acceptable level.

With the electrostatically atomizing equipment 10 of the present invention, a method for characterizing atomization can be implemented by taking following steps:
Step S01: producing a spray of electrostatically charged atomized coating composition by means of the indirect charging atomizer 101,
Step S02: optically capturing droplets of the spray by means of the optical measurement part 1021 wherein the optical measurement part is grounded and kept substantially equipotential to the bell cup of the indirect charging atomizer, and
Step S03: determining, by the data collecting and processing unit 1022, characteristic parameters of atomization (for example, at least one characteristic parameter of droplet size distribution and/or of homogeneity of spraying), on a basis of optical data obtained by the optical measurement part.

It is noted that “characteristic parameters of atomization” here refers to all the characteristic parameters that can be indicative of atomization behavior, including but not limited to characteristic parameters of droplet size distribution and/or of homogeneity of spraying arising from the atomization.

The droplets of the spraying formed by atomization in step S01 are captured optically by a traversing optical measurement L through the entire spray. The traversing optical measurement L may extend through the entire spray from outside to inside in an imaginary plane parallel to the substrate to be applied. It may go along a radial direction or a chord direction in relation to projection area of the spray on the imaginary plane, if the spray is imagined in the form of a cone. The implementation of this traversing measurement allows the entire spray and hence the entire droplet spectrum forming the spray, to be captured in its entirety. As a result, the capture of all of the droplet sizes forming the spray is made possible. The entire spray can be measured in its entirety and not just in individual regions of the spray. The traversing measurement allows point-

specific optical measurement of the droplets at numerous locations in the atomization spraying, and therefore determination in step S03 is achieved with higher precision. The optical capture is carried out by a fixed optical measurement at a fixed location inside the spray.

In step S02 of the method, the optical capture is accomplished by an optical measurement that is based on scattered light investigations on the droplets of liquid paint in spraying. And preferably at least one laser is used as light source in such measurement.
The optical capture in step S02 takes place preferably by means of PDA (phase doppler anemometry) and/or the time-shift technique (TS). From the optical data obtained when carrying out step S02 by means of PDA, it is possible in step S03 to determine at least one characteristic parameter of the droplet size distribution. From the optical data obtained in step S02 by means of TS, it is possible in step S03 to determine both of the droplet size distribution and the homogeneity of spraying.

The droplet size distribution in step S03 is determined by methods known to persons skilled in the art such as dN,50% (number-based median) and dV,50% (volume-based median). The homogeneity of spraying refers to the ratio between two quotients i.e. the ratio between T_1/T_{Total1} and T_2/T_{Total2}, wherein T_1 means the number of transparent droplets at the first position P1, T_2 means the number of transparent droplets at the second position P2, T_{Total1} means the number of all the droplets in the spray including transparent and non-transparent ones at the first position P1, and T_{Total2} means the number of all the droplets in the spray including transparent and non-transparent ones at the second position P2, wherein position P1 is closer to the center of the spraying than position P2, as shown in FIG.1. And preferably both positions are lying on a measuring axis passing through the spraying.

The invented method for characterizing atomization allows investigation on the differences between atomization with and without electrostatically charging for water-borne coating compositions. As shown in FIG.3, the higher the voltage is applied to the atomizer, the finer droplets are obtained.

The invented method for characterizing atomization allows investigation on how the rotation speeds of the bell cup influence the atomization effects. It can be seen in FIG.3, for water-borne coating composition, the higher the rotation speed of the bell cup leads to the smaller the dN,50% of the droplets. Moreover, when the rotation speed of the bell cup is around 25000rpm, the dN,50% of the droplets get reduced greatly by applying a voltage of about 45kV.

The invented method for characterizing atomization further comprises a step of placing a grounded metal mesh in a plane substantially parallel to the mouth plane of rotary bell cup. With the grounded metal mesh, an electric field can be created between the metal mesh and the charged droplets of coating, therefore the spray pattern is shaped to avoid

overspray. For the sake of safety, the metal mesh is put in a distance of from 15cm to 50cm, preferably from 20cm to 30cm, away from the edge of the bell cup of the atomizer.

The invented method for characterizing atomization comprises a step of covering a head portion of the optical measurement part with a metal mask comprising through holes for passing of light emitted from the head portion of the optical measurement part. The meal mask can capture flying paint droplets that otherwise may deposit on the head portion (i.e., lenses) of the optical measure part, and to keep the head portion clean.

The indirect charging part of the atomizer should be kept at a distance of at least 20cm, away from the surrounding grounded objects, so that the atomization of an external/indirect charging atomizer can be successfully and safely measured.

The invented method allows to directly measure electrostatic atomization of an indirect/external charging atomizer under high voltage. The obtained suitable conditions can be used for industrial applications, for example in basecoat paint shops of automotive OEM production lines.

By means of the invented method, it is possible to anticipate optical defects and/or surface defects of coating layers based on droplet size distribution and homogeneity of spraying. Sufficient atomization could reduce the wetness of the obtained coating layers and the wetness tends to cause drawbacks of pinholes, poor shade, flop and clouding *etc.*

Based on these characteristic parameters such as the droplet size distribution and the homogeneity of spraying, it is possible to predict properties of the coating layers and help to avoid drawbacks of pinholes, clouding and streak *etc.*

The method of the invention provides a simple and efficient approach for development of coating compositions without steps of curing or baking as well as the following performance tests.

Various modifications and variations conceivable by those skilled in the art can be made without departing from the scope or spirit of the present disclosure. This description and its disclosed examples are to be considered illustrative only, and the protection scope of the present disclosure is to be specified by the appended claims and their equivalents.

CLAIM

1. An electrostatically atomizing equipment, comprising parts of:
(A) an indirect charging atomizer comprising a rotary bell cup for atomizing and dispensing an electrically non-insulative coating composition,
(B) an indirect charging part having an input port for connection with a high voltage power that is fixed to the indirect charging atomizer for electrostatically charging the atomized and dispensed coating composition, and
(C) a device for quantitatively characterizing the atomization of the indirect charging atomizer comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition, wherein said optical measurement part is grounded and kept substantially equipotential to the bell cup of the indirect charging atomizer.

2. The electrostatically atomizing equipment according to claim 1, wherein said device for quantitatively characterizing the atomization of the indirect charging atomizer comprises a data collecting and processing unit that collects optical data from the optical measurement part and determines characteristic parameters of atomization based on collected data.

3. The electrostatically atomizing equipment according to claim 2, wherein the characteristic parameters comprise average size and size distribution of droplets of atomized coating composition after spraying and homogeneity of spraying.

4. The electrostatically atomizing equipment according to any one of claims 1 to 3, wherein it comprises a grounded metal mesh placed in a plane substantially parallel to a mouth plane of the rotary bell cup.

5. The electrostatically atomizing equipment according to claim 4, wherein the shortest path between the plane of metal mesh and the bottom plane of rotary bell cup is in a range of from 15cm to 50cm and preferably from 20cm to 30cm.

6. The electrostatically atomizing equipment according to any one of claims 1 to 5, wherein the optical measurement part has a metal mask at its head portion comprising through holes for passage of light emitted by the head portion of the optical measurement part.

7. The electrostatically atomizing equipment according to any one of claims 1 to 6, wherein the light source of the optical measurement part is laser.

8. The electrostatically atomizing equipment according to any one of claims 1 to 7, wherein the indirect charging part is fixed to atomizer header that has an input port connected to a high voltage power.

9. A method for characterizing atomization of the electrostatically atomizing equipment according to any one of claims 1 to 8, comprising steps of:
(i) spraying a coating composition atomized by the electrostatically atomizing equipment through a rotary bell cup,
(ii) detecting the atomized coating composition by an optical measurement part, and
(iii)determining characteristic parameters of atomization based on data obtained through the optical measurement part.

10. The method according to claim 9, wherein in step (i) a grounded metal mesh is placed in a plane substantially parallel to a mouth plane of the rotary bell cup.

11. The method according to claim 10, wherein the shortest path between the plane of metal mesh and the bottom plane of rotary bell cup is in a range of from 15cm to 50cm and preferably from 20cm to 30cm.

12. The method according to any one of claims 9 to 11, wherein in step (i) the indirect charging part is fixed to atomizer header that has an input port connected to a high voltage power.

13. The method according to any one of claims 9 to 12, wherein in step (ii) the optical measurement part has a metal mask at its head portion comprising through holes for passage of light emitted by the head portion of the optical measurement part.

14. The method according to any one of claims 9 to 13, wherein the light source of the optical measurement part is laser.

15. The method according to any one of claims 9 to 14, wherein in step (iii) the characteristic parameters comprise average size and size distribution of droplets of atomized coating composition after spraying and homogeneity of spraying.

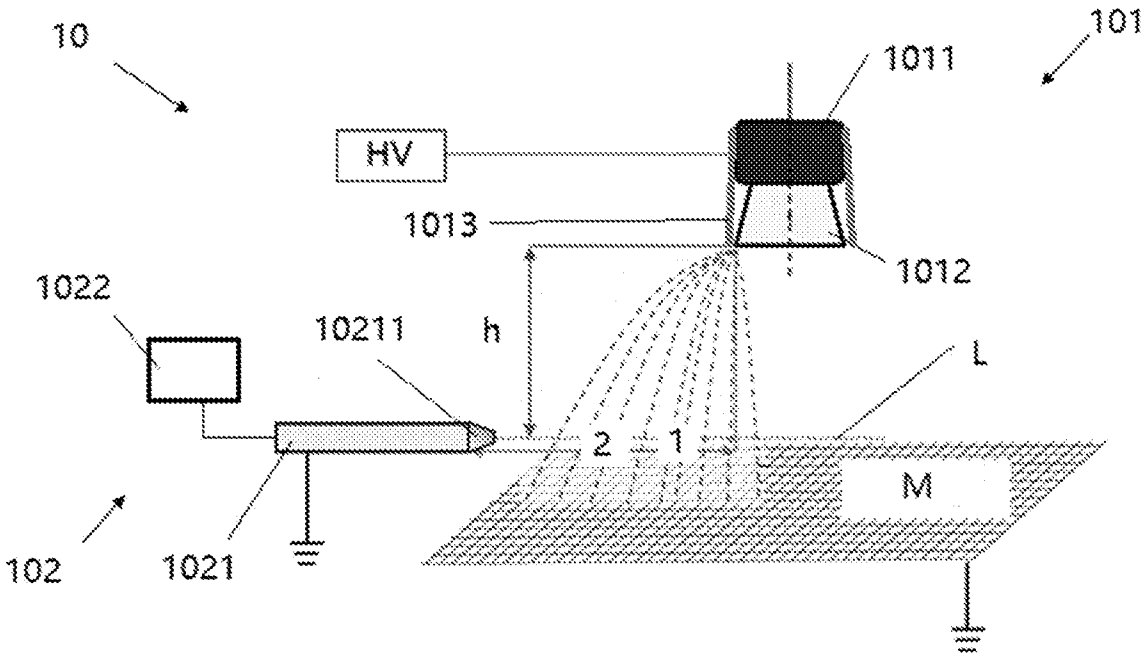


Figure 1

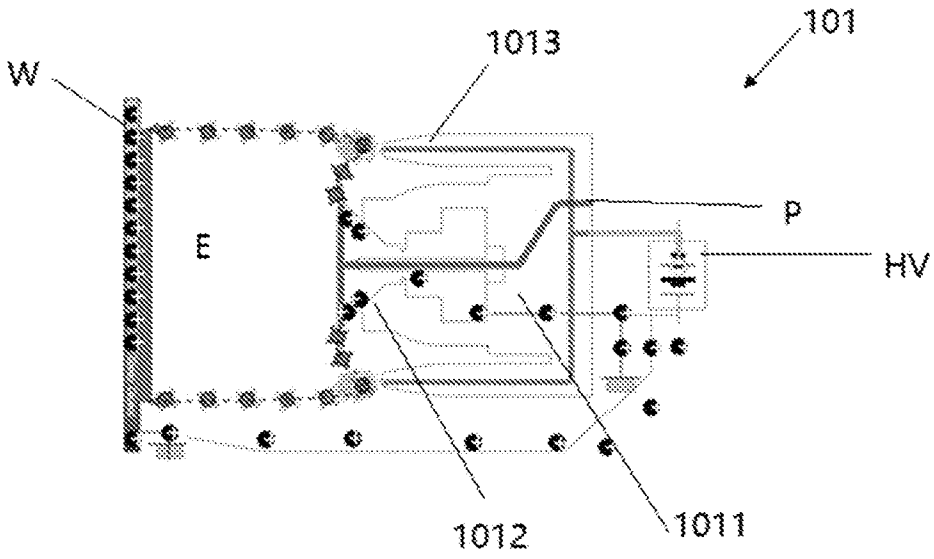
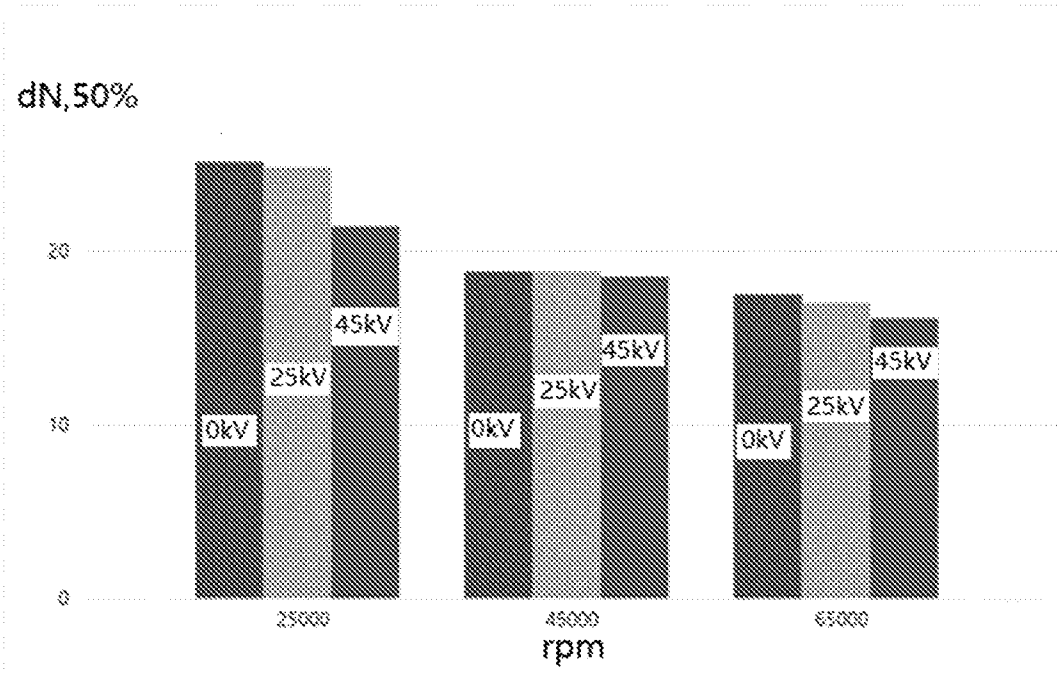


Figure 2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0kV
25kV
45kV
25000
45000
65000
rpm

Figure 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/CN2024/116842

A. CLASSIFICATION OF SUBJECT MATTER
INV. B05B5/04 B05B5/053 B05B12/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 10 2021 110175 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 27 October 2022 (2022-10-27) abstract; figure 1 paragraph [0002] paragraph [0011] - paragraph [0019] paragraph [0032]	1-3,7-9, 12,14,15
Y	WO 2021/032812 A1 (BASF COATINGS GMBH [DE]) 25 February 2021 (2021-02-25) abstract; figures 1-3 page 6, line 29 - page 7, line 31 page 11, line 29 - page 16, line 9	1-3,7-9, 12,14,15

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search	Date of mailing of the international search report
22 November 2024	02/12/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Frego, Maria Chiara

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INTERNATIONAL SEARCH REPORT

International application No
PCT/CN2024/116842

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 2022/410197 A1 (LE STRAT CÉDRIC [FR] ET AL) 29 December 2022 (2022-12-29) abstract; figures 1-6 paragraph [0083] paragraph [0109] - paragraph [0110] -----	2
Y	WO 2020/002245 A1 (BASF COATINGS GMBH [DE]) 2 January 2020 (2020-01-02) abstract; figure 1 page 6, line 29 - page 7, line 31 page 14, line 20 - line 28 page 15, line 16 - line 23 page 16, line 11 - page 23, line 26 -----	1-3,7-9, 12,14,15

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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