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(54) DEFORMABLE TUBE, COUPLER CUSHIONING ENERGY-ABSORPTION DEVICE FOR RAIL TRANSIT VEHICLE, AND RAIL VEHICLE

(57) The present application relates to a deformable tube comprising two or more thin-walled tubes that are nested, the thin-walled tubes being carbon fiber tubes or metal tubes, materials of two adjacent thin-walled tubes being different, and the thin-walled tubes indicating that the wall thickness of the tubes is 20 mm or less. Also provided is a coupler cushioning energy-absorption device for rail transit vehicles, comprising a traction rod (1) used for connecting to a coupler head (7), and a bearing plate (5) used for connecting to a coupler tail base (8). The bearing plate (5) and the traction rod (1) are connected by a guide rod (10); the end of the traction rod (1) facing the coupler tail base (8) is provided with an expansion block (2); a deformable tube is sleeved outside the guide rod (10); one end of the deformable tube abuts against one end surface of the bearing plate (5), and a bevel ring that abuts against the expansion block (2) is formed on the other end of the deformable tube, such that the deformable tube swells radially when the expansion block (2) presses the deformable tube; the end of the guide rod (10) close to the bearing plate (5) is provided with a support stage (11); and the outer peripheral surface of the support stage (11) is attached to the inner wall surface of the deformable tube. Further provided is a rail vehicle.

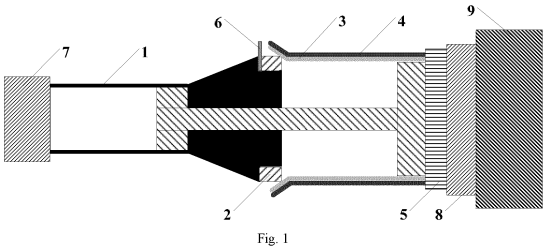

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a deformable tube and a coupler cushioning energy-absorption device for a rail vehicle with same, and a rail vehicle, belonging to the field of vehicle collision.

BACKGROUND OF THE INVENTION

[0002] The anti-collision design of rail vehicles requires that a vehicle anti-collision system runs in a reasonable order specifiedartificially during collision to absorb collision energy as much as possible, thus protecting the safety of passengers and drivers to the greatest extent and reducing vehicle damage.

[0003] At present, most anti-collision systems of rail vehicles are designed at the front ends of the vehicles, and mainly include a coupler cushioning device, an anti-creeper, a driver's cab variable structure, etc., involving a step-by-step energy absorption process. For example, Chinese patent application with publication number of CN108297892A discloses a collision energy absorption system for a rail train and a rail train, where when rail trains collide with each other, a coupler cushioning device moves towards a train body and forms a collision force bearing surface together with an anti-creeper, which can absorb collision kinetic energy more effectively and provide an anti-creeping function.

[0004] Chinese patent application with publication number of CN11126789A discloses a combined energy absorber, which includes a collision baffle, a flanging tube, a base and an energy absorption assembly. One end of the flanging tube is fixedly connected with the collision baffle, and a plurality of cutting grooves are formed on the wall of the flanging tube along the axis of the flanging tube; the other end of the flanging tube abuts against the base, and the side of the base far away from the flanging tube is used for connecting with a vehicle body. The energy absorption assembly is arranged in the flanging tube and fixedly connected with the collision baffle. The above patent is essentially a crimping energy-absorption device, the deformable part of which only bears an axial force. As we all know, in order to ensure the safety of a vehicle structure, drivers and passengers, the axial force on a cushioning energy-absorption device cannot exceed a certain limit, which limits the energy absorption capacity of most cushioning energy-absorption devices.

[0005] A swelling deformable tube is a main collision energy absorption structure of a coupler cushioning device, with relatively stable energy absorption capacity. The swelling deformable tube is mainly composed of an inner ejector rod, an energy absorbing thin-walled structure and a connecting device between the former two. When the structure is impacted longitudinally, the inner ejector rod squeezes the thin-walled structure. When the impact force reaches the critical strength of a sleeve, the thin-walled structure expands and deforms. The impact energy is consumed by the friction between the inner ejector rod and the thin-walled structure and by the outward swelling deformation of the thin-walled structure, which achieves a cushioning effect on the impacted rail vehicle. In order to protect the main structure of the vehicle from damage, the strength of the deformable tube is slightly lower than that of the vehicle body, which has also become a key factor to limit the energy absorption of the deformable tube.

[0006] The energy absorbing thin-walled structure of the swelling deformable tube widely used at the present stage is made of thin-walled metal, and the deformable tube mainly absorbs energy by means of the swelling deformation of the thin-walled structure, so when the deformable tube is impacted by collision, the load feedback is slow, the load fluctuation is large, the impact load on the protected vehicle body structure is unstable, the energy absorption is uneven, and a little energy is absorbed per unit volume. For example, Chinese utility model patent with publication number of CN201329871Y discloses an expandable deformable device installed between a coupler connecting part of a coupler cushioning device and an installation and hanging system.

SUMMARY OF THE INVENTION

[0007] Regarding the problem of insufficient energy absorption of a coupler of a rail vehicle with a swelling deformable energy absorption structure at present, the present invention aims to provide a deformable tube, a coupler cushioning energy-absorption device for a rail vehicle, and a rail vehicle, where the cushioning energy-absorption device improves the collision energy absorption of the deformable tube and optimizes the energy absorption behavior by means of optimized design of a thin-walled structure of the deformable tube.

[0008] In order to achieve the above objective, the technical solution adopted by the present invention is as follows:

A deformable tube includes two or more thin-walled tubes that are connected in a sleeved manner, the thin-walled tube is acarbon fiber tube or a metal tube, materials of two adjacent thin-walled tubes are different, and the thin-walled tube indicates that the wall thickness of the tube is 20 mm or less.

[0009] Therefore, the present invention designs a novel deformable tube structure through long-term research, and two adjacent layers of the deformable tube structure limit each other, which ensures the integrity of the remaining deformable structure, relieves the severe deformation of the remaining thin-walled metal structure, avoids rapid crushing of the remaining thin-walled carbon fiber structure, improves the integrity of the remaining energy absorption structure, reduces the fluctuation of impact load, and increases energy absorption during collision.

[0010] According to the embodiments of the present invention, the present invention may be further optimized. The following are technical solutions formed after optimization:

In a preferred embodiment, the deformable tube consists of two thin-walled tubes, wherein aninner layer of the deformable tube is a metal tube, and anouter layer of the deformable tube is a carbon fiber tube. Further, the metal tube is preferably an aluminum alloy tube.

[0011] In a preferred embodiment, the metal tube has a thickness of 2-7.5 mm, and the carbon fiber tube has a thickness of 2-15 mm.

[0012] Preferably, an epoxy resin layer is arranged between the two adjacent thin-walled tubes. Based on the same inventive concept, the present invention further provides a coupler cushioning energy-absorption device for a rail vehicle, which includes a traction rod used for connecting to a coupler head and a bearing plate used for connecting to a coupler tail base; the bearing plate and the traction rod are connected by a guide rod, and the end of the traction rod facing the coupler tail base is provided with an expansion block;

[0013] The above-mentioned deformable tube is sleeved outside the guide rod, one end of the deformable tube abuts against one end surface of the bearing plate, and a bevel ring that abuts against the expansion block is formed on the other end of the deformable tube, such that the deformable tube swells radially when the expansion block squeezes the deformable tube;

[0014] The end of the guide rod close to the bearing plate is provided with a support stage, and the outer peripheral surface of the support stage is attached to the inner wall surface of the deformable tube.

[0015] One end of the guide rod extends into the traction rod, and the guide rod is fixedly connected with the traction rod by a snap ring connector. The traction rod is connected with the coupler head by a snap ring connector.

[0016] A trigger indicator pin is arranged between the traction rod and the expansion block, the trigger indicator pin is arranged on the outer wall surface of the traction rod, and the outer end of the indicator pin protrudes relative to the outer wall surface of the expansion block. Preferably, the trigger indicator pin is located at the upper part of the top end of the traction rod, near the expansion block, and is a trigger indicator pin triggered by the deformation of the deformable tube.

[0017] One end of the bearing plate is fixedly connected with the coupler tail base by a snap ring connector or a rubber buffer, and the coupler tail base is fixed to a vehicle chassis. The expansion block is a hard structure embedded in the top end of the traction rod. According to the preferred embodiment of the present invention, the present invention relates to a coupler cushioning energy-absorption device of a swelling deformation type, and provides a double-layer or multi-layer thin-walled deformable tube structure design idea for a coupler deformable tube structure. The deformable structure of the present invention is an irreversible energy absorption element generally used with a rubber buffer.

[0018] The deformable tube structure is a part of the coupler cushioning energy-absorption device. Generally, the traction rod at the front end is connected with the coupler head, the bearing plate at the rear end is connected with the coupler tail base by a rubber buffer, and the coupler tail base is connected with the bearing plate and the vehicle chassis.

[0019] The double-layer or multi-layer thin-walled structure of the deformable tube is the main content and innovation of the present invention, wherein the inner layer of the deformable tube is a thin-walled metal structure, the material used for the inner layer includes but is not limited to aluminum alloy, carbon steel and the like, and the outer layer of the deformable tube is a thin-walled carbon fiber composite structure. The aluminum alloy/carbon fiber double-layer thin-walled structure is made by combining a carbon fiber epoxy resin prepreg with an outer surface of an aluminum alloy tube. In order to improve the interface effect between aluminum alloy and carbon fibers, a layer of epoxy resin is added between the aluminum alloy tube and the carbon fiber prepreg. The traditional deformable tube is usually of a single-layer thin-walled metal structure, and absorbs energy mainly by means of the swelling deformation of the thin-walled metal structure, so when the deformable tube is impacted by collision, the fluctuation of impact load is large, the impact load on the protected vehicle body structure is unstable, the energy absorption is uneven, and a little energy is absorbed per unit volume.

[0020] The outer thin-walled structure of the deformable tube is made of a carbon fiber composite. The carbon fiber composite has the advantages of high specific energy absorption, stable impact load, small mass, etc. When subjected to the same collision impact, the impact load on the thin-walled carbon fiber composite structure reaches a peak load faster than the thin-walled metal structure. However, the thin-walled carbon fiber composite structure alone is prone to microscopic defects, is easily broken after severe impact and loses the ability of continuous energy absorption. The double-layer or multi-layer thin-walled structure of the present invention solves this problem. Under the constraint of the inner thin-walled metal structure, the local failure of the thin-walled carbon fiber composite structure does not affect the continuous energy absorption of other parts, thus realizing continuous and stable energy absorption of the thin-walled carbon fiber composite structure and greatly increasing the energy absorption of the whole energy-absorption device.

[0021] The thin-walled carbon fiber structure is twined with two layers of prepreg (0°/90° and ±45°) along the outer wall of the aluminum alloy tube each time, and the initial twining positions of two layers of fibers are staggered by a certain distance to ensure cross laying of fibers, so as to ensure the overall structural strength and stiffness.

[0022] Therefore, the core of the present invention is to provide a deformable tube structure design scheme for a swelling deformable coupler cushioning energy-absorption device. By replacing the traditional single-layer thin-walled metal deformable tube with a double-layer or multi-layer thin-walled (thin-walled metal + thin-walled carbon fiber composite) deformable tube, the energy absorption during collision is increased, and the instantaneous impact hazard caused by collision is reduced.

[0023] Based on the same inventive concept, the present invention further provides a rail vehicle, which is characterized in that the coupler cushioning energy-absorption device for a rail vehicle is installed on a chassis of a vehicle body.

[0024] Compared with the prior art, the beneficial effects of the present invention are as follows:

For the swelling deformable tube structure, its thin-walled structure is a main energy absorption component. The traditional single-layer thin-walled metal structure spends a long time to reach a peak load under impact, with large load fluctuation and low total energy absorption during collision deformation. In addition, the abnormal high impact load caused by the large load fluctuation easily causes damage to the driver's cab and the vehicle body structure, threatening the safety of drivers and passengers.

[0025] For the deformable tube with a double-layer thin-walled structure (thin-walled metal layer + thin-walled carbon fiber composite layer), the double-layer thin-walled structure spends a short time to reach a peak load under impact, with small load fluctuation and stable energy absorption, so the total energy absorption during collision deformation is greatly improved compared with that of the single-layer thin-walled deformable tube and is generally increased by more than 10%, and the abnormal high impact load is effectively avoided, thus ensuring the safety of drivers and passengers.

[0026] Compared with the prior art CN201329871Y, the present invention creatively proposes a double-layer or multi-layer deformable tube structure, which preferably adopts double-layer deformable tube. That is, the effect of the combination of a carbon fiber layer and an aluminum alloy layer (metal layer) in the present application cannot be achieved by random combination of double-layer structures. In the present invention, the carbon fiber has high strength but is fragile, and the aluminum alloy has low strength but good ductility (toughness). During vehicle collision, the aluminum alloy can strongly support the structural integrity of the carbon fiber layer. Meanwhile, the carbon fiber has high specific energy absorption and stable impact load. At the same deformation length, the two materials cooperate with each other to maximize the energy absorption effect, which can also be verified in FIG. 3.

[0027] Compared with the crimping energy-absorption device provided by the prior art CN11126789A, the energy absorption mode of the present invention is swelling energy absorption, and the deformable tube bears axial force and radial force at the same time during compression, while the deformable part of the crimping energy-absorption device disclosed by CN11126789A only bears axial force. The present invention fully utilizes the radial energy absorption ability of the deformable tube on the basis of axial energy absorption, and greatly increases the total energy absorption ability of the whole device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] In order to explain the technical solutions and characteristics of the present invention more clearly, the following will briefly introduce a schematic diagram of a double-layer thin-walled (thin-walled metal layer + thin-walled carbon fiber composite layer) deformable tube described in the present invention and an accompanying drawing to be used in the description of an embodiment.

FIG. 1 is a schematic diagram of a coupler cushioning energy-absorption device of the present invention;

FIG. 2 is a structural schematic diagram of a double-layer thin-walled (thin-walled metal layer + thin-walled carbon fiber composite layer) deformable tube described in the present invention; and

FIG. 3 is a schematic diagram of impact load-displacement curve of an aluminum alloy single-layer thin-walled structure and an aluminum alloy + carbon fiber double-layer thin-walled structure provided by an embodiment of the present invention during collision.

[0029] In the figures:

1 - traction rod; 2 - expansion block; 3 - inner layer of the deformable tube; 4 - outer layer of the deformable tube; 5 - bearing plate; 6 - trigger indicator pin; 7 - coupler head; 8 - coupler tail base; 9 - vehicle chassis; 10 - guide rod; 11 - support stage.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0030] The present invention will be described in detail below with reference to the accompanying drawings and in combination with embodiments. It should be noted that the embodiments in the present invention and the features in the embodiments can be combined with each other without conflicts. For ease of narrative, the terms "upper", "lower", "left" and "right" described below are only consistent with the upper, lower, left and right directions of the drawings, and do not limit the structure.

[0031] In order to make those skilled in the art better understand the solution of the present invention, the present invention will be further described in detail below with reference to FIG. 1. FIG. 1 shows a coupler cushioning energy-absorption device of the present invention. The cushioning energy-absorption device mainly includes a coupler head 7, a deformable tube structure,

and a coupler tail base 8 fixed to a vehicle chassis 9. FIG. 2 is a schematic diagram of a deformable tube with double-layer thin-walled structure of the present invention. The deformable tube structure includes a traction rod 1, an expansion block 2, an inner layer of the deformable tube 3, an outer layer of the deformable tube 4, a bearing plate 5, and a trigger indicator pin 6. The traction rod 1 in the deformable tube structure is connected with the coupler head 7 by a snap ring connector, and the bearing plate 5 in the deformable tube structure is connected with the coupler tail base 8 by a snap ring connector. The bearing plate 5 and the traction rod 1 are connected by a guide rod 10, a deformable tube is sleeved outside the guide rod 10, one end of the deformable tube abuts against one end surface of the bearing plate 5, and a bevel ring that abuts against the expansion block 2 is formed on the other end of the deformable tube; the end of the guide rod 10 close to the bearing plate 5 is provided with a support stage 11, and the outer peripheral surface of the support stage 11 is attached to the inner wall surface of the deformable tube. The specific action mode of each structure when collision occurs is described below in detail.

[0032] When longitudinal collision occurs at a coupler of a rail vehicle, the double-layer thin-walled structure of the deformable tube is squeezed by the expansion block to swell and deform under impact force, so as to absorb collision energy.

[0033] A rail vehicle includes the above-mentioned coupler cushioning energy-absorption device. The traction rod 1 is connected with the coupler head by a snap ring connector, and moves backward together with the coupler head when collision occurs. The expansion block 2 is embedded in the top end of the traction rod. When the collision occurs, the expansion block 2 moves backward together with the traction rod 1 to squeeze the double-layer thin-walled structure of the deformable tube, such that the deformable tube swells. The trigger indicator pin 6 is installed beside the expansion block 2 near the top end of the traction rod. Specifically, the trigger indicator pin 6 is arranged on the outer wall surface of the traction rod 1, and the outer end of the indicator pin 6 protrudes relative to the outer wall surface of the expansion block 2. The trigger indicator pin 6 is an indicator pin for determining whether deformation of the deformable tube occurs. When the trigger indicator pin 6 is triggered, the trigger indicator pin is cut.

[0034] As shown in FIGS. 1 and 2, one end of the bearing plate 5 is connected with the coupler tail base by a snap ring connector and fixed to the vehicle chassis. The other end of the bearing plate 5 is in contact with the double-layer thin-walled structure of the deformable tube, to limit the longitudinal movement of the double-layer thin-walled structure of the deformable tube. The inner layer of the deformable tube 3 is preferably a thin-walled metal structure. When collision occurs, the inner layer of the deformable tube 3 is in direct contact with the expansion block 2. Under the action of a guiding curved surface, the expansion block 2 produces radially outward pressure on the inner wall of the inner layer of the deformable tube 3, such that the inner layer of the deformable tube 3 swells and deforms to absorb collision energy. The outer layer of the deformable tube 4 is preferably a thin-walled carbon fiber composite structure, and is connected with the inner layer of the deformable tube 3 into a whole by a bonding process.

[0035] Whencollision occurs, the inner layer of the deformable tube 3 first swells and deforms, and then drives the outer layer of the deformable tube 4 to expand outward. In this process, the inner layer of the deformable tube 3 has local deformation failure, and the thin-walled carbon fiber structure of the outer layer of the deformable tube 4 has local crushing. In the presence of the double-layer thin-walled structure, the inner layer of the deformable tube 3 and the outer layer of the deformable tube 4 limit each other, which ensures the integrity of the remaining deformable structure, relieves the severe deformation of the remaining thin-walled metal structure, avoids rapid crushing of the remaining thin-walled carbon fiber structure, improves the integrity of the remaining energy absorption structure, reduces the fluctuation of impact load, and increases energy absorption during collision.

[0036] With regard to the deformable tube structure involved in the present invention, the total energy absorbed by the structure during collision is represented by W, and the calculation formula is as follows:

$$W = \int_0^d F(x)dx$$

[0037] Herein, F represents impact load, x represents deformation displacement, and d represents total displacement during deformation. It can be seen that the total energy absorption of the deformable tube during deformation is an area surrounded by an impact load-displacement curve and abscissas, and the faster the impact load reaches a peak load, the greater the total energy absorption is.

[0038] FIG. 3 is a schematic diagram of impact load-displacement curves of an aluminum alloy single-layer thin-walled structure and a double-layer thin-walled structure having an aluminum alloy layer and a carbon fiber layer provided by an embodiment of the present invention during collision. With reference to FIG. 3, the response of the double-layer thin-walled structure to collision impact is faster than that of the aluminum alloy single-layer thin-walled structure, that is, the total energy absorption of the double-layer thin-walled structure is larger. Generally, the total energy absorption of the double-layer thin-walled structure can be increased by more than 10% compared with that of the aluminum alloy single-layer thin-walled structure in a normal deformation state. Meanwhile, the impact load fluctuation of the alu-

minum alloy single-layer thin-walled structure is more violent than that of the double-layer thin-walled structure. Under the same driver's caband vehicle body structure, the abnormal high impact load caused by the violent fluctuation of impact load will increase the probability of damage of the driver's cab and the vehicle body structure and threaten the safety of drivers and passengers. However, the deformable tube of the double-layer thin-walled structure has stable impact load, which can avoid the above situation.

[0039] In order to further optimize the above technical solution, maximize the energy absorption of the whole coupler cushioning energy-absorption device during collision, reduce the damage to the vehicle body structure, and improve the load feedback rate of a deformable device, the design of the thicknesses of the inner layer of the deformable tube 3 and the outer layer of the deformable tube 4 can be optimized to achieve best matching values. For example, the metal tube has a thickness of 2-7.5 mm, and the carbon fiber tube has a thickness of 2-15 mm.

[0040] The adhesive performance of the carbon fiber layer and the aluminum alloy layer used in this embodiment is excellent, and the probability that the carbon fiber layer and the aluminum alloy layer are not adhered to each other is low.

[0041] It should be noted that, on the basis of the above embodiment, the developed deformable tube structure design schemes of increasing the number of thin-walled layers of the deformable tube (e.g., more than two layers), and adjusting the thin-walled thickness of the deformable tube and the order of the aluminum alloy layer and thin-walled carbon fiber layer (e.g. the thin-walled carbon fiber layer is the inner layer and the thin-walled aluminum alloy layer is the outer layer) fall into the protection scope of the present invention.

[0042] The contents illustrated by the above embodiments should be understood as these embodiments are merely used for illustrating the present invention more clearly, rather than limiting the scope of the present invention. Various equivalent modifications made to the present invention by those skilled in the art after reading the present invention all fall within the scope defined by the appended claims of the present application.

Claims

1. A deformable tube, comprising two or more thin-walled tubes that are connected in a sleeved manner, wherein the thin-walled tube is a carbon fiber tube or a metal tube, materials of two adjacent thin-walled tubes are different, and the thin-walled tube indicates that the wall thickness of the tube is 20 mm or less.

2. The deformable tube according to claim 1, wherein the deformable tube consists of two thin-walled tubes, an inner layer of the deformable tube (3) is a metal tube, and an outer layer of the deformable tube (4) is a carbon fiber tube.

3. The deformable tube according to claim 2, wherein the metal tube is an aluminum alloy tube.

4. The deformable tube according to claim 1, wherein the metal tube has a thickness of 2-7.5 mm, and the carbon fiber tube has a thickness of 2-15 mm.

5. The deformable tube according to any one of claims 1-4, wherein an epoxy resin layer is arranged between two adjacent thin-walled tubes.

6. A coupler cushioning energy-absorption device for a rail vehicle, comprising a traction rod (1) used for connecting to a coupler head (7) and a bearing plate (5) used for connecting to a coupler tail base (8), wherein the bearing plate (5) and the traction rod (1) are connected by a guide rod (10), and an end of the traction rod (1) facing the coupler tail base (8) is provided with an expansion block (2);

   the deformable tube according to any one of claims 1-5 is sleeved outside the guide rod (10), one end of the deformable tube abuts against one end surface of the bearing plate (5), and a bevel ring that abuts against the expansion block (2) is formed on the other end of the deformable tube, such that the deformable tube swells radially when the expansion block (2) squeezes the deformable tube;
   an end of the guide rod (10) close to the bearing plate (5) is provided with a support stage (11), and an outer peripheral surface of the support stage (11) is attached to an inner wall surface of the deformable tube.

7. The coupler cushioning energy-absorption device for a rail vehicle according to claim 6, wherein one end of the guide rod (10) extends into the traction rod (1), and the guide rod (10) is fixedly connected with the traction rod (1) by a snap ring connector.

8. The coupler cushioning energy-absorption device for a rail vehicle according to claim 6, wherein a trigger indicator pin (6) is arranged between the traction rod (1) and the expansion block (2), the trigger indicator pin (6) is arranged on an outer wall surface of the traction rod (1), and an outer end of the indicator pin (6) protrudes relative to an outer wall surface of the expansion block (2).

9. The coupler cushioning energy-absorption device for a rail vehicle according to claim 6, wherein one end of the bearing plate (5) is fixedly connected with the coupler tail base (8) by a snap ring connector or

a rubber buffer, and the coupler tail base (8) is fixed to a vehicle chassis (9).

10. A rail vehicle, wherein the coupler cushioning energy-absorption device for a rail vehicle according to any one of claims 6-9 is installed on a vehicle chassis (9).

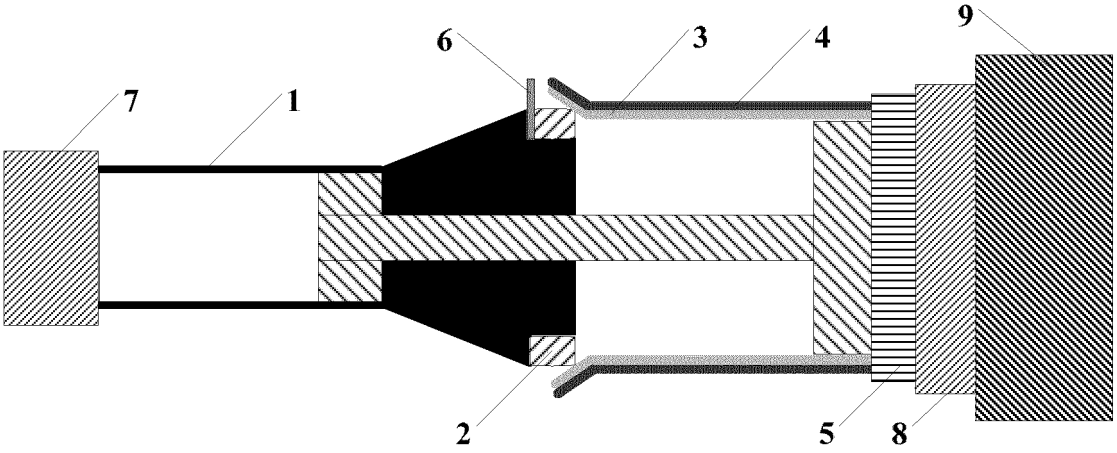

Fig. 1

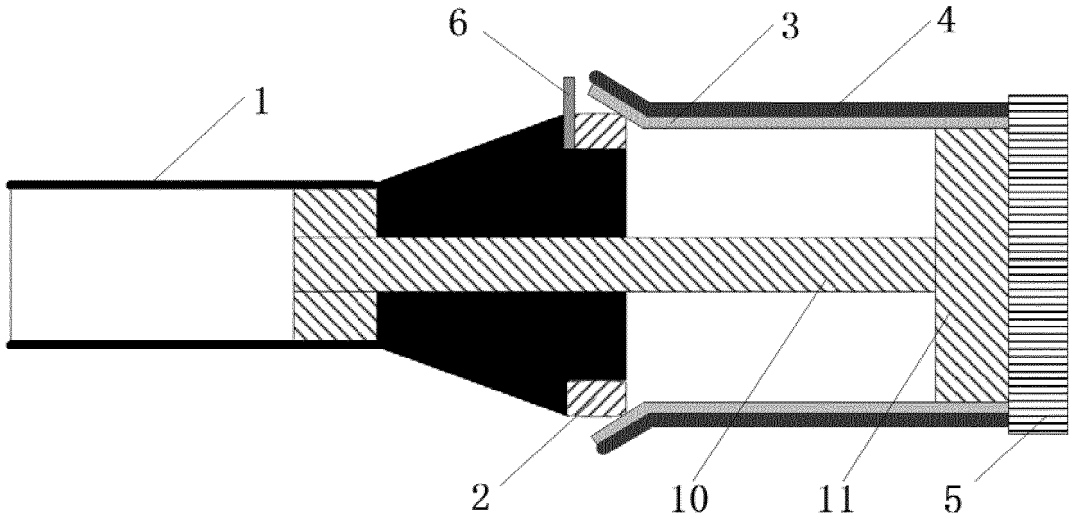

Fig. 2

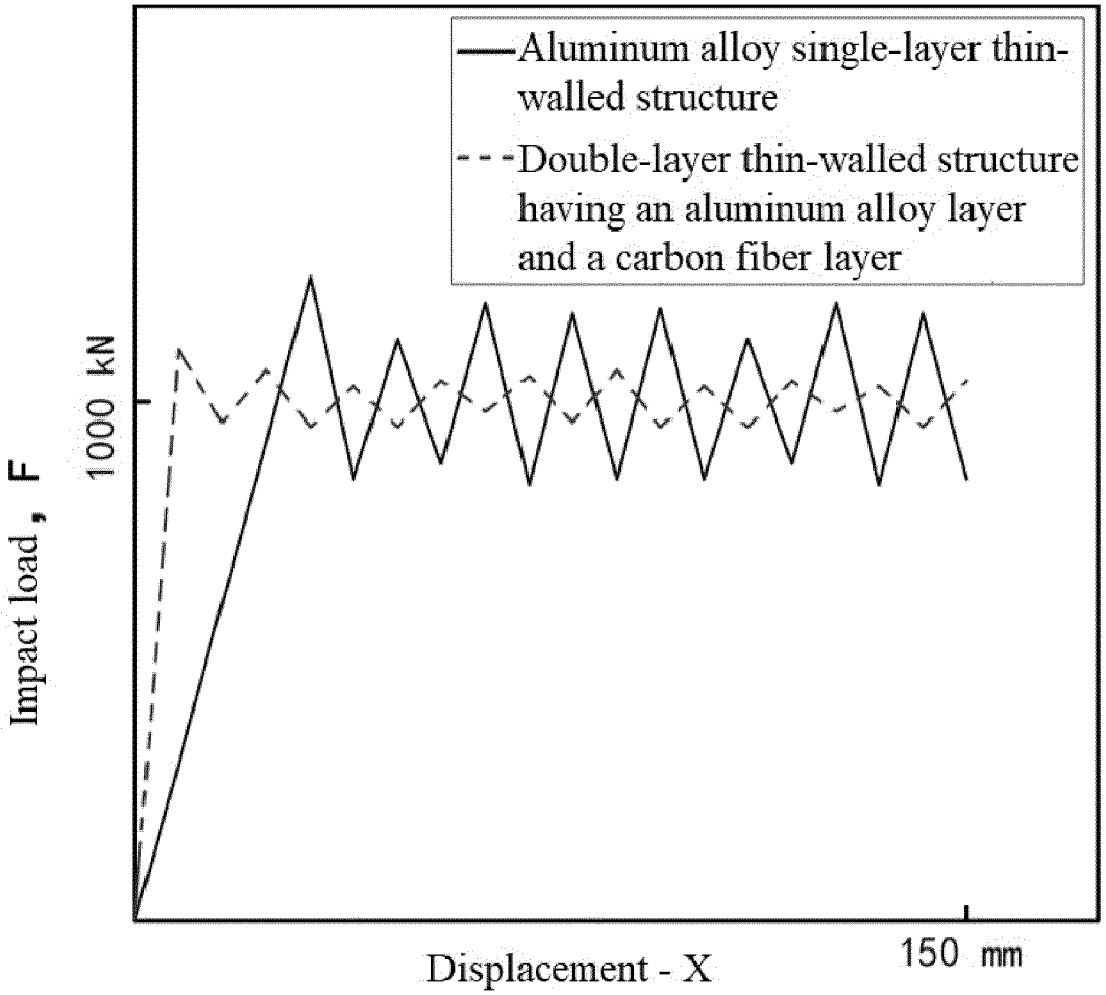
Aluminum alloy single-layer thin-walled structure
Double-layer thin-walled structure having an aluminum alloy layer and a carbon fiber layer
Impact load , F
1000 kN
Displacement - X
150 mm

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/106766

A. CLASSIFICATION OF SUBJECT MATTER

B61G 9/20(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B61G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

VEN, CNKI, CNABS; 车钩, 碰撞, 变形, 膨胀, 吸能, 缓冲, 压溃, 金属, 碳纤维; buffer, deform, crash, shock, absorb, energy, coupler, coupling, metal, carbon, fibre

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 111891169 A (CRRC ZHUZHOU LOCOMOTIVE CO., LTD.) 06 November 2020 (2020-11-06) claims 1-8, and entire description	1-10
A	CN 201329871 Y (CRRC QINGDAO SIFANG ROLLING STOCK RESEARCH INSTITUTE CO., LTD.) 21 October 2009 (2009-10-21) description, pages 1-4, figures 1-8	1-10
A	CN 110979384 A (CENTRAL SOUTH UNIVERSITY) 10 April 2020 (2020-04-10) entire document	1-10
A	CN 202264797 U (CSR QISHUYAN INSTITUTE CO., LTD.) 06 June 2012 (2012-06-06) entire document	1-10
A	JP 2012081934 A (JAPAN STEEL WORKS LTD.) 26 April 2012 (2012-04-26) entire document	1-10
A	CN 210126529 U (CRRC CHANGCHUN RAILWAY VEHICLES CO., LTD.) 06 March 2020 (2020-03-06) entire document	1-10

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
07 September 2021	**12 October 2021**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China**	Authorized officer
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	CN 106458233 A (DELLNER COUPLERS AB) 22 February 2017 (2017-02-22) entire document	1-10
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A	CN 105172827 A (CRRC QINGDAO SIFANG ROLLING STOCK RESEARCH INSTITUTE CO., LTD.) 23 December 2015 (2015-12-23) entire document	1-10
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Information on patent family members

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