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(54) System for electrospinning fibres

(57) The electrospinning fiber throwing system is equipped with the spinning capillaries (1) fixed in the spinning head (2) from a non-conducting material, with the separator (3) from a conductive material inside the head, linked to each of the capillaries (1) and kitted in the high-voltage terminals. The head (2) is mounted in a slidable manner on the horizontal guide (5) whose ends are mounted slidably on the vertical arms (6) of the system's load-bearing structure. Under the extrusion nozzles of the capillaries (1), the formed fiber take-up device (8) is located. The system is also equipped with the multi-threaded peristaltic pump (9), each thread of which being linked to one of the spinning capillaries (1), as well as with the reheating element located at the outlet of the formed fiber take-up device (8).

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Description

[0001] The subject of the invention is the electrospinning fiber throwing system.

[0002] Fiber throwing from polymer alloys or solutions using the electrospinning technique is based on the effects occurring in liquids and polymers under the influence of high voltage of specific polarity applied. In the first studies on fiber throwing through electrospinning, the system containing a single capillary with a nozzle, being an electrode feeding a polymer alloy or solution, connected to a high-voltage generator and a grounded collector electrode placed under it, was applied. The forces of the electrostatic field generated between the electrodes cause that a drop of polymer formed at the end of the nozzle undergoes a deformation into the so-called Taylor cone, which then, moving in the direction of the crown discharge current towards the grounded electrode, is accelerated and stretched to be finally collected on the surface of the collector electrode in the form of loosely packed fibers.

[0003] The work aimed at improving the efficiency of the electrospinning process focused on a change in the mode of taking up formed fibers as well as in the mode of feeding a polymer alloy or solution.

[0004] The Journal of Physics: Conference Series 142 (2008) 012027 Electrostatics 2007 describes an electrospinning system where the take-up of formed fibers is done by means of rotary rollers, made from a conductive material, which are covered with subsequent fiber layers until the assumed thickness thereof is reached, while the patent description US 2009/00910655 A1 presents an electro spinning system in which formed fibers are taken up by rotating discs.

[0005] In the first solutions to the improved spinning efficiency through the modified mode of feeding a polymer alloy or solution, the referenced alloy or solution was forced by compressed air or diffusion pumps. The foregoing techniques made it possible to isolate a polymer of high electric potential from the environment, thereby protecting system operators from electrocution, yet at the same time curbing the control of an amount of the extruded polymer and the time instability of the electro spinning process.

[0006] The Czech company Elmarko used an electrospinning system in which a spinning feed roller, immersed in a polymer solution, rotated, being covered with polymer film, while the voltage applied thereto caused that trickles of the polymer detached from the surface of the roller and formed fibers precipitated on an unwoven cloth belt traveling over the roller.

[0007] We also know an electrospinning system where the electro spinning process is intensified using a serrate-surfaced feed roller. This system needs applying an extra carrier in the form of a fabric or unwoven cloth to take up formed fibers.

[0008] The patent description EP 1982735 A1 presents an electro spinning system in which a polymer is fed by several capillaries situated one by one in single file, while formed fibers are taken up by a rotating roller, located vertically.

[0009] The invented electro spinning fiber throwing system, equipped with vertically positioned spinning capillaries connected to a source of high voltage and a device taking up formed fibers, located under the extrusion nozzles of the capillaries and linked to a driving unit, is characterized by the solution according to which the spinning capillaries are fixed in a spinning head from a non-conducting material, inside which there is a separator from a conductive material, connected to each of the capillaries and kitted in high-voltage terminals. The head is mounted in a slidable manner, by means of a horizontal transport mechanism connected to the driving motor, on a horizontal guide whose ends are mounted slidably as well, by means of a vertical transport mechanism connected to the driving motor, on the upright arms of the system's load-bearing structure. In addition, the system is equipped with a multithreaded peristaltic pump, each thread of which being linked to one of the spinning capillaries placed on the horizontal arm of the load-bearing structure. The unit taking up formed fibers is an advantageously rotationally fixed roller or conveyor. The head contains minimum 32 capillaries, advantageously spaced in four rows, at an advantageous distance of 3 cm from each other in each row and 6 cm between the rows. The system contains an ancillary reheating element in the form of a drying tunnel, which makes it possible to evaporate dissolvent residue, collected at the outlet of the fiber take-up device, from formed fibers.

[0010] According to the invention, the system is marked by a considerably higher efficiency of the fiber throwing process compared to the systems known hitherto. Furthermore, the hazard of operators' electrocution has been eliminated from the system.

[0011] The subject of the invention is represented as a built model in a figure showing the system from a front view.

[0012] The system is equipped with the 32 vertically situated spinning capillaries 1, fixed in the Teflon spinning head 2. The capillaries 1 are positioned in the four rows, at a distance of 3 cm from each other in each row and 6 cm between the rows. The head 2 has the built-in steel wool separator 3, linked to each of the capillaries 1 and kitted in the high-voltage terminals. The head 2 is mounted in a slidable manner, by means of the horizontal transport mechanism 4 connected to the driving motor, on the horizontal guide 5 whose ends are mounted slidably, by means of the vertical transport mechanism 7 connected to the driving motor, on the upright arms 6 of the system's load-bearing structure. Under the extrusion nozzles of the capillaries 1, there is a metallic formed fiber take-up roller 8, fixed rotationally in a holder providing a galvanic connection to the grounding and linked to the driving unit. The system is also equipped with the 32-thread peristaltic pump 9, each thread of which being connected to one of the spinning capillaries 1 placed on the horizontal arm

10 of the system's load-bearing structure. The system contains the drying tunnel situated along the path of fibers leaving the roller 8.

[0013] In order to produce nanofibers, the peristaltic pump 9 is filled with the polymer and the separator 3 is connected to the source of high voltage, thus starting the pumping of the polymer into the capillaries 1. When the capillaries 1 are filled with the polymer, the guide 5 with the head 2 is positioned at an adequate distance from the take-up roller 8 by means of the vertical transport mechanism 7. Next, the horizontal motion range of the head 2 along the guide 5 so it can extend over the entire work area of the roller 8 is set up by means of the horizontal transport mechanism 4 and the unit driving the roller 8 is activated. Once the roller 8 is set in rotary motion, the head 2 is set in horizontal motion along the guide 5 by means of the horizontal transport mechanism 4. Formed nanofibers are taken up on the grounded roller 8 in the form of unwoven cloth. The obtained layer of unwoven cloth, desirably thick, passes through the drying tunnel whose outlet releases the finished product.

[0014] The system was used for nanofiber throwing in the form of unwoven fabric from:

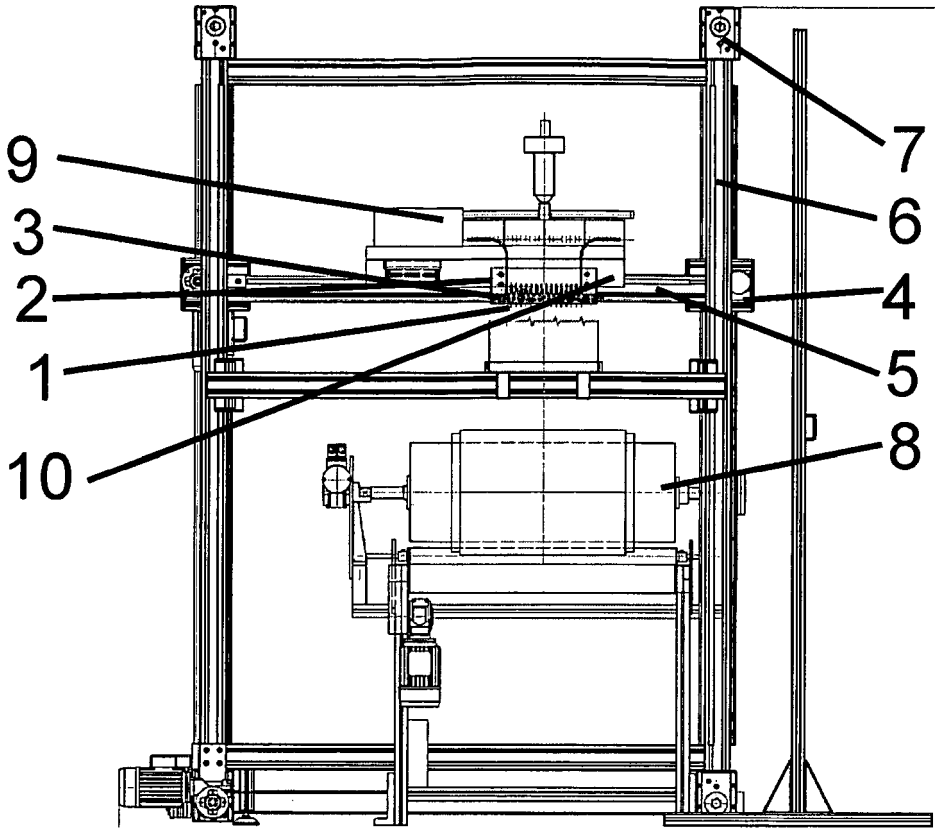
- 15% polyacrylonitrile (PAN) solution in dimethyl sulfoxide (DMSO) at a temperature of 20°C and a velocity of the peristaltic pump 9 of 0.5 rpm, in the electrostatic field generated by the voltage 20 kV, at a distance of 20 cm between the head 2 and the roller 8 and a rotational speed of the roller 8 of 30 rpm; obtained nanofibers with a diameter of 500 nm;
- 17% PAN solution in DMSO at a temperature of 20°C and a velocity of the peristaltic pump 9 of 0.5 rpm, in the electrostatic field generated by the voltage
- 20 kV, at a distance of 20 cm between the head 2 and the roller 8 and a rotational speed of the roller 8 of 30 rpm; obtained nanofibers with a diameter of 400 nm;
- 20% polycaprolactone solution in dichloromethane at a temperature of 20°C and a velocity of the peristaltic pump 9 of 0.5 rpm, in the electrostatic field generated by the voltage 25 kV, at a distance of 20 cm between the head 2 and the roller 8 and a rotational speed of the roller 8 of 30 rpm; obtained nanofibers with a diameter of 1,200 nm.

Claims

1. The electrospinning fiber throwing system equipped with the vertically situated spinning capillaries connected to the high-voltage source and with the formed fiber take-up device located under the extrusion nozzles of the capillaries and connected to the driving unit, **characterized by** the solution according to which the spinning capillaries (1) are fixed in the spinning head (2) from a non-conducting material, with the separator (3) from a conductive material inside the head, linked to each of the capillaries (1) and kitted in the high-voltage terminals, in addition to which the head (2) is mounted in a slidable manner, by means of the horizontal transport mechanism (4) connected to the driving motor, on the horizontal guide (5) whose ends are mounted slidably, by means of the vertical transport mechanism (7) connected to the driving motor, on the upright arms (6) of the system's load-bearing structure; furthermore, the system is equipped with the multithreaded peristaltic pump (9), each thread of which being linked to one of the spinning capillaries (1) placed on the horizontal arm (10) of the system's load-bearing structure, as well as with the reheating element in the form of the drying tunnellocated at the outlet of the fiber take-up device (8).

2. As per claim 1, the system **characterized by** the head (2) containing minimum 32 capillaries advantageously spaced in the four rows, at an advantageous distance of 3 cm from each other in each row and 6 cm between the rows.

3. As per claim 1, the system **characterized by** the formed fiber take-up device (8) in the form of the advantageously rotationally mounted metal roller or conveyor.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EUROPEAN SEARCH REPORT

Application Number
EP 10 01 4817

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14 March 2011	Verschuren, Jo

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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