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(54) Title: PROCESS FOR REMOVING FOULING DEPOSITS FROM DIELECTRIC SURFACE OF ELECTROSTATIC CHARGE TARGET ELECTRODE

(57) Abstract

A process for removing from dielectric surface (16) of electrostatic target electrode fouling deposits (50) generated substantially as tiny solidified polymer particles during flash-spinning of fibrous web structures. The particles are attracted to and deposited on the dielectric surface (16) of the target electrode (14) used for corona charging of the fibrous web structure and the resulting fouling deposit (50) increases the rate of loss in charging efficiency of fibrous structures. The process comprises brushing off fouling deposits by a self-cleaning rotating brush arrangement (45) to prevent build up of the deposits (50) on the surface (16) of the electrostatic target electrode (14) and to thusly significantly increase charging efficiency and lifetime of target electrode dielectric surfaces.
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PROCESS FOR REMOVING FOULING DEPOSITS FROM DIELECTRIC SURFACE OF ELECTROSTATIC CHARGE TARGET ELECTRODE

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to a process for cleaning of dielectric surfaces of target electrodes during operation thereof in the application of electrostatic charge to fibrous structures, and relates more particularly to a process for removal of fouling deposits accumulating upon target electrodes in the application of electrostatic charge to multifibrous webs during manufacture thereof by flash-spinning, subsequent charging and spreading, and depositing onto a moving surface.

2. Prior Art and Other Considerations:

Processes and apparatus for flash-spinning multifibrous webs of interconnecting fibrous filaments, including electrostatic charging of thusly spun fibrous structures for spreading and depositing thereof, are known in the art. U.S. Patent No. 3,578,739 issued to George discloses an apparatus for applying electrostatic charge to flash-spun fibrous structures, wherein the fibrous structures pass through a charging zone between a corona discharge electrode and a target electrode, the target electrode having a conductive base and a high-resistance surface covering. The high-resistance dielectric surface covering is provided to reduce a problem-causing effect associated with flash-spinning and electrostatic charging of fibrous structures, namely the
generation of small separated particles which become attracted to the target electrode and build up an electrically insulating film thereupon. When the potential drop across this film exceeds its dielectric strength, breakdown occurs and tiny craters are created that become a source of "back corona", causing neutralization of the charge on the fibrous structures with consequent degradation and loss of process performance. The high-resistance dielectric surface covering spreads out the charging field, thereby reducing current density, and it restricts the amount of current that may be drawn to points of breakdown. Measures taken in the past to postpone the effects of target electrode fouling by particle deposits, such as rotation of target electrode, use of a scraper to remove particles from the surface of the target electrode, and continuously wiping a conductive liquid onto the rotating target surface are discussed in the patent to George. Thus the apparatus of U.S. Patent No. 3,578,739 reduces the undesirable effect of target electrode fouling by particle deposits.

The dielectric surface covering of the target electrode disclosed by George in the aforementioned patent provides significantly improved performance at process throughput rates customarily utilized in the past. Demands have since increased for much higher production rates and consequently increased throughputs of flash-spun fibrous structures have been accompanied by increased generation of fouling deposits. In addition, higher throughputs have required higher charging current densities. As a result, target electrodes become fouled more rapidly than in the past. Consequently, the measures taken by George, as taught in the aforementioned patent, have been found to provide only relatively short useful in-process operating times for target electrodes, when operated at presently demanded production rates,
particularly due to the rapid build up of fouling deposits and the consequent loss of charging efficiency.

U.S. Patent No. 3,860,369 to Brethauer et al also discloses an apparatus for making non-woven fibrous sheets, and including electrostatic charging of the web in a corona discharge zone that includes a metal target disc electrode which is preferably covered with a dielectric insulating surface as disclosed in U.S. Patent No. 3,578,739. Brethauer et al indicates use of a rotating brush for clearing of any debris from the target plate and from adjacent parts.

The present invention is intended to substantially reduce the aforesaid problems caused by flash-spun particles depositing upon target electrodes that have resulted in relatively short useful target electrode operating life, and accordingly, the invention has as a primary object the provision of a process for removal of fouling deposits from target electrode surfaces during operation thereof by a self-cleaning rotating brush apparatus, so that target electrodes cleaned thereby achieve useful in-process operating lifetimes that are significantly longer than heretofore possible.

SUMMARY OF THE INVENTION

In accordance with principles of the present invention, regions on the target electrode surface upon which accumulate fouling deposits, comprising tiny solidified polymer particles generated during flash-spinning and electrostatic charging of fibrous web structures, are brushed by a self-cleaning rotating brush apparatus during the manufacture of the fibrous web structures, whereby fouling deposits are removed and charging efficiency for fibrous web structures is improved, so that useful in-process operating lifetimes of target electrodes are significantly increased.

The process of the invention comprises brushing the revolving target electrode surface with a cylindrical
brush having substantially radial bristles whose tips thereby remove fouling deposits from the target electrode surface. The brush is rotated about its axis and is adjustably spring-loaded against the moving target electrode surface. The brush is continuously cleaned by brushing against a cleaning bar that flicks away fouling deposits collected on the bristles.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference numerals refer to like parts throughout different views. The drawings are schematic and not necessarily to scale, emphasis instead being placed upon illustrating principles of the invention.

FIG.1 is a schematic cross-sectional elevation of a flash-spinning apparatus including a brush apparatus for use in the process according to the present invention;

FIG.2 is an enlarged schematic view of a portion of FIG.1, showing schematically the vicinity of a target electrode fouled by deposits; and

FIG.3 is an enlarged schematic sectional view of a brush apparatus for use in the process according to principles of the invention.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring now to FIG.1, a flash-spinning apparatus 10 is schematically depicted therein that is used in production of multifibrous web structures. The shown apparatus comprises charging means for electrostatically charging such structures. The charging means includes an ion gun 12 and a target electrode 14; the latter being generally shaped in form of an annular disc. Target electrode 14 is provided with a dielectric surface layer 16, and is concentrically disposed about a baffle 18.
Baffle 18 is revolved about axis 20, as indicated by arrow 22. A spinneret 24 is supplied with a pressurized polymer solution that issues from orifice 28 and forms a fibrous structure 26. An aerodynamic shield comprises a first member 30 and a second member 32. Target electrode 14 together with second member 32 are adapted to be rotated independently of baffle 18, but concentrically therewith, by means not shown here. A collecting surface 34 is comprised in an endless belt 36 that is carried by rolls of a powered conveyor means 38.

Fibrous structure 26, issuing from orifice 28, is deflected by aerodynamic influences and by the surface shape of baffle 18 downwardly to and along dielectric surface layer 16 of target electrode 14, and therefrom between first and second shield members 30 and 32, and continues to move downwardly toward and onto moving collecting surface 34.

Ion gun 12, comprised in first shield member 30, is supplied with a potential of 50 to 100 kilovolts. Target electrode 14 is connected to electrical ground via a here not shown contact ring and brush arrangement. A corona discharge is produced between ion gun 12 and target electrode 14, and continuously charges fibrous structure 26, thereby causing spreading thereof. Collecting surface 34 is electrically conductive and is grounded or given an opposite charge relative to the charge imposed on fibrous structure 26. Consequently, fibrous structure 26 is attracted to and deposited upon collecting surface 34 in flattened sheet-like form and is conveyed by powered conveyor means 38 to an accumulating means 42.

In producing nonwoven sheets from continuous fibrous structures in an apparatus as, for example, hereinbefore indicated in FIG.1, uniform electrostatic charging of fibrous structure 26 is required to maintain spread of its partially interconnected filaments and to effectively deposit the structure in flattened form onto collecting
surface 34. An electrostatic charge is imparted to fibrous structure 26 during its passage between ion gun 12 and the portion of target electrode 14 nearest thereto. Fibrous structure 26 passes through the unipolar region formed over the surface of target electrode 14. The unipolar region is established by the flow of ions from the corona discharge device, namely ion gun 12, to target electrode 14. The charge captured by fibrous structure 26 has the same polarity as the charge of ion gun 12. As an identical polarity charge is imparted to components of fibrous structure 26, Coulomb repulsion forces spread such components apart.

Tiny solidified polymer particles, generated as a by-product of flash-spinning, also issue from spinneret 24 and are also charged by ions emitted from ion gun 12. While charged fibrous structure 26 is carried to the oppositely charged collecting surface 34, the charged polymer particles are attracted to and predominantly deposited upon dielectric surface layer 16.

A brush apparatus 45 is disposed in a distal region from the charging region between ion gun 12 and target electrode 14. Particle-fouled surface regions of dielectric surface layer 16 are brought within reach of brush apparatus 45 by the rotation of the annular target electrode 14, and the deposited particles are removed by brushing.

Referring now to FIG.2, fibrous structure 26 issues from spinneret 24, is deflected downwardly along baffle 18, continues to move downwardly through a charging region between ion gun 12 and target electrode 14, and is carried to the oppositely charged collecting surface 34. Target electrode 14 comprises a metal target base 48 and dielectric surface layer 16. As hereinabove described in conjunction with FIG.1, charged tiny polymer particles are deposited upon dielectric surface layer 16 and form thereupon a fouling layer 50. Build up of fouling layer
50 is detrimental to the charging process and causes rapid degradation of charging efficiency. Consequently, prevention or elimination of accumulation of fouling layer 50 is highly desirable.

Fouling layer 50 is a nonconducting film upon target electrode 14. As the thickness of this film and therewith the voltage drop thereacross increases, breakdown of the film occurs when the breakdown potential is exceeded by the voltage drop. Tiny craters are created thereby and "back corona" discharges take place. The ions produced by the back corona decrease the unipolarity of the charging region and thusly cause a loss of charge available to fibrous structure 26. It will be understood that the effectiveness of electrostatic charging is thereby significantly degraded.

This difficulty was first recognized in the art in conjunction with the operation of bare metal target electrodes, and it has been somewhat alleviated by provision of a high-resistance layer covering over metal targets, as for instance disclosed in the hereinbefore referenced U.S. Patent No. 3,578,739. However, whereas the therein disclosed high-resistance layer coverings extend the useful operating life of target electrodes and thereby alleviate the difficulties, the accumulation of fouling particle layers upon target electrodes has remained a continuing problem and prolonging of useful target electrode lifetimes has been seriously hampered thereby.

In order to substantially eliminate this problem and thereby to significantly extend useful lifetimes of target electrodes, the present invention provides a process for removal of the fouling particle layer, during the aforesaid flash-spinning process, by use brush apparatus 45 for in-process removal of fouling layer 50.
Referring now to FIG. 3, brush apparatus 45 is shown therein as it is disposed in spatial relationship to target electrode 14. Target electrode 14 has the general shape of an annular ring and it comprises metal target base 48 and dielectric surface layer 16. Target electrode 14 is disposed concentrically about revolving baffle 18, and is rotated about its axis independently therefrom. Brush apparatus 45 comprises a brush assembly 52 securely mounted upon a shaft 54 that is rotatably borne in a gearbox 56, a compression spring-loading device 58 disposed between a support 60 and gearbox 56, a compression adjusting means 62 mounted on gearbox 56 and bearing upon an adjustment support 64, and a brush cleaning bar 66 borne in gearbox 56. Brush cleaning bar 66 is preferably rotated about its axis, although it can be stationary. Shaft 54 extends through gearbox 56, as indicated, and is driven by a power drive means not shown here, for instance via a flexible drive shaft. When brush cleaning bar 66 revolves, it is driven from shaft 54 via gearing in gearbox 56 and it is preferably provided with a substantially triangular cross-sectional shape to promote cleaning and clearing of bristles in brush assembly 52, although other cross-sectional shapes can be used therefor effectively.

Support 60 and adjustment support 64 are rigidly mounted to structural members of flash-spinning apparatus 10 (not shown here). Gearbox 56 is pivotably mounted to structural members of flash-spinning apparatus 10, having a pivot axis parallel to shaft 54, so that substantially tangential contact along a length of brush assembly 52 is maintained with dielectric surface layer 16 by the action of compression spring-loading device 58, while brush contact preloading is selectively adjusted by compression adjusting means 62. Additionally, pivotable mounting of gearbox 56 facilitates hinging thereof and disengagement of brush assembly 52 from contact with dielectric surface.
layer 16 for maintenance and similar purposes. It will be understood that a disengagement of compression spring-loading device 58 will be required under these circumstances.

5 Brush assembly 52 preferably comprises a plurality of cylindrical brushes 68, having substantially radially oriented bristles, that are assembled upon shaft 54 and secured thereto, for instance by threaded nuts and locking arrangements, as shown here. For example, each cylindrical brush is .76 centimeters wide and 6.4 centimeters in diameter and comprises about 2000 nylon filament bristles, each bristle having a diameter of .041 centimeters.

10 In use of brush apparatus 45, brush assembly 52 is adjusted by compression adjusting means 62 onto dielectric surface layer 16 within a resilient brush contact interference range between about zero and .51 centimeters and preferably between about .1 to .25 centimeters, having a brush contact preloading force provided by compression spring-loading device 58 of between .68 and 3.41 to 3.64 kilograms. Shaft 54 is powered and revolves at a speed of about 150 to 190 RPM and preferably about 170 RPM to result in a bristle tip speed of between about 50.8 and 63.5 centimeters per second. Brush cleaning bar 66 is disposed parallel to shaft 54 and at a distance therefrom to result in a resilient brush contact interference between the bristles and the surface of brush cleaning bar 66. This contact interference effects substantial removal of particles collected upon bristles by flicking such particle off the bristles.

15 The use of brush apparatus 45 in flash spinning apparatus 10 significantly prolongs the useful in-process lifetime of target electrodes 14 by effectively removing fouling layer 50 from dielectric surface layer 16. Since brush apparatus 45 is self-cleaning by the action of
brush cleaning bar 66, as hereinbefore described, its own service-free operating life vastly exceeds the life of critical components of flash-spinning apparatus 10. Dielectric surface lifetimes during in-process operation without the use of a fouling layer removing brush apparatus have been found to be increased at least about two and one half times when a process according to principles of the present invention is applied.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes and modifications in form and details may be made therein without departing from the spirit and scope of the invention.
The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A process for removing fouling deposits from a dielectric surface of an electrostatic charge target electrode in flash-spinning of fibrous web structures, comprising the steps of:
   (a) rotating a brush assembly, said brush assembly including a plurality of bristles substantially radially disposed within a cylindrical outline, said brush assembly being securely mounted concentrically upon a rotating shaft borne in a gearbox;
   (b) brushing off said dielectric surface and thereby removing said fouling deposits therefrom by said brush assembly;
   (c) carrying said fouling deposits away from said dielectric surface by said plurality of bristles;
   (d) clearing said fouling deposits from said plurality of bristles by a brush cleaning bar, said brush cleaning bar being radially spaced from said rotating shaft, said brush cleaning bar contacting said plurality of bristles and thereby removing said fouling deposits from said plurality of bristles; and
   (e) flicking off said fouling deposits by the combined action of said brush cleaning bar and said plurality of bristles.

2. The process according to claim 1, wherein step (a) is effected by driving said rotating shaft at a speed that results in a bristle tip velocity of said plurality of bristles in the range of about 50.8 to 63.5 centimeters per second at the cylindrical periphery of said brush assembly.

3. The process according to claim 1, wherein said
gearbox is pivotally mounted in a pivotal mounting arrangement for a contact engagement with and disengagement from said dielectric surface, said gearbox being provided with a compression spring-loading device, said compression spring-loading device preloading said brush assembly toward said contact engagement, and wherein said gearbox is further provided with an adjusting means for adjustment of an amount of interference in said contact engagement between said brush assembly and said dielectric surface.

4. The process according to claim 3, wherein said preloading effects a preload force in the range of .68 and 3.64 kilograms between said brush assembly and said dielectric surface.

5. The process according to claim 3, wherein said amount of interference is adjusted in the range of zero and .51 centimeters.

6. The process according to claim 1, wherein steps (d) and (e) are executed by revolving said brush cleaning bar about its longitudinal axis to enhance its bristle clearing effect.

7. The process according to claim 6, wherein said brush cleaning bar has a substantially triangular cross-sectional shape to further augment its bristle clearing effect.

8. The process according to claim 1, wherein steps (a) and (b) are preceded by the steps of:
   (a) resiliently preloading said brush assembly onto said dielectric surface;
   (b) contacting said dielectric surface with said plurality of bristles; and
(c) adjusting an amount of contact interference between said dielectric surface and said plurality of bristles.

9. The process according to claim 8, wherein step (a) is executed by spring-loading to a force in the range between .68 and 3.64 kilograms.

10. The process according to claim 8, wherein step (b) is executed by contacting to a contact interference between said dielectric surface and said plurality of bristles.

11. The process according to claim 8, wherein step (c) is executed to within the range of zero and .51 centimeters.
INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 4

According to International Patent Classification (IPC) or to both National Classification and IPC

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II. FIELDS SEARCHED

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9 Later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

10 Document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

11 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.

12 Document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search: 20 July 1989

Date of Mailing of this International Search Report: 09 AUG 1989

International Searching Authority: ISA/US

Signature of Authorized Officer: HUBERT C. LORIN

Form PCT/ISA/210 (second sheet) (Rev.11-87)