

PASSIVE SAFETY PROTECTIVE BELLOWS STRUCTURE FOR ROLLING STOCK, ROLLING STOCK AND METHOD

[0001] The present application claims the priority to Chinese Patent Application No. 202410627511.X, titled "PASSIVE SAFETY PROTECTIVE BELLOWS STRUCTURE FOR ROLLING STOCK, ROLLING STOCK AND METHOD", filed with the China National Intellectual Property Administration on May 20, 2024, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present application relates to the technical field of rail transit and, in particular, to a passive safety protective bellows structure for a rail vehicle, a rail vehicle, and a method.

BACKGROUND

[0003] The statements in this section only provide background information related to the present application, which do not necessarily constitute the prior art.

[0004] In the field of rail transit, adjacent carriages are connected generally by flexible connection to ensure relative movement between the adjacent carriages. The flexible connection employs bellows for transition between the adjacent carriages to block airflow and reduce drag during operation.

[0005] The conventional bellows has an internal hollow structure, and an external rubber capsule which is configured to deform under compression during operation. When a rail vehicle is involved in a tail-end collision that causes uncoupling, the adjacent carriages are compressed against each other. The inventors found that, in this accident, a conventional bellows structure cannot effectively buffer collision and compression between the adjacent carriages, so that end walls of the adjacent carriages come into direct contact during the collision. Due to high collision energy and significant impact force between the adjacent carriages, the compression between the carriages resulting from such collision inflicts secondary impact upon the carriages and occupants, causing secondary injuries to the occupants and significant damage to the carriages.

SUMMARY

[0006] In view of the shortcomings of the related art, a first object of the present application is to provide a passive safety protective bellows structure for a rail vehicle, which can effectively resist to the impact force and avoid formation of the secondary impact, absorb impact energy, and reduce the damage and injuries to the carriages and the occupants.

[0007] A second object of the present application is to provide a rail vehicle including a passive safety protective bellows structure, which can effectively reduce damage to the rail vehicle during the collision.

[0008] To achieve the above objects, the following technical solutions are proposed according to the present application.

[0009] A passive safety protective bellows structure for a rail vehicle includes a capsule which is installed on the rail vehicle via a bellows mounting seat. There is a chamber formed between the capsule and the bellows mounting seat. An expandable air curtain is disposed in the chamber. The air curtain is supported by multiple fixing devices arranged along a circumferential direction of the rail vehicle.

[0010] Each fixing device includes a fixed seat which is mounted to the bellows mounting seat and is movably connected on each side to a support member via a rotatable member. An elastic member is movably disposed between the rotatable member and the fixed seat on each side of the fixed seat. The support member is detachably connected to a fixing cover with a space formed between them to both support and restrain the air curtain therein. The support member includes a retractable part. The retractable part is configured to be in an extended state under action of the elastic member, and to retract as the air curtain expands such that the support member is separated from the fixing cover under pressure exerted by the expanding air curtain.

[0011] In the bellows structure as described above, the multiple fixing devices are disposed in the chamber to support the air curtain. The space formed between the fixing cover and the support member effectively restrains the air curtain to prevent it from swaying in the chamber. The support member is subjected to a first force exerted by the fixing cover. The elastic member provides a second force applied to the support member via the rotatable member. In

this way, the retractable part remains in an extended state under action of the elastic member. The air curtain exerts pressure on the support member during expansion, which causes the retractable part of the support member to retract so as to disengage the fixing cover from the support member as the air curtain expands.

5 **[0012]** In the passive safety protective bellows structure for the rail vehicle as described above, the air curtain is formed with an airflow port connected to an inflation device and a deflation device through pipelines. A switch is disposed at the airflow port. Each of the switch, the inflation device, and the deflation device is connected to a control unit.

10 **[0013]** The control unit is coupled to a main controller of the rail vehicle. Upon receiving a signal indicating the collision, the main controller of the rail vehicle transmits it to the control unit, which controls operation of the switch, the inflation device, and the deflation device.

[0014] Alternatively, the air curtain is a safety airbag that can expand rapidly at the moment of collision, and automatically deflate under compression once expanded to closely contact an inner wall of the capsule.

15 **[0015]** In the passive safety protective bellows structure for the rail vehicle as described above, the support member includes two vertical stoppers arranged oppositely and connected to an open-ended stopper and a closed-ended stopper respectively. A groove is formed in a side portion of the open-ended stopper, and a side portion of the closed-ended stopper is inserted into the groove of the open-ended stopper, and the closed-ended stopper is movable
20 relative to the groove so as to form the retractable part.

[0016] A distance between the two vertical stoppers is less than a width of the fixed seat, so each rotatable member is positioned at an acute angle relative to the fixed seat. In this way, the elastic member remains in a compressed state in a normal condition, ensuring relative positioning between the open-ended stopper and the closed-ended stopper, and is further
25 compressed as the airbag expands.

[0017] The fixed seat has the same length as the support member.

[0018] In the passive safety protective bellows structure for the rail vehicle as described above, both the open-ended stopper and the closed-ended stopper are bent.

30 **[0019]** The open-ended stopper and the closed-ended stopper each are connected to a top side or a middle portion of the corresponding vertical stopper, so as to minimize a contact area

between the expanding air curtain and the vertical stoppers.

[0020] In the passive safety protective bellows structure for the rail vehicle as described above, the groove of the open-ended stopper has a predetermined depth. Rotatable rollers are respectively arranged on opposite sides of the groove at intervals and are rotatable relative to the open-ended stopper. The provision of the rotatable rollers facilitates a reduction in frictional force encountered during movement of the closed-end stopper towards the open-end stopper.

[0021] In the passive safety protective bellows structure for the rail vehicle as described above, the fixing cover is U-shaped, and the vertical stoppers are connected to opposite side walls of the U-shaped fixing cover by means of snap-fit fasteners. The arrangement of the snap-fit fasteners ensures reliable connection between the fixing cover and the vertical stoppers, and facilitates the separation of the fixing cover from the vertical stoppers when the support member is subjected to pressure.

[0022] In the passive safety protective bellows structure for the rail vehicle as described above, the fixed seat is provided with a lateral seat on each side of the fixed seat. The provision of the lateral seat facilitates the moveable connection with the rotatable member. The rotatable member is provided at each end of each lateral seat. Accordingly, a total of four rotatable members are provided.

[0023] The rotatable member includes a linkage assembly, which includes two links. Each link is pivotally connected at one end to the vertical stopper and is pivotally connected at the other end to the lateral seat. The two links, the vertical stopper, and the lateral seat form a parallelogram mechanism. A third link is connected between the two links, and one of the two links is connected to the elastic member.

[0024] In the passive safety protective bellows structure for the rail vehicle as described above, the elastic member includes a support spring, one end of which is mounted on the fixed seat via a support seat, and the other end of which is connected to the rotatable member. The support spring can be compressed. When the air curtain is unexpanded, the support spring counteracts the force exerted by the fixing cover on the support member, so that the open-ended stopper and the closed-ended stopper remain in an extended state. As the air curtain expands to exert pressure on the support member, the support spring can be further compressed.

[0025] In the passive safety protective bellows structure for the rail vehicle as described above, the fixed seat is formed with a hole, and the fixed seat is mounted to the bellows mounting seat by means of a fastener passing through the hole.

[0026] In a second aspect, there is further provided a rail vehicle including the passive safety protective bellows structure for the rail vehicle as described above.

[0027] In a third aspect, there is further provided a method for operating a passive safety protective bellows structure for a rail vehicle, including:

mounting the fixed seat of the fixing device on the bellows mounting seat, and supporting the air curtain by the support member;

arranging the fixing cover of each fixing device on one side of the air curtain and connecting the fixing cover to the support member, so as to support and constrain the air curtain by the fixing device to prevent the air curtain from swaying in the chamber during operation of the rail vehicle;

installing the capsule onto the bellows mounting seat;

inflating the air curtain following a collision with the rail vehicle, wherein the air curtain expands rapidly during inflation so as to apply pressure to the support member and the fixing cover, and under the pressure, the support member is moved relative to the fixing cover and towards the fixed seat;

disengaging the fixing cover from the support member by compression of the elastic member and retracting of the retractable part of the support member during movement of the support member; and

further expanding the air curtain until it conforms to an inner wall of the capsule, at which point bellows structures of adjacent carriages have been filled with air, and the air curtain bears part of impact force to prevent direct contact between end walls of the adjacent carriages, and deflating the air curtain at the end of the collision to absorb, through deflation process, energy generated by the collision between the adjacent carriages.

[0028] The beneficial effects of the present application are as follows.

1) In the present application, the bellows structure is reasonably configured. The multiple fixing devices are disposed in the chamber to support the air curtain. The space formed

between the fixing cover and the support member effectively restrains the air curtain to prevent it from swaying in the chamber. The support member is connected to the fixed seat via the rotatable member. The elastic member is disposed between the rotatable member and the fixed seat. The support member is subjected to a first force exerted by the fixing cover.

5 The elastic member applies a second force to the support member through the rotatable member. In this way, the retractable part remains in an extended state under action of the elastic member. The air curtain exerts pressure on the support member during expansion, which causes retraction of the retractable part of the support member to disengage the fixing cover from the support member as the air curtain expands. Thus, during a collision of the rail
10 vehicle, the air curtain bears part of the impact force to prevent direct contact between end walls of adjacent carriages. By utilizing inflation and deflation process of the air curtain, it is possible to reduce secondary damage and injuries to the carriages and occupants caused by the crushing between the carriages, minimize severity of damage caused by the collision and achieve passive safety protection for the rail vehicle.

15 2) In the present application, the support member is reasonably configured. The support member includes the vertical stoppers connected to an open-ended stopper and a closed-ended stopper respectively. A side portion of the closed-ended stopper can be inserted into the groove of the open-ended stopper to form the retractable part. In a normal condition, the closed-ended stopper is inserted into the groove but does not reach a bottom surface of the
20 groove under the action of the elastic member. As the air curtain expands, the closed-ended stopper can move along the groove under the action of pressure to facilitate the separation of the fixing cover from the vertical stoppers.

3) In the present application, the fixing cover is U-shaped, forming a space between it and the support member. Both the fixing cover and the support member can support
25 circumferentially the air curtain. The fixing cover is connected to the vertical stopper by the snap-fit fasteners. The arrangement of the snap-fit fasteners ensures reliable connection between the fixing cover and the vertical stopper, and facilitates the separation of the fixing cover from the vertical stopper when the support member is subjected to pressure.

4) In the present application, the rotatable member includes a linkage assembly which
30 includes two links. The two links, the vertical stopper and the lateral seat form a parallelogram mechanism, ensuring relative movement between the two vertical stoppers in

an x direction, and thus ensuring relative movement between the open-ended stopper and the closed-ended stopper in the x direction.

5) In the present application, the elastic member structure is reasonably configured. The elastic member is connected between the fixed seat and the rotatable member. The elastic member is positioned at an acute angle relative to the fixed seat. When the air curtain is unexpanded, the elastic member counteracts the force of the fixing cover exerted on the support member, so that the open-ended stopper and the closed-ended stopper remain in an extended state. As the air curtain expands and exerts pressure on the support member, the elastic member can be further compressed.

6) In the present application, the method for operating the bellows structure includes firstly installing the fixing device to support the air curtain, and then installing the capsule. When the rail vehicle is involved in a collision, the expanding air curtain bears part of the impact force to prevent direct contact between end walls of adjacent carriages. At the end of the collision, it is possible to absorb energy generated by the collision between adjacent carriages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The accompanying drawings, which form part of the present application, are given to aid in further understanding of the present application. Illustrative embodiments of the present application and their descriptions are given to explain the present application, but do not constitute an improper limitation on the present application.

[0030] FIG. 1 is a front view of a passive safety protective bellows structure for a rail vehicle according to one or more embodiments of the present application.

[0031] FIG. 2 is a schematic view of the passive safety protective bellows structure for the rail vehicle according to one or more embodiments of the present application, with a chamber filled with an air curtain.

[0032] FIG. 3 is a sectional view showing internal installation of the passive safety protective bellows structure for the rail vehicle according to one or more embodiments of the present application.

[0033] FIG. 4 is a sectional view of the passive safety protective bellows structure for the

rail vehicle according to one or more embodiments of the present application, with the chamber filled with the air curtain.

[0034] FIG. 5 is a schematic structural view of a fixing device of the passive safety protective bellows structure for the rail vehicle according to one or more embodiments of the present application.

[0035] FIG. 6 is an axonometric view of the fixing device of the passive safety protective bellows structure for the rail vehicle according to one or more embodiments of the present application.

[0036] FIG. 7 is a schematic view showing structural changes in the fixing device of the passive safety protective bellows structure for the rail vehicle according to one or more embodiments of the present application during inflation of the air curtain.

[0037] FIG. 8 is a schematic view of the passive safety protective bellows structure for the rail vehicle according to one or more embodiments of the present application between adjacent carriages upon completion of inflation.

[0038] In the accompanying drawings, distances between or dimensions of various parts have been exaggerated to illustrate their positions. All schematic views are intended for illustrative purposes only.

[0039] List of reference numerals:

- | | |
|------------------------|----------------------------|
| 1. chamber; | 2. capsule; |
| 3. fixing device; | 4. fastening bolt; |
| 5. air curtain; | 6. fastening bolt hole; |
| 7. fixing cover; | 8. snap-fit fasteners; |
| 9. open-ended stopper; | 10. closed-ended stopper; |
| 11. rotatable roller; | 12. vertical stopper; |
| 13. elastic member; | 14. fixed seat; |
| 15. support seat; | 16. lateral seat; |
| 17. control unit; | 18. bellows mounting seat; |
| 19. rotatable member; | 20. space; |

21. groove;

19-1. first link;

19-2. second link;

19-3. third link.

DETAILED DESCRIPTION OF THE EMBODIMENTS

5 [0040] It should be noted that the following detailed description is illustrative and is intended to provide further explanation of the present application. Unless otherwise specified, all technical and scientific terms used herein have the same meaning as commonly understood by those skilled in the art to which the present application pertain.

[0041] It should be noted that the terms used herein are only for the purpose of describing
10 specific embodiments, and are not intended to limit the exemplary embodiments according to the present application. As used herein, the singular form is also intended to include the plural form, unless otherwise expressly specified. In addition, it should be understood that when the terms "including" and/or "comprising" are used in the specification, they indicate the presence of features, steps, operations, devices, components, and/or combinations thereof.

15 [0042] As described in the section of background, secondary damage to the carriages and occupants is caused by the crushing between the carriages during a collision of conventional rail vehicles. To address this technical issue, a passive safety protective bellows structure for a rail vehicle is provided according to the present application.

First Embodiment

20 [0043] In a particular embodiment of the present application, referring to FIGS. 1 and 2, a passive safety protective bellows structure for a rail vehicle includes a capsule 2 which is installed on a rail vehicle via a bellows mounting seat 18. There is a chamber 1 formed between the capsule 2 and the bellows mounting seat 18. An expandable air curtain 5 is disposed in the chamber 1. The air curtain 5 is supported by multiple fixing devices 3
25 arranged along the circumferential direction of the rail vehicle.

[0044] The fixing device 3 includes a fixed seat 14 mounted on the bellows mounting seat 18. The fixed seat 14 is movably connected to a support member via a rotatable member 19. An elastic member 13 is movably disposed between the rotatable member 19 on each side and the fixed seat. The support member 13 is detachably connected to a fixing cover 7 with a
30 space formed between them to both support and restrain the air curtain therein. The fixing

cover 7 is arranged opposite to the fixed seat. The support member includes a retractable part which remains in an extended state under action of the elastic member 13. The retractable part can retract as the air curtain 5 expands, such that the support member is separated from the fixing cover 7 under pressure generated due to expansion of the air curtain, which facilitates further expansion of the air curtain 7 until it conforms to an inner wall of the capsule 2. Thus, it is possible to avoid the crushing between carriage end walls, since the air curtain 5 bearing part of impact force.

[0045] It should be explained that the capsule 2 refers to a rubber capsule arranged between two adjacent carriages of the rail vehicle to reduce noise and drag during operation of the rail vehicle.

[0046] In an example, the fixed seat 14 is a fixed plate. The fixed seat 14 is formed with a fastening bolt hole at its center. Referring to FIG. 3, the fixing device 3 is mounted to the bellows mounting seat 18 by means of a fastening bolt 4 passing through the fastening bolt hole. The fixed seat is provided with a lateral seat 16 on each side, which is connected perpendicularly to the fixed seat. Each lateral seat is movably connected to the rotatable member 19.

[0047] Moreover, it is readily understood that, except for the retractable part, the components of the fixing device are arranged symmetrically with respect to a central axis of the fastening bolt hole in a normal condition.

[0048] Referring to FIGS. 5 and 6, the support member includes two vertical stoppers 12 arranged oppositely on both sides and connected to an open-ended stopper 9 and a closed-ended stopper 10 respectively. A groove 21 is formed in a side portion of the open-ended stopper. A side portion of the closed-ended stopper is inserted into the groove 21 of the open-ended stopper 9, and the closed-ended stopper is movable relative to the groove 21 so as to form the retractable part. The open-ended stopper 9 and the closed-ended stopper 10 are respectively mounted to the inner sides of the corresponding vertical stoppers 12. The air curtain 5 is constrained in a space defined and enclosed by the open-ended stopper 9, the closed-ended stopper 10, and the fixing cover 7. A portion of the open-ended stopper that is provided with the groove 21 is collinear with a portion of the closed-ended stopper that is inserted into the groove. When the air curtain 5 is unexpanded, one end of the closed-ended stopper 10 is inserted into the groove 21 but does not reach a bottom surface of the groove.

[0049] A distance between the two vertical stoppers 12 is less than a width of the fixed seat 14, so the rotatable member on each side is positioned at an acute angle relative to the fixed seat. In this way, the elastic member 13 remains in a compressed state in the normal condition, ensuring relative positioning between the open-ended stopper 9 and the closed-ended stopper 10, and is further compressed as the airbag 5 expands.

[0050] In this embodiment, the fixing cover 7 is U-shaped. An inner surface of each of both side walls of the fixing cover 7 is fixed to the corresponding vertical stopper 12 by means of a snap-fit fastener 8. A height of each of the two side walls of the fixing cover 7 is less than that of the vertical stopper 12. Thus, each of the side walls on both sides of the fixing cover 7 may be snap-fitted to an outer surface of an upper half portion of the corresponding vertical stopper 12, thereby avoiding interference with the movement of the rotatable member. The snap-fit fastener includes a protrusion on an outer side of the vertical stopper 12 and a recess on an inner side of the fixing cover 7. The provision of the snap-fit fastener 8 can not only ensure reliable connection between the fixing cover and the vertical stopper 12, but also facilitate the separation of the fixing cover from the vertical stopper 12.

[0051] It can be understood that both the open-ended stopper 9 and the closed-ended stopper 10 may be bent to form the space 20 between the support member and the fixing cover 7 while reducing a contact area between the air curtain and the vertical stopper 12. The open-ended stopper 9 is connected at one end to an upper half portion of the inner surface of the vertical stopper 12 on one side, and is formed with the groove 21 on the other side. The groove has a predetermined depth, and the groove has a height less than a thickness of the open-ended stopper. One end of the closed-ended stopper 10 is inserted into the groove, and the closed-ended stopper is movable relative to the groove. The other end of the closed-ended stopper is connected to an upper half portion of the vertical stopper 12 on the other side. Multiple rotatable shafts 11 are arranged on opposite sides of the groove of the open-ended stopper 9. The rotatable rollers 11 are rotatable relative to the open-ended stopper, and are arranged at intervals, which can effectively reduce resistance generated when the closed-ended stopper 10 moves in the groove of the open-ended stopper 9.

[0052] In an example, the vertical stopper 12 is a vertical stopping plate of a predetermined length, the open-ended stopper 9 is an open-ended stop plate of a predetermined length, and the closed-ended stopper 10 is a closed-ended stop plate of a predetermined length. The

lengths of the vertical stopper, the open-ended stopper and the closed-ended stopper may be the same as that of the fixed seat. The fixing cover has a width less than that of the fixed seat. The rotatable members are respectively arranged at four corners of the fixed seat. Correspondingly, each rotatable member is accompanied by one elastic member 19.

5 **[0053]** It is readily understood that the fixed seat 14 is provided with a lateral seat 16 on each side, which has the same length as the fixed seat. The lateral seat is provided with the rotatable member at each end. Accordingly, a total of four rotatable members are provided. The lateral seat 16 is perpendicular to the fixed seat. The lateral seat 16 has a predetermined height. The lateral seat 16 extends in height beyond the fixed seat to enable the arrangement
10 of a first link and a second link. The arrangement of the lateral seat 16 facilitates the movable connection with the rotatable members 19.

[0054] The rotatable member 19 includes a linkage assembly, which includes a first link 19-1 and a second link 19-2. One end of the first link 19-1 is pivotally connected to a middle portion of a vertical stopper 12 on the same side, and the other end of the first link 19-1 is
15 pivotally connected to a side portion of the lateral seat 16 away from the fixed seat 14. One end of the second link 19-2 is pivotally connected to a bottom end (an end away from the fixing cover 7) of the vertical stopper 12 on the same side, and the other end of the second link 19-2 is pivotally connected to a side portion of the lateral seat 16 close to the fixed seat 14. A third link 19-3 is connected between the first link 19-1 and the second link 19-2. The
20 third link 19-3 is pivotally connected to both the first link and the second link. The first link 19-1, the second link 19-2, the lateral seat 16 and the vertical stopper 12 form a parallelogram structure, ensuring relative movement between the vertical stoppers 12 on both sides in an x direction, and thus ensuring relative movement between the open-ended stopper 9 and the closed-ended stopper 10 in the x direction.

25 **[0055]** The elastic member 13 is pivotally connected at one end to a support seat 15 mounted on the fixed seat 14, and is connected at the other end to the side of the second link 19-2 close to the lateral seat 16. A connection point of the third link 19-3 and the second link 19-2 is situated between the elastic member 13 (a connection point of the elastic member 13 and the second link) and the end of the second link connected to the lateral seat, such that the
30 elastic member 13 is positioned at an acute angle relative to the fixed seat 14. The other end of the support seat is connected to the second link to provide support for the rotatable

member.

[0056] In an example, the elastic member 13 may be a support spring having certain stiffness and capable of adjusting its length within a determined range.

5 [0057] The air curtain 5 may be a long strip-shaped air curtain arranged along the circumferential direction of the rail vehicle, not forming a complete loop. When inflated, the air curtain 5 has a volume equal to that of the chamber 1.

[0058] In this embodiment, the air curtain 5 is formed with an airflow port fitted with a switch such as a solenoid valve. The airflow port is connected to an inflation device and a deflation device through pipelines. Each of the switch, the inflation device, and the deflation device is coupled to a control unit 17 installed on an end wall outside the bellows structure. The control unit is coupled to a main controller of the rail vehicle to receive signals transmitted from the rail vehicle for activating the switch and the inflation device to rapidly inflate the air curtain 5. An air pressure sensor is disposed inside the air curtain 5. The control unit is coupled to the air pressure sensor to obtain pressure inside the air curtain 5 and set a maximum pressure for the air curtain 5. Upon receiving a signal indicating the maximum pressure has been reached, the control unit is configured to deactivate the inflation device and activate the deflation device to rapidly evacuate air from the air curtain.

[0059] The inflation device may be a conventional inflation device, and the deflation device may be a suction pump.

20 [0060] The control unit 17 may be a PLC controller or any other type of controller.

[0061] According to the bellows structure in this embodiment, the air curtain is arranged longitudinally along a length direction of the support member, and both ends of the air curtain extend beyond respective ends of the support member. The support member is subjected to a first force exerted by the fixing cover. The elastic member 13 applies a second force to the support member via the rotatable member 19. When the air curtain is unexpanded, the retractable part remains in an extended state under the action of the elastic member. The air curtain exerts pressure on the support member during expansion, and the support member, under the action of the pressure, causes the closed-ended stopper 10 to move along the groove towards the open-ended stopper 9.

30 [0062] A method for operating a passive safety protective bellows structure for a rail vehicle

includes following steps.

[0063] Multiple fixing devices each are mounted on a bellows mounting seat by a fastening bolt. The fixing devices for supporting the same air curtain may be arranged on the same circumference of the rail vehicle or may be slightly offset from one another. For each fixing device, a front end of a closed-ended stopper 10 is inserted into a groove of an open-ended stopper 9.

[0064] An air curtain 5 is placed on surfaces of the closed-ended stopper 10 and the open-ended stopper 9, and a fixing cover 7 is assembled with vertical stoppers 12 by means of snap-fit fasteners 8, so as to hold the air curtain 5 in place.

[0065] The capsule 2 is installed to the bellows mounting seat 18.

[0066] Upon a main controller of the rail vehicle receives a signal indicating collision with the rail vehicle or a signal indicating uncoupling of a coupler of the rail vehicle (the method by which the main controller of the rail vehicle receives the signal indicating collision with the rail vehicle or a signal indicating uncoupling of the coupler of the rail vehicle pertains to conventional technologies), it sends the signal to the control unit, and the control unit 17 activates the switch and the inflation device to inflate the air curtain 5 promptly.

[0067] During inflation, the air curtain 5 expands rapidly to exert pressure on the surfaces of the open-ended stopper 9 and the closed-ended stopper 10, as well as an inner surface of the fixing cover 7. Under the pressure, the surfaces of the open-ended stopper 9 and the closed-ended stopper move relative to the inner surface of the fixing cover 7. Since a contact area between the air curtain 5 and the vertical stopper 12 is negligible, the pressure generated by the airbag 5 is borne by the inner surface of the fixing cover 7 and outer surfaces of the open-ended stopper 9 and the closed-ended stopper 10. Under the pressure, the open-ended stopper 9 and the closed-ended stopper 10 move towards the fastening bolt 4. During this process, a support rod is compressed, and the closed-ended stopper moves along the groove towards the open-ended stopper.

[0068] The vertical stoppers 12 on both sides move towards each other. Upon moving a predetermined distance, the snap-fit fastener 8 no longer restricts the fixing cover 7. As shown in FIG. 7, the fixing cover 7 is pushed away under the action of the pressure caused by the expansion of the air curtain 5.

[0069] Once no longer constrained by the fixing cover, the air curtain 5 continues to expand until it fits against the inner wall of the capsule 2. At this point, the bellows of adjacent carriages have been filled with air, as shown in FIG. 8. That is, at the moment of the collision between the adjacent carriages of the rail vehicle after uncoupling, the air curtain expands rapidly to cause the bellows of the adjacent carriages in close contact, and the inflated air curtain 5 bears part of impact force to prevent direct contact between end walls of the adjacent carriages. At the end of the collision, the air curtain 5 deflates rapidly to absorb energy generated by the collision between the adjacent carriages, thereby preventing secondary damage and injuries to the carriages and occupants.

10 Second Embodiment

[0070] The difference between this embodiment and the first embodiment is that the air curtain is a safety airbag. The safety airbag can expand rapidly at the moment of collision, and automatically deflate under compression after it is expanded to closely contact the inner wall of the capsule, so as to absorb the energy generated by the collision between adjacent carriages through the deflation process.

Third Embodiment

[0071] This embodiment provides a rail vehicle including the passive safety protective bellows structure for the rail vehicle as described in the first embodiment or the second embodiment.

[0072] The above are only preferred embodiments of the present application, and are not intended to limit the present application. For those skilled in the art, the present application may have various modifications and changes. Any modifications, equivalent replacements, improvements, etc. made within the spirit and principle of the present invention shall be included within the scope of protection of the present application.

CLAIMS

1. A passive safety protective bellows structure for a rail vehicle, comprising a capsule which is installed on the rail vehicle via a bellows mounting seat, wherein:

5 a chamber is formed between the capsule and the bellows mounting seat, and an expandable air curtain is disposed in the chamber and is supported by a plurality of fixing devices arranged along a circumferential direction of the rail vehicle;

each fixing device comprises a fixed seat which is mounted to the bellows mounting seat and is movably connected on each side to a support member via a rotatable member, and an
10 elastic member is movably disposed between the rotatable member and the fixed seat on each side of the fixed seat; and

the support member is detachably connected to a fixing cover with a space formed therebetween to both support and restrain the air curtain therein, the support member comprises a retractable part, the retractable part is configured to be in an extended state under
15 action of the elastic member, and to retract as the air curtain expands such that the support member is separated from the fixing cover under pressure exerted by the expanding air curtain.

2. The passive safety protective bellows structure for the rail vehicle according to claim 1,
20 wherein the air curtain is formed with an airflow port connected to an inflation device and a deflation device through pipelines, a switch is disposed at the airflow port, and each of the switch, the inflation device, and the deflation device is connected to a control unit coupled to a main controller of the rail vehicle; or

the air curtain is a safety airbag.

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3. The passive safety protective bellows structure for the rail vehicle according to claim 1, wherein the support member comprises two vertical stoppers arranged oppositely and connected to an open-ended stopper and a closed-ended stopper respectively, a groove is formed in a side portion of the open-ended stopper, a side portion of the closed-ended stopper

is inserted into the groove of the open-ended stopper, and the closed-ended stopper is movable relative to the groove so as to form the retractable part;

a distance between the two vertical stoppers is less than a width of the fixed seat; and
the fixed seat has the same length as the support member.

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4. The passive safety protective bellows structure for the rail vehicle according to claim 3, wherein both the open-ended stopper and the closed-ended stopper are bent; and

each of the open-ended stopper and the closed-ended stopper is connected to a top side or a middle portion of the corresponding vertical stopper.

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5. The passive safety protective bellows structure for the rail vehicle according to claim 3, wherein the groove of the open-ended stopper has a predetermined depth, rotatable rollers are respectively arranged on opposite sides of the groove at intervals and are rotatable relative to the open-ended stopper.

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6. The passive safety protective bellows structure for the rail vehicle according to claim 3, wherein the fixing cover is U-shaped, and the vertical stoppers are connected to opposite side walls of the U-shaped fixing cover by means of snap-fit fasteners, respectively.

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7. The passive safety protective bellows structure for the rail vehicle according to claim 3, wherein the fixed seat is provided with lateral seats on opposite sides of the fixed seat, and

the rotatable member is provided at each end of each lateral seat, and the rotatable member comprises a linkage assembly, which comprises two links, each link is pivotally connected at one end to the vertical stopper and is pivotally connected at the other end to the lateral seat, wherein the two links, the vertical stopper, and the lateral seat form a parallelogram mechanism, a third link is connected between the two links, and one of the two links is connected to the elastic member.

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8. The passive safety protective bellows structure for the rail vehicle according to claim 3, wherein the elastic member comprises a support spring, one end of which is mounted to the fixed seat via a support seat, and the other end of which is connected to the rotatable member.

5 9. The passive safety protective bellows structure for the rail vehicle according to claim 1, wherein the fixed seat is formed with a hole, and the fixed seat is mounted to the bellows mounting seat by means of a fastener passing through the hole.

10 10. A rail vehicle, comprising the passive safety protective bellows structure for the rail vehicle according to any one of claims 1 to 9.

11. A method for operating the passive safety protective bellows structure for the rail vehicle according to any one of claims 1 to 9, comprising:

15 mounting the fixed seat of each fixing device on the bellows mounting seat, and supporting the air curtain by the support member;

arranging the fixing cover of each fixing device on one side of the air curtain and connecting the fixing cover to the support member, so as to support and constrain the air curtain by the fixing device to prevent the air curtain from swaying in the chamber during operation of the rail vehicle;

20 installing the capsule onto the bellows mounting seat;

inflating the air curtain following a collision of the rail vehicle, wherein the air curtain expands rapidly during inflation so as to apply pressure to the support member and the fixing cover, and under the pressure, the support member is moved relative to the fixing cover and towards the fixed seat;

25 disengaging the fixing cover from the support member by compression of the elastic member and retracting of the retractable part of the support member during movement of the support member; and

further expanding the air curtain until it conforms to an inner wall of the capsule, at which point bellows structures of adjacent carriages have been filled with air, and the air

curtain bears part of impact force to prevent direct contact between end walls of the adjacent carriages, and deflating the air curtain at the end of the collision to absorb, through deflation process, energy generated by the collision between the adjacent carriages.