CONDUCTIVE FABRIC MEDICAL TUBE USING CONDUCTIVE YARN

FIELD OF INVENTION

The present invention relates to the field of electrically conductive fabric being applied on medical flexible tubings. More particularly, the invention relates to method of making an electrically conductive fabric via weaving of conductive yarn before it is being over-molded at both ends in order to connect with other medical devices.

BACKGROUND OF THE INVENTION

For medical applications, flexible tubing with helically wound heating conductor is commonly found in devices such as breathing equipment, CPAP (Continuous Positive Airway Pressure) machine, etc. Flexible tubing with helically wound heating conductor can be found in the prior art PCT/SG2022/050368 that relates to the Method of Making Flexible Tubing with Embedded Wire Conductor. This present invention proposes another alternative to having an extruded flexible tubing with embedded wire conductor whereby it involves using fabric yarn that has the electrically conductive properties, thus eliminating the need to use embedded wire conductor.

There are some benefits to using fabric-based material for the flexible extruded tubing. Prior art GB2598553 relates to the fabric weaving on flexible extruded tubing whereby the tubing is made of polymeric-based material. However, the weaved fabric disclosed in GB2598553 does not have any electrically conductive property.

The present invention proposed an alternative method in the use of weaving fabric yarn with electrically conductive properties. Fabric is insulating and it is suitable for use in

cold country regions whereby it is able to provide good thermal control of the heated air within the flexible tubing. In addition, fabric-based material is more comfortable to the skin as compared to polymeric material. Having a soft fabric-like material coming into contact with the human skin can provide some added benefits. Such fabric-based materials serve to provide the required softness and comfort to the human skin which can be hard to be replicated on a polymeric material (such as plastic). Moreover, the fabric-like materials exhibit other properties such as good abrasion resistance and tear strength, yet comfortable and offer infinite aesthetics opportunities. In addition, fabric can come in many different color, patterns and textures. Thus, this highlights the benefits of using fabric-based materials.

Currently there are various ways available in the prior art that enable the fabric yarn to be electrically conductive in nature. First and foremost, the material for the fabric substrate has to exhibit good stretchability so that it is easily stretchable and can easily be fabricated into a tube form. For the fabric to be electrically conductive, we incorporate metal wires, metal meshes or metalized yarns into the fabrics. Electrically conductive yarn is made of a central metal strand with regular yarn woven around it. It is however also possible to coat a base polymer (such as polyester or polyamide-6) with metal like silver. Furthermore, electrically conductive yarns can also be produced from carbon nanotubes (CNT). Individual CNT-based fibres are spun into a fibre directly from a solution whereby the solution contains either pre-made dissolved CNTs or a combination of chemicals required to synthesis CNTs. Hence tens to hundreds of individual fibres can be woven into a yarn. For the present invention, the use of **stretchable electrically conductive yarn** is more appropriate since such stretchable yarn is being optimised for repeated elongations and are designed to be highly durable.

The next stage would be to use a vertical circular mount weaving machine with a cylindrical-like jig or mandrel being positioned at the central axis. The cylindrical-like jig or mandrel acts as a guide to help facilitate the weaving of the fabric material so as to form a cylindrical fabric shape. Besides the mandrel, there are also other components within the weaving machine but it varies depending on the machine design and configuration being utilised for the present invention. There are yarn stands next to the weaving machine that contain the stretchable fabric and the electrically conductive yarns. The weaving machine will then continuously inter-weave the stretchable fabric with the electrically conductive fabric yarns around the cylindrical-like jig or mandrel. This weaving process will continue until the cylindrical fabric tube is taking shape. Concurrently the weaved fabric tube is being pulled upwards as it is being weaved. To pull the weaved fabric tube upwards, there are special pulley mechanism to facilitate the weaved tube to be pulled vertically upwards after weaving and then have it transported (via conveyor) to the cutting station for it to be cut out to the desired length as per stipulated specifications.

The weaved electrically conductive fabric tube is now in a cylindrical form. The inner layer of the cylindrical weaved fabric tube will then be coated with a layer of silicone in order to ensure that the air inside the fabric tube will not permeate out via the weaved fabric. This can be done by first mounting the weaved conductive fabric tube onto a customized vertical-mounted holder or special vertical jig, such that this holder or jig can hold the fabric tube properly in a vertical manner and be secured especially during the silicone coating process.

Next a special type of customized cylindrical brush head is utilised and dipped into a tank of chemical silicone solution before application. The brush head will absorb the

silicone and be inserted into the internal diameter of the cylindrical fabric tube in order to coat it. With a mechanical activation, the brush will rotate continuously and at the same time, it moves down along the entire inner diameter of the cylindrical fabric tube. This ensures that the full inner surface area of the fabric tube is covered with silicone. After the fabric tube has been coated, the fabric tube is transferred to a curing / drying station. Upon passing the curing / drying station, the fabric tube is now ready to move to the next stage of over-molding the two (2) ends.

The fabric tube is designed to have electrically conductive links / linkages at each of its two ends that are joined to the inner lining of the electrically conductive yarn. Each of these two ends are then separately over-molded with a polymeric-based external enclosure with a certain diameter. The diameter of the stretchable fabric tube is smaller than the enclosure, thus ensuring a tight and nice fit on the enclosure after over-molding. Once over-molded, the electrically conductive links / linkages on the fabric tube can then connect to the clip-on lead frame connector at the enclosure portion. At each end on the fabric tube, the external enclosure is specially mated to fit into an individual opening in a medical device whereby the external enclosure has grooves that can dovetail with the electrically conductive pins on the medical device side. This entire arrangement will enable the fabric tube to connect from one medical device to another medical device. Hence this helps to ensure proper electrical connectivity in order for the medical devices to work accordingly via the electrically conductive fabric tube.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings attached here are to aid comprehension of the description of the invention here. The drawings are not to scale and they are to be used for merely illustrating the principles and concepts of the invention only.

To aid in comprehension of the invention, the drawings are separated into the various Figures as described below:

Figure 1 illustrates an overall perspective view of the various key components and functions related to weaving process for the embodiment of the present invention.

Figure 2 illustrates a flattened section view of the key components for the electrically conductive fabric tube.

Figure 3 illustrates another overall perspective view of the various key components and functions for the embodiment of the present invention.

Reference numbers

1	Weaving Machine (for weaving of conductive yarn)
2	Yarn Ends
3	Conveyor System / Mechanism
4	Weaved Fabric Tube with conductive yarn
5	Cutting Station
6	Conductive Yarn and Stretchable Fabric Yarn
7	Holder
8	Jig
9	Curing Oven
10	Cylindrical Brush
11	Link / Linkages
12	Conductive Yarn (weaved together with fabric)
13	Conductive Fabric Setup
14	Enclosure A with lead frame connector to Medical Device A
15	Enclosure B with lead frame connector to Medical Device B
16	Medical Device A
17	Medical Device B
18	Electrically Conductive Pins
19	Yarn Stands

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT OF THE PRESENT INVENTION

In the following description, details are provided to describe the embodiment of the application. It shall be apparent to the person skilled in the art, however, that the embodiments may be practiced without such details.

The present invention relates to the field of electrically conductive fabric being applied on the medical flexible tubing. More particularly, the invention relates to method of making the electrically conductive fabric tube using electrically conductive yarn that is weaved into an electrically conductive fabric tube before it is being over-molded at both ends in order to connect with other medical devices. Such fabric tube is suitable for use in medical applications whereby air will flow through the fabric tube with data and thermal control transferring from one point to another.

Figure 1 illustrates an overall perspective view of the various key components and functions related to weaving process for the embodiment of the present invention. It illustrates a range of different stretchable fabric yarn as well as electrically conductive yarn, both denoted as **6** and are located on the yarn stands **19**. The yarn stands **19** are located next to the vertical circular mount weaving machine **1.** Both the stretchable fabric yarn and the electrically conductive yarn which are denoted as **6**, are being fed into the vertical circular mount weaving machine **1** via special transport means which can either be manual or automated feeding system. Within the weaving machine **1**, there is a cylindrical-like jig or mandrel that acts as a guide to help facilitate the weaving of the stretchable fabric with the electrically conductive yarn **6** so as to form a cylindrical fabric shape. As illustrated in **Figure 1**, the weaving machine **1** will then continuously inter-weave the yarns of the stretchable fabric with the electrically conductive fabric

yarns (both denoted as **2**) around the cylindrical-like jig or mandrel. This weaving process will continue until the cylindrical fabric tube is taking shape. Concurrently the weaved fabric tube **4** is being pulled upwards as it is being weaved as illustrated in **Figure 1**. To pull the weaved fabric tube upwards, there are special conveyor pulley mechanism **3** to facilitate the weaved tube **4** to be pulled vertically upwards after weaving and then have it transported (via conveyor) to the cutting station **5** for it to be cut out to the desired length as per stipulated specifications.

The weaved electrically conductive fabric tube **4** is now in a cylindrical form as illustrated in **Figure 1**. **Figure 2** illustrates a flattened section view of the key components for the embodiment of the present invention for the electrically conductive fabric tube **4.** There are links / linkages (denoted as **11**) that are joined to the individual lining of the electrically conductive yarn **12** weaved together with the fabric. The inner layer of the cylindrical weaved electrically conductive fabric tube **4** will then be coated with a layer of silicone in order to ensure that the air inside the fabric tube **4** will not permeate out via the weaved fabric. As illustrated in **Figure 1**, this can be done by first mounting the weaved conductive fabric tube **4** onto a customized vertical-mounted jig **8** placed within a holder **7** such that the fabric tube **4** can be held properly in a vertical manner and be secured especially during the silicone coating process. This is then followed by using a special type of customized cylindrical brush head **10** dipped inside a tank of chemical silicone solution before application. The brush **10** will absorb the silicone before it is then inserted into the internal diameter of the fabric tube **4** in order to coat it. With a mechanical activation, the brush **10** will rotate continuously and at the same time, it moves down along the entire inner diameter of the cylindrical fabric tube **4**. This ensures that the full inner surface of the fabric tube **4** is coated with silicone.

Hence after the inner diameter of the fabric tube **4** has been coated, the fabric tube **4 i**s then removed from the vertical-mounted holder **7**, with the customized vertical-mounted jig **8** intact. The fabric tube **4** is then transferred to a curing oven **9** as illustrated in **Figure 1** so as to cure and dry the coated silicone. This is to ensure that air will not permeate or leaked out and this is important especially for medical device applications.

After curing and drying, the fabric tube **4** is ready to move to the next stage of over-molding the two (2) ends. As illustrated in **Figure 3**, each of these two ends are then separately over-molded with a polymeric-based external enclosure (denoted as **14** and **15**) with a certain diameter. The diameter of the stretchable fabric tube **4** is smaller than the enclosure **14** and **15**, thus ensuring a tight and nice fit on the enclosure **14** and **15** after over-molding. Once over-molded, the electrically conductive links / linkages **11** on the fabric tube **4** can then connect to the clip-on lead frame connector at the enclosure portion **14** and **15**. At each end on the fabric tube **4** as illustrated in **Figure 3**, the external enclosure (denoted as **14** and **15**) is specially mated to fit into an individual opening in medical device denoted as **16** and **17** respectively whereby the external enclosure **14** and **15** has grooves that can dovetail with the electrically conductive pins **18** on the medical device side **16** and **17**. This entire arrangement will enable the fabric tube to connect from one medical device to another medical device. Hence this helps to ensure proper electrical connectivity in order for the medical devices to work accordingly via the conductive fabric tube **4**.

Therefore, the present invention presented an innovative method of making an electrically conductive fabric tube (using conductive yarn) that is suitable for use in medical applications whereby air will flow through the fabric tube from one point to another with data and thermal control.

While what has been described hereinabove is the preferred embodiment of the invention, those skilled in the art will understand that numerous modifications may be made without departing from the spirit and scope of the invention. The embodiments described herein are meant to be illustrative only and should not be taken as limiting the invention, which can be expressly set forth in the following claims.

CLAIMS

What is claimed is:

1. A **method** for manufacturing an electrically conductive fabric tube that is suitable for use in medical applications, whereby it comprises of the following:
   (a) selecting a unique fabric yarn with good stretchability; followed by
   (b) preparing the stretchable electrically conductive yarn by either one of the following methods:
      i. incorporating metal wires, metal meshes or metalized yarns into the fabrics; or
      ii. coating a base polymer (such as polyester or polyamide 6) with metal like silver; or
      iii. spinning individual carbon nanotubes (CNT)-based fibres into a fibre directly from a solution whereby the solution contains either pre-made dissolved CNTs or a combination of chemicals required to synthesis CNTs, such that tens to hundreds of individual fibres can then be woven into a yarn; followed by
   (c) loading the stretchable fabric and the electrically conductive yarn onto yarn stands next to the vertical circular mount weaving machine with a cylindrical-like jig or mandrel being positioned at the central axis; followed by
   (d) using the weaving machine to start inter-weaving the stretchable fabric with the yarn ends of the electrically conductive yarn around the cylindrical-like jig or mandrel, whereby the weaving process will continue until the cylindrical electrically conductive fabric tube is taking shape; followed by
   (e) having the weaved electrically conductive fabric tube being pulled upwards as it is being weaved; followed by
   (f) cutting it out to the desired length at the cutting station based on the

stipulated specifications; followed by

(g) mounting the weaved conductive fabric tube onto a customized vertical-jig place within the mounted holder, such that this holder and/or jig can hold the fabric tube securely; followed by

(h) using a special type of customized brush to dip into a chemical silicone solution; followed by

(i) inserting the brush into the fabric tube; followed by

(j) mechanically activating the brush such that it will rotate continuously & at the same time, it moves down and up and coats along the entire inner diameter of the cylindrical fabric tube with a layer of silicone coating, followed by

(k) removing the fabric tube with the vertical-mounted jig from the holder and transferring to a curing station; followed by

(l) curing and drying the coating silicone to ensure that air inside the fabric tube will not permeate or leaked out; followed by

(m) incorporating specially customized electrically conductive links / linkages at the two (2) ends of the fabric tube such that they are joined to the inner lining of the electrically conductive yarn; followed by

(n) over-molding each end of the fabric tube with an external enclosure that is made of polymeric-based material with a certain diameter; such that

i. once over-molded, the electrically conductive links / linkages on the fabric tube can then connect to the clip-on lead frame connector at the enclosure portion; and wherein

ii. at each end of the fabric tube, the external enclosure is specially mated to fit into an individual opening in a medical device; and

iii. the enclosure has grooves that can dovetail with the electrically conductive pins on the medical device side.