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for:

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in the name of:

L'AIR LIQUIDE, SOCIETE ANONYME POUR L'ETUDE ET
L'EXPLOITATION DES PROCEDES GEORGES CLAUDE

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ABSTRACT

This control device, for a system which includes a treatment device (2) through which the substrate (3) runs, is characterized in that it includes a data processing unit (10) which receives a datum regarding the speed at which the substrate is running through the device, the data processing unit being connected to means (14, 15) for controlling the gas supply means (7) and the electrical power supply means (8) in order to regulate the flow of gas and the electrical power which are delivered to the device, as a function of the speed of the substrate through the latter, so as to obtain a surface treatment of the substrate with an equivalent quality whatever the latter's speed through the device.

Single figure

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CONTROL PROCESS AND DEVICE FOR THE OPERATION OF A SYSTEM FOR TREATING THE SURFACE OF A SOLID RUNNING SUBSTRATE

The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

The present invention relates to a control device for the operation of a system for treating the surface of a solid running substrate by dielectric-barrier electrical discharge in a controlled gaseous atmosphere.

By way of illustration, the following application examples may be mentioned: the treatment of polymer films for food packaging or the manufacture of capacitors.

Already known in the prior art, for example the document in the name of E. Prinz which appeared in "Plastics Southern Africa" in June 1983, pages 50 et seq., are surface treatment systems of this type which include a treatment device through which the substrate to be treated runs, this device being connected to means for supplying the treatment device with gas, to means for supplying the latter with electrical power in order to produce the electrical discharge and to gas suction means.

Such systems enable substrates to be treated in order to improve their properties, especially those of adhesion, of wettability and of gas or liquid impermeability, thereby enabling their fields of application to be extended.

Thus it has already been proposed, by the document EP-516,804 in the name of the Applicant, to deposit a thin layer of silicon oxide bonded to a substrate made of a polymer material, which comprises subjecting one surface of the substrate to a dielectric-barrier electrical discharge and exposing this surface to an atmosphere containing a silane, by virtue of which a deposition of silicon oxide, bonded to the surface of the substrate, is formed.

The treatment devices for implementing this type of process are generally integrated into a line for the continuous production or conversion of such substrates (for the purpose, for example, of printing, laminating or metallizing them) and these devices are regulated using a pre-established recipe depending

especially on the characteristics of the conversion/production into which they are integrated.

However, it will be appreciated that this has a number of drawbacks, especially with regard to the reproducibility of the quality of the substrate resulting from the treatment since it is extremely difficult permanently to adapt the operating parameters of these treatment devices to the operating conditions of such a conversion or production line.

10 The object of the invention is therefore to solve these problems.

For this purpose, the subject of the invention is a control device for the operation of a system for treating the surface of a solid running substrate by dielectric-barrier electrical discharge in a controlled gaseous atmosphere, the system being of the type which includes a treatment device through which a substrate to be treated runs, this device being connected to means for supplying the treatment device with gas, to means for supplying the latter with electrical power in order to produce the electrical discharge and to gas suction means, the control device being characterized in that it includes a data processing unit which receives, as input, a datum regarding the speed at which the substrate is running through the treatment device, the data processing unit being connected, on the output side, to means for controlling the gas supply means and to means for controlling the electrical power supply means, in order to regulate the flow of gas delivered by the or each of the gas supply means and/or the electrical power delivered by the electrical power supply means to the device, as a function of the speed at which the substrate is running through the treatment device, so as to obtain a surface treatment of the substrate with an equivalent quality whatever the speed at which the latter is running through the treatment device.

As will be clearly apparent to those skilled in the art, the notion of "quality" of the treatment obtained according to the invention varies from one product to another and from one industrial site to another, for example depending on the applications (inking, metallization, etc.) or as a function of the specifications required by each site.

By way of illustration, but with no limitation implied, mention will be made here of the following examples of measurements, made on such or such an industrial site, for evaluating the quality and acceptability of the components treated:

- measurements of the surface tension of treated polymer films;
- measurements of the spread (wetting angle) of a drop of water on the treated surface;
- evaluation, in terms of surface tension, of inks which have been calibrated beforehand by the industrial body;
- ink adhesion tests using the sticky-tape method in which the tensile force before disbondment is measured (a test well known to metallurgists);
- corrosion tests such as that performed by applying an electrical voltage to the metallization and observing the variation in this metallization over time (ageing).

It will be therefore understood that the notion of "equivalent" quality according to the invention should be interpreted, depending on the circumstances for example, as being dependent on the result of the test or tests commonly performed by each user site, and therefore on the result of the test performed and defined as being acceptable by the user site in question. By way of illustration, mention may thus be made of a tensile force at rupture in the sticky-tape test or, by way of a second example, a wetting angle of a drop of water on the treated support.

Advantageously, the data processing unit is connected, on the output side, to means for controlling the suction rate of the suction means.

5 The invention will be more clearly understood on reading the description which follows, given solely by way of example and with reference to the appended drawing which shows a schematic diagram illustrating the structure and the operation of a control device according to the invention.

10 Recognizable in this figure is, in fact, a control device for the operation of a system for the surface treatment of a solid running substrate by dielectric-barrier electrical discharge in a controlled gaseous atmosphere.

15 In this figure, the system is denoted by the general reference 1 and includes, in a general way, a treatment device of appropriate type, denoted by the general reference 2, through which the substrate to be treated runs, this substrate being denoted by the
20 general reference 3 in this figure.

This substrate is, for example, in the form of a sheet of film to be treated which runs between a stationary part 4 of the treatment device 2 and a rotating part 5 thereof, this device also including
25 support means denoted by the general reference 6 (it will be understood that the part 4 is stationary during the treatment phase, the system usually being mounted on jacks enabling it to be raised and lowered during other phases).

30 This treatment device, and more particularly the stationary part 4 thereof, is connected to means for supplying the treatment device with gas, these being denoted by the general reference 7 in this figure, to means for supplying the latter with
35 electrical energy, denoted by the general reference 8 in this figure, in order to produce the electrical discharge in the device and to gas suction means

denoted in a general way by the reference 9 in this figure.

The various means which have just been described may have any appropriate structure, for example one known in the prior art, so that they will not be described in more detail below.

According to the invention, the control device also includes a data processing unit, denoted by the general reference 10 in this figure, which includes, for example, any appropriate computer 11 associated with storage means 12, this data processing unit 10 receiving, as input, a datum regarding the speed at which the substrate 3 is running through the treatment device 2, this datum being supplied, for example, by a rotation speed sensor 13 associated with the rotating part 5 of the treatment device.

On the output side, this data processing unit 10 is connected to means 14 for controlling the gas supply means 7 and to means 15 for controlling the electrical power supply means 8 in order to regulate the flow of gas delivered by the or each of the gas supply means, for example if the latter include several gas sources, and/or the electrical power delivered by the electrical power supply means to the device, as a function of the speed at which the substrate is running through the treatment device, so as to obtain a surface treatment of the substrate with an equivalent quality whatever the speed at which the latter is running through the treatment device.

Moreover, and as shown, the gas suction means denoted by the general reference 9 may include at least first suction means 16 placed on the input side of the treatment device and second suction means 17 placed on the output side of the treatment device (it should be understood that input and output of the treatment device are defined with respect to the direction in which the objects to be treated are running through the device), the data processing unit 10 then being

connected respectively to means 18 and 19 for
controlling the suction rates of the first and second
suction means 16, 17 respectively, as a function of the
rate at which gas is supplied to the device by the
5 corresponding supply means 7.

It will also be noted that the controlled
gaseous atmosphere in the treatment device may contain
any gas whether of inert, oxidizing or reducing nature,
as is described in the aforementioned prior document
10 (EP-516,804).

Various teachings relating to this composition
and the deposition process may be found in this
document.

It will therefore be appreciated that the data
15 processing unit integrated into the control device
according to the invention makes it possible to
regulate, firstly, the flow of gas supplied to the
device, secondly, the electrical power applied to the
latter and, finally, the gas suction rate, in order to
20 adapt these operating parameters of the device and to
regulate them as a function of the speed at which the
substrate is running through the device, thereby
maintaining an equivalent quality of treatment of the
substrate while it is passing through this device.

25 This therefore enables the operating conditions
of the treatment device to be adapted to the operating
conditions of the conversion or production line in
which such a device is integrated in order to maintain
the productability of the treatment.

30 These various parameters for controlling the
operation of the treatment device are regulated
conventionally, for example using programs and data
stored in the processing unit 10.

The various necessary items of information are
35 firstly established by analysing the operation of the
device, for example under various conditions, thereby
enabling the various relationships linking the various
parameters for controlling the operation of this device

to be established, these relationships then being used to regulate the operation of the latter.

It will also be noted that the data processing unit 10 may be connected to a centre for the remote control/monitoring of the treatment system via data transmission means, denoted by the general reference 20 in this figure.

These data transmission means may also have any appropriate structure enabling them to exchange data between this unit and the remote control/monitoring centre.

Finally, the data processing unit may also be associated with a man/machine interface which includes means 21 for inputting data, for example by an operator, and data display means 22.

This data processing unit 10 may also include means for simulating and/or modelling the operation of the treatment device 2, making it possible, on the basis of (established) input parameters of the device, to determine an estimated treatment of the substrate 3 on the output side of the device or alternatively, on the basis of a desired treatment of the substrate 3 on the output side of the device 2, to determine estimated input parameters thereof.

These various means may, for example, consist of programs which are incorporated into the treatment unit and are established, for example experimentally, in order to provide the desired simulation and/or modelling.

The input parameters for such simulation and/or modelling means may therefore include a number of elements among which mention may be made of:

- the type of substrate to be treated,
- the rate at which the latter is running through the treatment device,
- the electrical power delivered by the power supply means to the treatment device,
- the composition of the gaseous atmosphere,

- the gas supply rate,
- the gas suction rate,
- the nature or the geometry of the electrodes producing the electrical discharge, or

5 - the characteristics of the electrical signal producing the discharge (frequency, amplitude, shape of the signal, etc).

Of course, various embodiments of the various means which have just been described may be envisaged.

In a general way, the actual structure of these means may be conventional, the
10 operation of the latter by the data processing unit 10 being regulated by controlling these means, for example in terms of voltage, current or another quantity.

Throughout the description and claims of this specification the word "comprise" and variations of that word, such as "comprises" and "comprising", are not intended to exclude other additives or components or integers.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A control device for the operation of a system for treating the surface of a solid running substrate by dielectric-barrier electrical discharge in a controlled gaseous atmosphere, the system being of the type which includes a treatment device through
 5 which the substrate to be treated runs, this treatment device being connected to means for supplying the treatment device with gas, to means for supplying the latter with electrical power in order to produce the electrical discharge and to gas suction means, wherein said control device includes a data processing unit capable of receiving, as input, a datum regarding the speed at which the substrate is running
 10 through the treatment device, the data processing unit being connected, on the output side, to means for controlling the gas supply means and to means for controlling the electrical power supply means, in order to regulate the flow of gas delivered by the or each of the gas supply means and/or the electrical power delivered by the electrical power supply means to the device, as a function of the speed at which the substrate
 15 is running through the treatment device, so as to obtain a surface treatment of the substrate with an equivalent quality whatever the speed at which the latter is running through the treatment device.
2. A control device according to claim 1, wherein the data processing unit is connected, on the output side, to means for controlling the suction rate of the gas
 20 suction means.
3. A control device according to claim 2, wherein the data processing unit is designed to regulate the suction rate of the suction means as a function of the gas supply rate of the gas supply means.
4. A control device according to claim 2 or 3, wherein the suction means include
 25 at least first suction means placed on the input side of the treatment device and second suction means placed on the output side of the treatment device and in that the data processing unit is connected, on the output side, to means for controlling the suction rates of the first and second suction means.
5. A control device according to any one of the preceding claims, wherein the
 30 data processing unit furthermore includes means for simulating and/or modelling the operation of the treatment device making it possible, on the basis of established input parameters of the treatment device, to determine an estimated treatment of the

substrate on the output side of the device or, on the basis of a desired treatment of the substrate on the output side of the device, to determine estimated input parameters thereof.

6. A control device according to any one of the preceding claims, wherein the data processing unit is connected to a centre for the remote control/monitoring of the treatment system via data transmission means.

7. A control device according to any one of the preceding claims, wherein the data processing unit is connected to at least one man/machine interface.

8. A control device according to any one of the preceding claims, wherein the datum regarding the speed at which the substrate is running through the treatment device is delivered to the data processing unit by a speed sensor associated with the treatment device or to a line for the production or conversion of substrates, into which line the device is integrated.

9. A control process for the operation of a system for treating the surface of a solid running substrate by dielectric-barrier electrical discharge in a gaseous atmosphere, the system being of the type which includes a treatment device through which the substrate to be treated runs, this device being connected to means for supplying the treatment device with gas, to means for supplying the latter with electrical power in order to produce the electrical discharge and to gas suction means, wherein said process includes the implementation of the following steps:

- the speed at which the substrate is running through the treatment device is measured;

- the gas supply means and the electrical power supply means are controlled in order to regulate the flow of gas delivered by the or each of the gas supply means and/or the electrical power delivered by the electrical power supply means to the device, as a function of the speed at which the substrate is running through the treatment device, so as to obtain a surface treatment of the substrate with an equivalent quality whatever the speed at which the latter is running through the treatment device.

10. A control process according to claim 9, wherein the suction rate of the suction means is furthermore controlled.

11. A control process according to claim 10, wherein the suction rate of the suction means is regulated as a function of the gas supply rate of the gas supply means of the device.

12. A control process according to claim 11, wherein the suction means include at least first suction means placed on the input side of the treatment device and second suction means placed on the output side of the treatment device and in that the suction rates of the first and second suction means are regulated.

13. A control process according to any one of claims 9 to 12, wherein operations for simulating and/or modelling the operation of the treatment device are carried out, making it possible, on the basis of established input parameters of the device, to determine an estimated treatment of the substrate on the output side of the device or, on the basis of a desired treatment of the substrate on the output side of the device, to determine estimated input parameters thereof.

14. A control process according to claim 13, wherein the input parameters for the simulation/modelling operations comprise one or more of the elements of the following list:

- the type of substrate to be treated,
- the speed at which the latter is running through the treatment device,
- the power delivered by the power supply means to the treatment device,
- the composition of the gaseous atmosphere, and
- the gas supply rate.

15. A control process according to any one of claims 9 to 14, wherein the treatment system is remotely controlled via data transmission means.

16. A control device according to claim 1 substantially as hereinbefore described with reference to the drawings.

17. A control process according to claim 9 substantially as hereinbefore described with reference to the drawings.

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