

Wearable Device, System and Manufacturing Method for Neck Protection

Technical Field

5 The present invention relates to a wearable safety device and a method for manufacturing the same and in particular, the present invention relates to an airbag device for protecting the neck portion of human beings, a manufacturing method, and a control unit for the device.

10 Background

 Automotive airbag systems, as protective devices for drivers and passengers during traffic accidents, have been implemented for many years. However, motorcycle safety protective gear is not equipped with airbags. Motorcycles account for a large proportion of traffic accidents, and head and neck injuries constitute a large proportion of serious and fatal accidents involved. Although helmets may provide protection for the head of a motorcycle user to certain extents, helmets fail to provide effective protection for the user's neck, creating a safety blind spot that is easily overlooked.

20 Summary

 The present invention provides an airbag for neck protection to enhance the safety of motorcycle users. The wearable safety device described herein includes a helmet and a protective airbag installed on the bottom edge of the helmet, as well as corresponding control devices for controlling the airbag. In the event of an accident, for example, when driving a motorcycle and colliding with another object, the airbag is activated and inflated, forming a cushioning airbag around the neck portion of the motorcycle user. This airbag inflates almost instantaneously after the accident and may also detach from the helmet to independently surround the user's neck. The airbag encircles the user's neck and is supported by the shoulders and chest of the user, and the lower edge of the helmet. Before the motorcycle user falls to the ground or is thrown from the motorcycle to impact surrounding objects, the inflated airbag forms protection for the user's head and neck portion, thereby greatly reducing the severity of injury.

The wearable safety device of the present invention includes a helmet and an openable, flexible airbag compartment installed on the inner side of the bottom edge of the helmet, with the airbag folded at non-inflated state and stored within the airbag compartment. An electronic control unit is installed along the outer side of the lower edge of the helmet bottom, including devices such as a sensor, an integrated circuit board, a controller, a battery, a gas source, and an air tube. The necessary space for the airbag compartment can be created by modifying the soft inner lining of the helmet, without the need to alter the rigid shell of the existing helmet. In the event of an accident, when the motorcycle user collides with an object, the sensor detects changes in the motorcycle user's motion state by acquiring measurement data, and evaluates the potential extent of neck injury. This data is transmitted to the controller to determine if a predetermined critical threshold has been reached. If so, the airbag is activated and inflated to form a cushioning airbag ring that tightly surrounds the neck portion of the motorcycle user. The airbag can inflate rapidly at the instant of the accident, for example, within one-hundredth of a second after the accident, thereby forming protection for the motorcycle user's neck before the accident causes injury to the user, thus greatly reducing fatal injuries to personnel.

Brief Description of Drawings

The present invention is described in detail through specific embodiments with reference to the following figures:

FIG. 1 is a schematic view of a motorcyclist encountering a traffic accident situation.

FIG. 2 is a top perspective view of a wearable safety device according to one embodiment of the present invention.

FIG. 3 is a bottom perspective view of the wearable safety device shown in FIG. 2.

FIG. 4 is a perspective view of the wearable safety device shown in FIG. 2 when the airbag is inflated.

5 FIG. 5A is a top view of the airbag cut sheets according to one embodiment of the present invention.

FIG. 5B is a top view of the airbag cut sheets according to another embodiment of the present invention.

10 FIG. 5C is a top view of the airbag cut sheets according to yet another embodiment of the present invention.

FIG. 5D is a schematic diagram illustrating the cutting and joining method for the airbag embodiment shown in FIG. 5A.

15 FIG. 5E is a schematic diagram illustrating the cutting and joining method for the airbag embodiments shown in FIGS. 5B and 5C.

20 FIG. 5F is a perspective top view of the cut sheets for the embodiment shown in FIG. 5A after joining and at an inflated state.

FIG. 5G is a perspective top view of the cut sheets for the embodiments shown in FIGS. 5B and 5C after joining and at an inflated state.

25 FIG. 6 is a schematic diagram illustrating the structure of an airbag compartment and the method for folding the airbag according to one embodiment of the present invention.

30 FIG. 7 is a schematic diagram illustrating the position of the airbag and the end tension straps for a full-face helmet according to one embodiment of the present invention.

FIG. 8 is a schematic diagram illustrating the position of the airbag and the end hook-and-loop fasteners for an open-face helmet according to one embodiment of the present invention.

5 FIG. 9A is a schematic diagram illustrating the position of the control unit and inflation system along the bottom edge of a full-face helmet according to one embodiment of the present invention.

10 FIG. 9B is a diagram illustrating the placement and use of the components of the control unit along the bottom edge of the full-face helmet shown in FIG. 9A.

FIG. 9C is a partially enlarged view of FIG. 9A.

15 FIG. 10A is a schematic diagram illustrating the position of the control unit and inflation system along the bottom edge of an open-face helmet according to another specific embodiment of the present invention.

20 FIG. 10B is a diagram illustrating the position of the components of the control unit along the bottom edge of the full-face helmet (Note: Should likely be open-face helmet) shown in FIG. 10A.

FIG. 10C is a partially enlarged view of FIG. 10A.

25 FIG. 11 is a schematic diagram illustrating the process of the airbag compartment opening and airbag inflating airbag according to one embodiment of the present invention.

30 FIG. 12A is a schematic top view illustrating the positional relationship between the full-face helmet airbag and the airbag compartment before inflation, according to one embodiment of the present invention.

FIG. 12B is a schematic top view illustrating the longitudinal folding relationship of the full-face helmet airbag before and after inflation, as shown in FIG. 12A.

FIG. 13A is a schematic longitudinal cross-sectional view illustrating the positional relationship between the full-face helmet airbag and the airbag compartment before inflation, according to one embodiment of the present invention.

5 FIG. 13B is a schematic longitudinal cross-sectional view illustrating the positional relationship between the full-face helmet airbag and the airbag compartment after inflation, as shown in FIG. 13A.

10 FIG. 14A is a schematic top view illustrating the positional relationship between the open-face helmet airbag and the airbag compartment before inflation, according to another specific embodiment of the present invention.

15 FIG. 14B is a schematic top view illustrating the longitudinal folding relationship of the open-face helmet airbag before and after inflation, as shown in FIG. 14A.

 FIG. 15A is a schematic longitudinal cross-sectional view illustrating the positional relationship between the open-face helmet airbag and the airbag compartment before inflation, according to one embodiment of the present invention.

20 FIG. 15B is a schematic longitudinal cross-sectional view illustrating the positional relationship between the open-face helmet airbag and the airbag compartment after inflation, as shown in FIG. 15A.

Detailed Description

25 As shown in FIGS. 1-4, a motorcycle user, such as a motorcyclist 10, is equipped with a wearable safety device 100 for use while riding a motorcycle 20. According to one embodiment, the wearable safety device 100 of the present invention includes a helmet 110, an airbag compartment 120 attached to the inner side of the helmet's bottom edge, and a control unit assembly 130 attached to the outer side of the helmet's bottom edge. In the event of an accident, for example, when the motorcycle 20 driven by the motorcyclist 10 collides with an object 30, the accident triggers the protective device to inflate the folded airbag stored inside the airbag compartment. The inflated airbag detaches from the

airbag compartment and independently embraces the rider's neck, forming an airbag 142 that surrounds the neck. The airbag 120 inflates and expands within one-hundredth to several tenths of a second, allowing the inflated airbag to embrace the motorcyclist's neck before the rider 10 is thrown from the motorcycle 20. The inflated airbag provides protection to the neck 12 of the motorcyclist 10, greatly reducing injuries to the rider. The shape and size of the airbag 142 are set to be suitable for surrounding the neck 12 of the motorcyclist 10. When the helmet 110 is worn by a user (e.g., a motorcyclist), acceleration values can be measured by a sensor to calculate the head movement state and the stress state on the neck 12. When the real-time calculated head movement state and neck stress state exceed a pre-set critical value, the control unit issues an activation signal, and the wearable safety device 100 inflates the airbag 142. The inflated airbag detaches from the helmet and independently surrounds the neck, forming timely protection for the motorcyclist 10.

Airbag Compartment

The cross-section shown in FIG. 6 is the a-a sectional view from FIG. 3. The material of the illustrated airbag compartment 120 can be elastic rubber or silicone, formed by extrusion or molding. The airbag compartment 120 includes a fixed strip 127 and a movable strip 126. The fixed strip 127 is connected to the inner side of the helmet's lower edge and is provided with a flange structure 128 and a groove structure 129 on both sides; the movable strip 126 is U-shaped with an open mouth, and the two ends of the open mouth are also provided with a corresponding flange structure 128 and a groove structure 129 that mate with the fixed strip 127. When the flange structure 128 of the movable strip 126 is inserted into the groove structure 129, the two components of the airbag compartment 120 press into each other and tightly buckle together due to the elasticity of the groove opening. Taking the single-port inflation mode described below as an example, as shown in FIG. 11, when the airbag is inflated and expands to a volume that reaches the capacity of the airbag compartment 120, the expanding airbag exerts pressure from the inside to the outside of the airbag compartment 120 and pushes against the fixed strip 127 and the movable strip 126. Due to the elastic effect of the groove, the movable strip 126 first detaches at the rear neck portion, gradually transitioning to the front end of the airbag compartment, until the movable strip 126 is completely detached and the airbag

compartment 120 is fully opened, allowing the airbag to inflate and expand to the pre-set volume.

Airbag Compartment Structure

5 In the structure shown in FIG. 11, the fixed strip 127 is connected to the inner side of the helmet 110's lower edge, and the opening of the airbag compartment 120 is oriented obliquely downward and to the left. The inflation interface of the airbag 142 is located directly behind the connection side of the fixed strip 127 and the inside of the helmet, with the inflation direction 141 from right to left. According to the folding method of the
10 airbag, the airbag will also expand and unfold obliquely downward and to the left. Under the pressure of inflation inside the airbag, when the airbag expands to push against the fixed strip 127 and the movable strip 126 from the inside, the engaging mechanism of the flange structure 128 and the groove structure 129 separates, causing the movable strip 126 to detach from the fixed strip 127, and the expanded airbag 143 ejects along the popping
15 direction 118. For an open-face helmet 114, the airbag compartment 120 can be set as a U-shaped structure; for a full-face helmet 112, the airbag compartment 120 can be set as a closed-loop structure or a U-shaped structure. The upper and lower edges of the movable strip 126 are generally at 90 degrees. To ensure that the detachment direction of the upper and lower edges of the movable strip 126 remains consistent and to avoid a situation
20 where one side detaches while the other side is blocked, which would affect the smooth opening of the airbag compartment, a typical example is shown in FIG. 6, where the flange structure 128 and the groove structure 129 at the upper and lower engaging positions of the movable strip 126 and the fixed strip 127 are swapped, which ensures a consistent detachment direction while also satisfying the structural rationality of the cross-
25 section.

Airbag Structure

In an exemplary embodiment shown in FIGS. 5A, 5B, and 5C, the airbag 142 is manufactured using sheets of soft, airtight material, such as a high-strength textile coated
30 with a polymer material. The material sheets include a first main sheet 160 and a second main sheet 161. The first main sheet and the second main sheet each have a partially annular main body portion 162, an outer perimeter 163, an inner perimeter 164, a first end portion 165, a second end portion 166, and an air duct portion 167. The outer perimeter

163 of the first main sheet 160 is airtightly joined with the outer perimeter 163 of the second main sheet 161. The inner perimeter 164 of the first main sheet 160 is airtightly joined with the inner perimeter 164 of the second main sheet 161. The first end portion 165 of the first main sheet 160 is airtightly joined with the first end portion 165 of the second main sheet 161. The second end portion 166 of the first main sheet 160 is airtightly joined with the second end portion 166 of the second main sheet 161. The air duct portion 167 of the first main sheet 160 is airtightly joined with the air duct portion 167 of the second main sheet 161 to form an air inlet.

The cross-sectional diameter of the airbag can be set to match the body size of the motorcycle user, for example, about 10-15 cm for an adult size, so that after inflation, the airbag can provide sufficient protective restriction to the bending of the user's neck without excessively squeezing the user's jaw. The airbag's inner diameter 153 is set to be slightly larger than the user's neck diameter, so that the airbag fits well with the neck without leaving excessive space that would reduce the constraint of the airbag on the user's neck. The airbag's outer diameter 154 is set by comprehensively considering the airbag cross-sectional size, airbag volume, and the circumference of the helmet's lower edge, so that the airbag, when inflated and detached from the helmet, forms independent protection for the neck. In extreme cases, even if the helmet falls off due to a collision, the airbag will not lose its protective effect on the neck.

Airbag Manufacturing Method

As shown in FIGS. 5A, 5B, 5C, 5D, and 5E, the airbag can be manufactured using any of three cutting methods, which differ in the structure and manufacturing steps of the open ends and the inner perimeter: According to the method shown in FIG. 5A, two annular open-cut sheets 155 are directly sewn together along with the ends. According to the method shown in FIG. 5B, two end cut sheets can also be added to the basis of FIG. 5A, with the difference that the end opening is preserved during the initial sewing process, and the two end cut sheets are used for secondary sewing. According to the method shown in FIG. 5C, the inner seam line 157 of the two annular open-cut sheets 155 is sewn first, then the two annular open-cut sheets 155 are turned inside out, so that the seam line that contacts the neck is hidden inside the airbag, and then the open ends are sewn closed with two circular end cut sheets 156. All three methods can achieve the pre-set inflated airbag

shape. On this basis, three inflation ports 135 are provided at both ends and the central rear part of the airbag, respectively. The inflation port 135 transitions from the airbag body to an elongated air intake channel. This channel can remain flexible during and after inflation, allowing for slight displacement of the airbag during expansion, thereby providing mutual independence between the airbag 142 and the helmet 110. The airbag can adopt a single-port (central rear) inflation mode; it can also adopt a dual-port (both ends) inflation mode, which is more conducive to closing the airbag ends; or it can adopt a three-port inflation mode, which makes the airbag inflation more uniform and efficient.

The cut airbag material is joined using heat-press bonding to form the complete airbag. According to the cutting method shown in FIGS. 5A and 5D, all outer seam lines 158 of the two annular open-cut sheets 155 are sewn in a single process. The advantage of this method is that it can be processed in a curtain-style integrated manner in one forming step. The material selection only requires single-sided sewable material, making processing simple and low-cost.

According to the method shown in FIGS. 5B and 5E, the airbag is processed by sewing four cut sheets. This includes two annular open-cut sheets 155 and two circular end cut sheets 156. The seam allowance is widened by about 5 mm for the heat-press bonding surface. The open ends are closed by the two circular end cut sheets 156, and the naturally formed bevel at the closing edge prevents the opening edge from being sharp after the airbag is inflated, avoiding neck discomfort. The airbag opening is located directly below, opposite the inflation port, and between the other two upper inflation ports. The processing sequence is as follows: first, the two annular open-cut sheets 155 are sewn along the outer seam line, keeping the end openings reserved, and then the circular end cut sheets 156 are sewn to the openings. The advantage of this method is that the airbag ends are full, which facilitates the closure of the airbag tail ends and the opening of the airbag compartment ends.

According to the method shown in FIGS. 5C and 5E, the inner seam line 157, which contacts the neck, is sewn first along the airbag's inner diameter, and then turned inside out. Then, the annular open-cut sheets 155 are sewn along the outer seam line 158, keeping the end openings reserved, and finally, the two circular end cut sheets 156 are

sewn using the end outer seam line 158'. The advantage of this method is that the inner seam line does not directly contact the neck, resulting in better comfort, and the airbag ends are full, which facilitates the closure of the airbag tail ends and the opening of the airbag compartment ends. Since sewing is required on both sides during the manufacturing process, a double-sided sewable material is selected.

Lateral Folding of the Airbag

FIG. 6 shows the a-a cross-section of the airbag and the airbag compartment. The lateral cross-section direction of the airbag 142 is the X-direction shown in FIGS. 5A and 5B. The purpose of lateral folding is to make the cross-sectional size of the airbag after folding smaller than the cross-sectional cavity of the airbag compartment. FIG. 6 schematically shows the lateral folding method of the airbag: it can be achieved by repeatedly folding the two overlapping sheets of material 5-7 times before inflation. The folded height is less than the inner cavity height of the airbag compartment 120, allowing the folded airbag to be accommodated within the airbag compartment. The remaining space in the airbag compartment 120 is used for the longitudinal folding of the airbag, so that the entire airbag can be housed within the airbag compartment. Arrow 118 in FIG. 11 indicates the inflation direction 141, allowing the airbag to expand smoothly along the predetermined direction during the inflation process.

Longitudinal Folding of the Airbag (FIGS. 5, 12, 14)

Longitudinal Folding of the Full-Face Helmet 112 Airbag The purpose of the longitudinal folding of the airbag 142 is to allow the folded airbag to be accommodated in the annular airbag compartment 122. FIG. 12A shows the mutual relationship between the lower edge (approximately elliptical) of the full-face helmet 112 and the position of the airbag compartment and the airbag 142 before and after inflation. After inflation, the airbag expands outward near the back of the neck, while the position of the airbag around other parts of the neck remains largely unchanged before and after inflation. The storage method for the airbag 142 is shown in FIG. 12B, where the folded lines within the airbag compartment indicate the longitudinal folding of the airbag. The specific implementation method is as follows: the lateral folding unfolds from the exact rear (Y-direction shown in FIG. 5A) along the longitudinal center line of the airbag (dashed line in FIG. 5A) in folding units of approximately 30 degrees to both sides, with each unit temporarily fixed

with a clip or thin thread. When folding is halfway, because the outer diameter of the airbag is greater than the inner diameter, a part of the airbag's outer diameter, along with the length of the two open ends and the remaining inner diameter of the airbag, needs to be considered as the inner side of the lateral fold, and the remaining outer diameter 154 of the airbag continues to complete the lateral fold as the other side. This forms two turning points 151 on the outer diameter of the airbag (as shown in FIG. 12B). When folding is complete, the turning points become the tail ends of the folded airbag connected to the airbag tension straps 148. The folded airbag is sequentially placed into the annular airbag compartment 122 starting from the central point at the rear to both sides. Since the total length of the annular folded airbag along with the airbag tension straps is greater than the length of the annular airbag compartment 122 (about 20%-30% longer), the folded airbag needs to be longitudinally pleated at the back of the neck. The density of the longitudinal pleating gradually decreases as it unfolds to both sides until it straightens out at the airbag tension straps. This method minimizes the relative displacement between the airbag's inner diameter and the neck during inflation and ensures smooth deployment. Finally, the temporary fixings are removed, and the movable strip of the airbag compartment is closed to complete the longitudinal folding of the airbag.

Airbag Tension Strap

As shown in FIG. 7, for the full-face helmet 112, the function of the airbag tension strap 148 at the airbag opening is to tightly close the two ends of the airbag opening after the airbag is fully inflated, allowing the airbag to tightly hoop the neck and achieve better protection. The two ends of the airbag tension strap 148 are fixed near the two open ends of the airbag, and its length is set to exactly bring the two ends of the airbag into contact and tighten them after inflation. As shown in FIG. 12A, the airbag tension strap 148 is located at the airbag's outer diameter 154, inside the lower edge of the helmet. Since the circumference of the annular airbag compartment 122 is greater than the longitudinal length of the folded airbag 142, the airbag tension strap 148 does not need to be folded when placed into the airbag compartment 120. The airbag tension strap 148 can be made of the same material as the airbag 142.

Hook-and-Loop Fastener

For the full-face helmet 112, to tighten the two ends of the inflated airbag, an end hook-and-loop fastener 149 can also be set on the circular end cut sheet 156 to replace the airbag tension strap. As shown in FIG. 7, for the cutting method shown in FIG. 5A, the airbag ends can be orthogonal at 90 degrees or bevelled to increase the contact area, converting part of the forward tension of the hook-and-loop fastener 149 into shear force, which is more conducive to end tightening. For the cutting method shown in FIG. 5B, the hook-and-loop fastener 149 can be set on both the upper and lower surfaces of the end duckbill 152. Since the contact surface is not orthogonal, it is more conducive to end tightening.

Longitudinal Folding of the Open-Face Helmet 114

Airbag The purpose of the longitudinal folding of the airbag 142 is to allow the folded airbag to be accommodated in the U-shaped airbag compartment 124. FIG. 14A shows the mutual relationship between the lower edge (approximately horseshoe-shaped) of the open-face helmet 114 and the position of the airbag compartment and the airbag 143 before and after inflation. After inflation, the airbag expands outward near the back of the neck, while the position of the airbag around other parts of the neck remains largely unchanged before and after inflation. The storage method for the airbag 143 is shown in FIG. 14B, where the folded lines within the airbag compartment indicate the longitudinal folding of the airbag. The specific implementation method is as follows: the lateral folding unfolds from the exact rear (Y-direction shown in FIG. 5B) along the longitudinal center line of the airbag (dashed line in FIG. 5B) in folding units of approximately 30 degrees to both sides, with each unit temporarily fixed with a clip or thin thread. When folding is halfway, because the outer diameter of the airbag is greater than the inner diameter, a part of the airbag's outer diameter, along with the length of the two open ends and the remaining inner diameter of the airbag, needs to be considered as the inner side of the lateral fold, and the remaining outer diameter 154 of the airbag continues to complete the lateral fold as the other side. This forms two turning points 151 on the outer diameter of the airbag (as shown in FIG. 14B). When folding is complete, the turning points become the tail ends of the folded airbag. The folded airbag is sequentially placed into the U-shaped airbag compartment 124 starting from the central point at the rear to both sides. Since the total length of the U-shaped folded airbag is greater than the length of the U-shaped airbag compartment 124, the folded airbag needs to be longitudinally pleated. The

longitudinal pleating is adopted with equal density until the entire folded airbag is placed into the airbag compartment. Finally, the temporary fixings are removed, and the movable strip of the airbag compartment is closed to complete the longitudinal folding of the airbag.

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Hook-and-Loop Fastener

For the open-face helmet 114, a hook-and-loop fastener 149 can be set at the end duckbill 152 of the airbag to also achieve the purpose of assisting end closure, as shown in FIG. 8. For the airbag made according to the cutting method shown in FIG. 5A, the airbag ends can be orthogonal at 90 degrees or bevelled to increase the contact area, converting part of the forward tension of the hook-and-loop fastener 149 into shear force, which is more conducive to end tightening. For the cutting method shown in FIG. 5B, the hook-and-loop fastener 149 can be set on both the upper and lower surfaces of the end duckbill 152. Since the contact surface is not orthogonal at 90 degrees, it is more conducive to end tightening.

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Working Process of the Airbag and Airbag Compartment

Taking the single-port inflation mode as an example, FIGS. 13A and 13B show the change in the shape of the full-face helmet 112 airbag before and after inflation and the process of the movable strip 126 detaching. FIGS. 15A and 15B show the change in the shape of the open-face helmet 114 airbag before and after inflation and the process of the movable strip 126 detaching. It can be seen from the figures that the two front ends of the airbag move forward during the inflation process, causing a relative displacement with the neck 12. Therefore, dual-port inflation is more conducive to the closure of the airbag ends to form protection.

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Control Unit 130 FIGS. 9A, 9B, 10A, and 10B show the positions of the various components for the full-face helmet 112 and the open-face helmet 114, respectively, where the arrow 116 indicates the forward direction of the helmet. The inflation system and other components inside the control unit 130 are shown in FIGS. 9A, 9B, 10A, and 10B. The inflation system consists of a gas delivery tube 145, a four-way joint 144, and inflation tubes 146. The control unit 130 is installed on the outer side of the helmet's bottom edge, placed symmetrically with respect to the helmet's longitudinal axis. The

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control unit 130 includes a control unit casing 139, inside which are installed components such as a motion sensor 132, an integrated circuit board 134, a gas cylinder 136, an adapter 137, a battery 138, a gas tube 145, and connecting wires.

5 Control Unit Casing

The control unit casing 139 is a combined injection molded part with a U-shaped semicircular cross-section, consisting of a semicircular outer shell and a bottom plate. The control unit casing 139 is installed on the outer side of the helmet's lower edge to keep it as close as possible to the neck, reducing the impact of the added device on helmet wearing, minimizing the increase in weight, eccentricity, and rotational inertia, and improving the comfort of wearing the helmet. The control unit casing 139 and the bottom shell can be installed on the helmet shell with screws and can use a closed rubber seal to enhance sealing and waterproofing. All components of the control unit 130 are installed on the bottom plate of the control unit casing, where the heavier gas cylinder 136 and battery 138 can be installed at the two ends of the U-shaped control unit casing 139, level with the neck, to minimize the helmet's rotational inertia in the forward direction. Once the airbag helmet is activated, the control unit 130 will not be reused.

Gas Generator

The gas generator includes a gas cylinder 136 and an adapter 137. The gas cylinder stores a fixed amount of compressed gas, such as helium. The adapter houses an igniter and a gas channel, with an outlet nozzle connected externally. The igniter is triggered when the control unit sends an ignition signal, opening the gas cylinder. The compressed gas flows through the adapter 137 along the inflation direction 141 and the gas delivery tube 145 to the four-way joint 144. The four-way joint 144 symmetrically distributes the gas to the inflation tubes 146, which are then connected to the airbag inlets 135. The choice of inflation mode can be conveniently switched by opening or closing the air inlets. The inflation volume of the gas cylinder 136 is determined by its volume, gas pressure, and the inflation volume of the airbag. Taking this embodiment as an example, the airbag volume is about 6-7 Liters, and the inflation pressure is about 8-9 kilopascals.

Motion Sensor

The motion sensor 132 (see FIGS. 9B, 10B, 13A, and 15A) is located at the rear of the helmet's lower bottom, symmetrically positioned with respect to the helmet's forward axis, and its orientation should be orthogonal to the Z-direction of the cervical spine, to meet the requirements for three-dimensional measurement. The motion sensor 132 is installed on the integrated circuit board 134, so the integrated circuit board 134 must meet the aforementioned orientation requirements.

Integrated Circuit Board

The integrated circuit board 134 integrates a control module, a storage module, a driver module, as well as auxiliary power management modules, GPS modules, Bluetooth modules, a charging panel, and others. Given the space limitations within the control unit, there may be more than one integrated circuit board. The Bluetooth module can communicate with mobile devices, such as a mobile phone, to maintain contact and form a human-machine interface. The storage module records real-time values detected by the sensor. In the event of an accident, critical values can be sent to the cloud via Bluetooth to establish a deep learning critical state model using AI technology, which can then gradually and clearly display the movement and deformation states of the neck during a critical state. This feature is helpful for understanding the mechanism of neck injury, improving product algorithms, and developing new products for different needs.

Battery

The selection of the battery 138 needs to consider factors such as shape, capacity density, battery life, charging characteristics, volume, and weight. The battery installation position also considers the factors of balancing helmet eccentricity and reducing added rotational inertia. For environmental protection and sustainability purposes, a small solar panel can also be installed inside the control unit casing. During helmet use, the solar panel collects sunlight to provide auxiliary power or charging, which can save battery power consumption and extend the charging interval.

Power Switch The power switch for the airbag helmet can be set on the buckle switch 133 on the chin tension strap 135, and the switching function is realized through a wire and a microswitch during the buckling and unbuckling process. When the buckle

switch is inserted, the power is connected while the helmet is tightened to the jaw by the chin tension strap, and the self-check procedure is immediately completed, with the result reflected on the mobile phone. The power switch can also be set on the charging panel along with a waterproof charging socket. The charging panel is recessed and forms an integral part of the control unit casing 139, with a small, openable compartment door set at the corresponding position, held tightly closed by magnetic attraction.

Although the embodiments of the present invention have been described in the accompanying drawings and explained in the foregoing detailed description, it should be understood that the present invention is not limited to the disclosed embodiments, and its spirit should not depart from the content recited and set forth by the following claims. An understanding of the present invention should encompass rearrangements, modifications, substitutions, and replacements, all of which should be included within the scope of the claims without departing from the spirit of the invention.

Claims

1. A wearable device for neck protection, comprising:

an airbag, wherein the airbag is made from material sheets of a flexible and airtight

5 material, the material sheets including a first main sheet and a second main sheet, the first main sheet and the second main sheet each having a partially annular main body portion, an outer perimeter, an inner perimeter, a first end portion, a second end portion, and an air duct portion, wherein the outer perimeter of the first main sheet is airtightly joined with the outer perimeter of the second main sheet, the inner perimeter of the first main sheet is airtightly joined with the inner perimeter of the second main sheet, the first end portion of the first main sheet is airtightly joined with the first end portion of the second main sheet, the second end portion of the first main sheet is airtightly joined with the second end portion of the second main sheet, and the air duct portion of the first main sheet is airtightly joined with the air duct portion of the second main sheet to form an air inlet;

10 wherein the airbag is capable of deforming from a folded state to an inflated state, in the folded state, the main body portion of the first main sheet is in contact with the main body portion of the second main sheet; in the inflated state, the main body portion of the first main sheet is separated from the main body portion of the second main sheet to form a gas containment space therebetween.

2. The wearable device according to claim 1, wherein the air duct portion includes a first air duct portion, a second air duct portion, and a third air duct portion, the first air duct portion is located in the middle of the main body portion of the first main sheet and the main body portion of the second main sheet, the second air duct portion is located between the middle portion and the first end portion, and the third air duct portion is located between the middle portion and the second end portion.

3. The wearable device according to claim 1, wherein the material sheets further include a first end sheet and a second end sheet, the outer edge of the first end sheet is airtightly joined with the first end portion of the first main sheet and the first end portion of the second main sheet, and the outer edge of the second end sheet is airtightly joined with the

second end portion of the first main sheet and the second end portion of the second main sheet.

4. The wearable device according to claim 1, wherein the airtight joining includes at least one or a combination of heat pressing and bonding, adhesive bonding, and sewing.

5. The wearable device according to claim 1, further comprising a first tension strap and a second tension strap that are mutually connectable and disconnectable, the first tension strap being fixedly connected to the first end, and the second tension strap being connected to the second end.

6. A method for manufacturing a wearable device for neck protection, the method comprising:

cutting and forming material sheets from a fabric, wherein the fabric is a flexible and airtight material, the material sheets including a first main sheet and a second main sheet, the first main sheet and the second main sheet each having a partially annular main body portion, an outer perimeter, an inner perimeter, a first end portion, a second end portion, and an air duct portion;

affixing the inner perimeter of the first main sheet to the inner perimeter of the second main sheet, affixing the outer perimeter of the first main sheet to the outer perimeter of the second main sheet, affixing the first end of the first main sheet to the first end of the second main sheet, and affixing the second end of the first main sheet to the second end of the second main sheet, to form a gas containment space; airtightly joining the air duct portion of the first main sheet with the air duct portion of the second main sheet to form an air inlet, the air inlet being in fluid communication with the gas containment space.

7. The method according to claim 6, wherein the air duct portion includes a first air duct portion, a second air duct portion, and a third air duct portion, the first air duct portion is located in the middle of the main body portion of the first main sheet and the main body portion of the second main sheet, the second air duct portion is located between the middle portion and the first end portion, and the third air duct portion is located between the middle portion and the second end portion, and the manufacturing method includes

airtightly joining the respective first air duct portion, second air duct portion, and third air duct portion of the first main sheet and the second main sheet separately, to form a first air inlet, a second air inlet, and a third air inlet.

5 8. The method according to claim 6, wherein the material sheets further include a first end sheet and a second end sheet, the manufacturing method including airtightly joining the outer edge of the first end sheet with the first end portion of the first main sheet and the first end portion of the second main sheet, and airtightly joining the outer edge of the second end sheet with the second end portion of the first main sheet and the second end portion of the second main sheet.

9. The method according to claim 6, further comprising fixedly connecting a first tension strap to the first end, and fixedly connecting a second tension strap to the second end.

15 10. A wearable system for neck protection, comprising:
a helmet, comprising a helmet body and an accommodating chamber separably coupled to a lower perimeter of the body;
an airbag according to any one of claims 1 to 5, wherein, in the folded state, the airbag is accommodated in the accommodating chamber;
20 a compressed gas container, the compressed gas container being coupled to the helmet body and being in fluid communication with the at least one air inlet;
a control unit, the control unit being coupled to the helmet body,
a gas generator and the compressed gas container coupled to the control unit;
wherein the control unit is set to activate the gas generator when the movement state of
25 an object wearing the helmet reaches a critical value, causing the compressed gas container to inflate the airbag with compressed gas through the at least one air inlet, so as to change the airbag from the folded state to the inflated state.